GRADALL®

Service Manual

Part Number 80884014

XL3100V - XL4100V - XL5100V
XL4130V

(4x2) S/N 3120000375 & After
(4x4) S/N 3140000378 & After

(6x4) S/N 4140000100 & After
(Railgear) S/N 4140R00100 & After
(Railgear) S/N 4130R00100 & After
(6x4) S/N 4160000088 & After

(6x4) S/N 5140000100 & After
(6x6) S/N 5160000100 & After

Revised
December 7th, 2018

This manual, and all manuals for the Gradall Hydraulic Excavator product line, can be viewed or downloaded, free-of-charge, at www.mygradall.com

IMPORTANT! - If printed, or downloaded in electronic format, this is an uncontrolled copy of the manual. The current version can be viewed/downloaded at www.mygradall.com

GRADALL®

Operator & Safety Manual

Keep this manual with machine at all times.

XL3100V - XL4100V - XL5100V
XL4130V

(4x2) S/N 3120000375 & After
(4x4) S/N 3140000378 & After

(6x4) S/N 4140000100 & After
(Railgear) S/N 4140R00100 & After
(Railgear) S/N 4130R00100 & After
(6x6) S/N 4160000088 & After

(6x4) S/N 5140000100 & After
(6x6) S/N 5160000100 & After

80884013

Revised
December 7th, 2018

This manual, and all manuals for the Gradall Hydraulic Excavator product line, can be viewed or downloaded, free-of-charge, at www.mygradall.com

REVISION LOG

February 12th, 2016 - A - Original Issue of Manual
April 14th, 2016 - B - Added battery shutdown warning
January 6th, 2017 - C - Added description to chassis lube points in Section 5. Revised Upper Cab Heater Spec. Added XL4100V & XL5100V Weight & Dimension Specs.
December 7th, 2018 - D - Op Manual Revision Log

This manual is a very important tool! Keep it with the machine at all times.

The purpose of this manual is to provide owners, users, operators, lessors, and lessees with the precautions and operating procedures essential for the safe and proper machine operation for its intended purpose.

Due to continuous product improvements, Gradall Industries, Inc. reserves the right to make specification changes without prior notification. Contact Gradall Industries, Inc. for updated information, or access the most recent version of this manual at www.mygradall.com.

Operator Qualifications

The operator of the machine must not operate or drive the machine until this manual has been read, training is accomplished and operation of the machine has been completed under the supervision of an experienced and qualified instructor.

Operators of this equipment must possess a valid, applicable driver's license, be in good physical and mental condition. Operator must not be using medication which could impair abilities nor be under the influence of alcohol or any other intoxicant during the work shift.

In addition, the operator must read, understand and comply with instructions contained in the following material furnished with the hydraulic excavator:

- This Operator & Safety Manual
- AEM Off-Highway Dump Truck Manual
- AEM Hydraulic Excavator Safety Manual
- All instructional decals and plates
- Any optional equipment instructions furnished

The operator must also read, understand and comply with all applicable Employer, Industry and Governmental rules, standards and regulations.

If any manual is missing or illegible, get a replacement from your employer, distributor, or from Gradall Industries.

Modifications

Any modification to Gradall products must be approved by Gradall.

This product must comply with all safety related bulletins. Contact Gradall Industries, Inc. or the local authorized Gradall representative for information regarding safety-related bulletins which may have been issued for this product.

Gradall Industries, Inc. sends safety related bulletins to the owner of record of this machine. Contact Gradall Industries, Inc. to ensure that the current owner records are updated and accurate.

Gradall Industries, Inc. must be notified immediately in all instances where Gradall products have been involved in an accident involving bodily injury or death of personnel or when damage has occurred to personal property or the Gradall product.

FOR:

- Accident Reporting and Product Safety Publications
- Current Owner Updates
- Questions Regarding Product Applications and Safety
- Standards and Regulations Compliance Information
- Questions Regarding Product Modifications

CONTACT:

Product Safety and Reliability Department
Gradall Industries, Inc.
406 Mill Avenue
New Philadelphia, OH 44663
Phone: 330-339-2211
Toll-Free: 1-800-445-4752

Other Publications Available

Illustrated Parts Manual..80884012

Service Manual 80884014

NOTES:

TABLE OF CONTENTS

Section 3 - Operation

Section 4 - Attachments

Section 5 - Lubrication & Maintenance

Section 6 - Emergency Procedures

Section 7 - Specifications

Index

SECTION 1 - GENERAL SAFETY PRACTICES

1.1 HAZARD CLASSIFICATION SYSTEM

Safety Alert System and Safety Signal Words

⚠ DANGER

OW0010

DANGER indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING

OW0021

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION

OW0031

CAUTION indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

1.2 GENERAL PRECAUTIONS

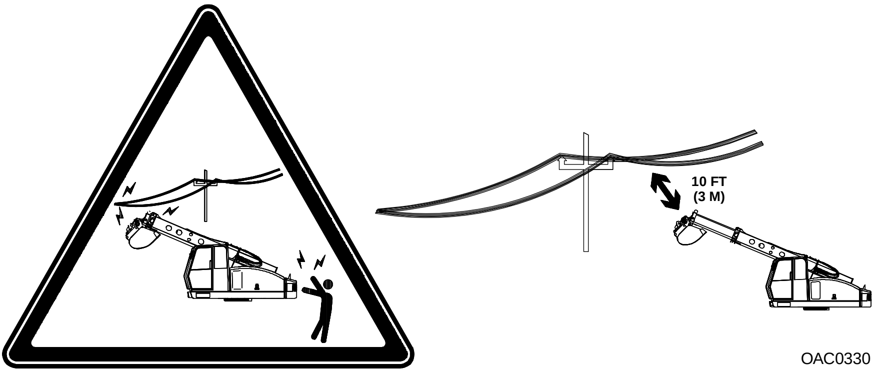
⚠ WARNING

OW0021

Before operation, read & understand this manual. Failure to comply with the information in this manual could result in machine damage, property damage, personal injury or death.

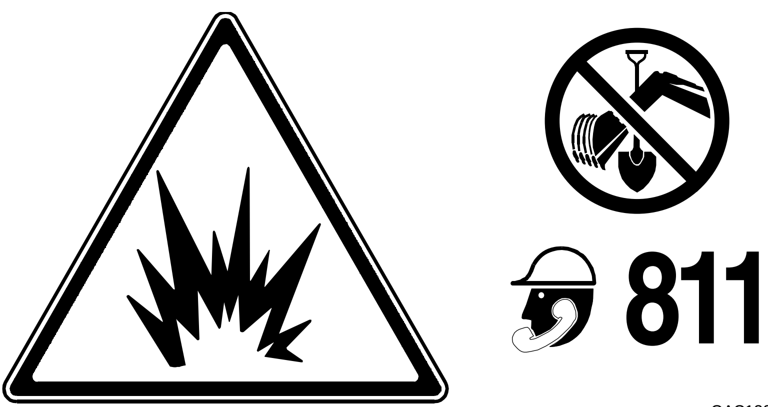
1.3 OPERATION SAFETY

Electrical Hazards



OAC0330

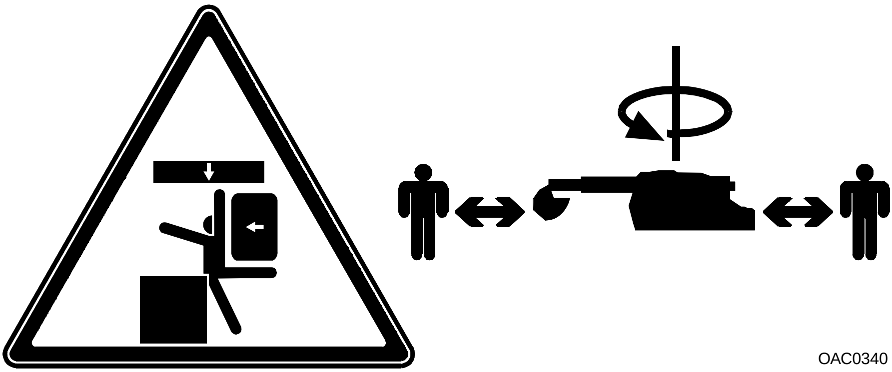
- This machine is not insulated and does not provide protection from contact or being near electrical current.
- **NEVER** operate the excavator in an area where overhead power lines, overhead or underground cables, or other power sources may exist without ensuring the appropriate power or utility company de-energizes the lines.
- Always check for power lines before raising boom.



OAC1290

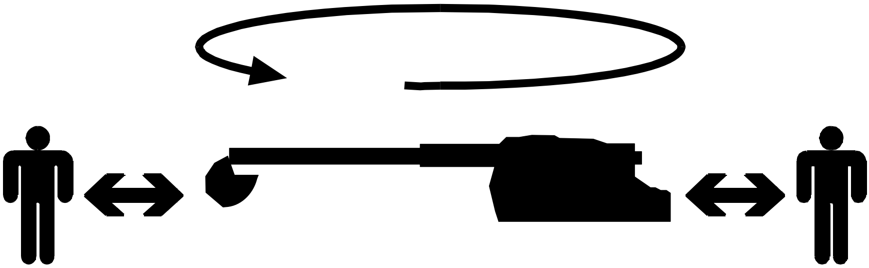
Always **"Call Before You Dig"**. Contact your local One-Call (811 in USA) or the One-Call referral number (888-258-0808 in USA and Canada) to have underground utilities located before digging.

Swing Hazards



OAC0340

- Keep others away from machine while in operation. Ensure others are clear of the swing radius prior to swinging upperstructure.
- Never carry a water can, equipment, or other worker's tools or personal items on the machine.
- Never permit anyone close enough to machine to become trapped between undercarriage and upperstructure.
- Position machine to prevent possibility of a person being crushed between counterweight and another object.
- Do not allow anyone inside the cab(s) (other than the operator) while in operation.
- Always be careful when using mirrors; distances are distorted and field of view is limited, especially when swinging. Always use a signal person when working in tight quarters.
- Be aware of undercarriage cab, if equipped, and undercarriage components when swinging upperstructure or digging. Position unit so that it won't be necessary to swing boom close to cab or undercarriage components.

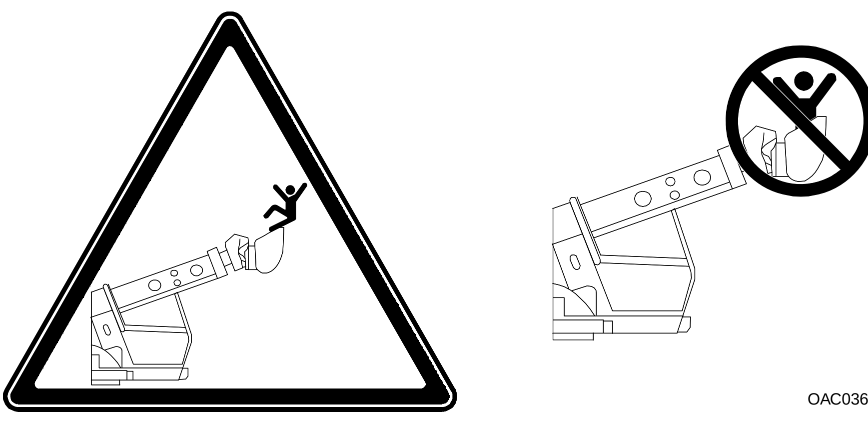


- The circle of safety is a circle around the excavator with the boom at full extension.
- Establish and inform others of the circle of safety. Keep others from entering into the circle of safety.

Slip and Fall Hazard

OAC0350

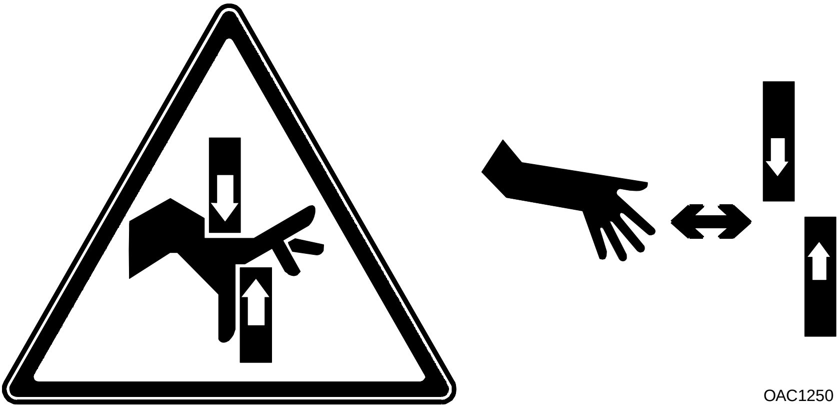
- Always maintain 3-point contact using proper hand holds and steps provided when mounting or dismounting. Never grab control levers or steering wheel when mounting or dismounting machine.
- Repair or replace damaged steps and grab handles.
- Keep grab handles, steps, and walkways free of mud, oil, grease and other foreign material. Replace non-skid surface material as required.
- Do not get off machine until shutdown procedure has been performed.
- Align upperstructure with undercarriage before dismounting.



OAC0360

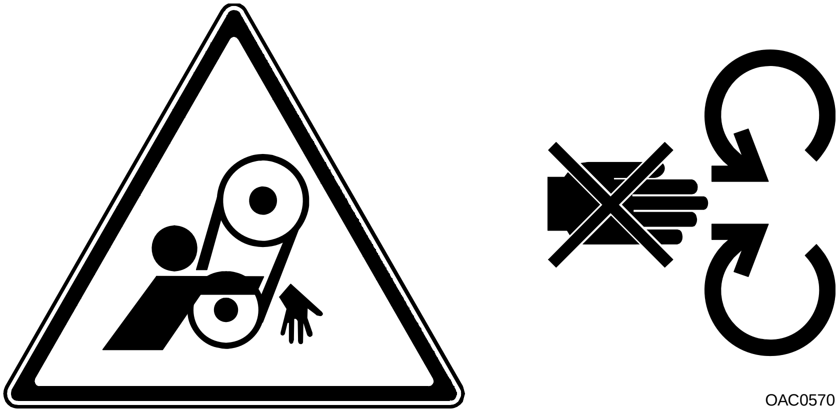
- **Keep others off machine** while in operation.
- **Do not lift personnel with this machine.**

Crush Hazards



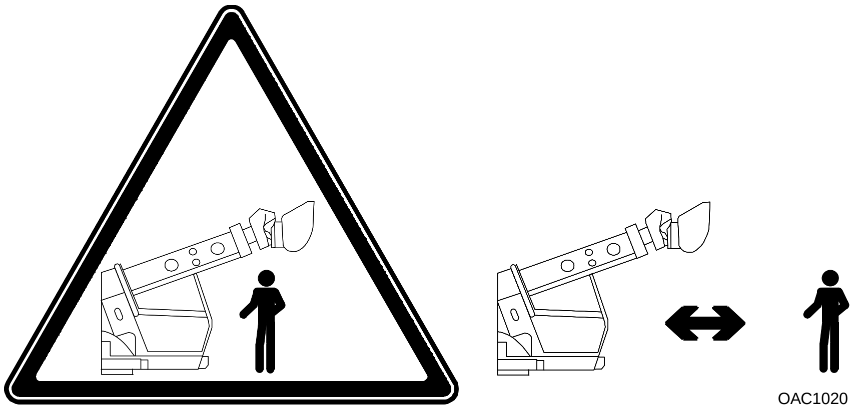
OAC1250

- Do not lean on boom or reach into boom holes, bucket linkage or boom rollers until the attachment or boom is resting on the ground and the engine is stopped.
- Be sure all access covers are in the fully open position before performing any procedures inside compartments.



OAC0570

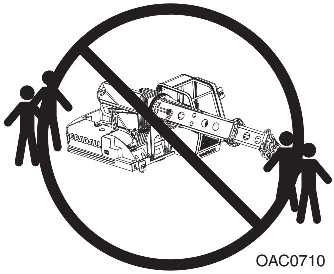
- Stay clear of moving parts while engine is running.
- Rotation of undercarriage cab steering wheel will occur during remote steering operation. Do not occupy undercarriage cab during remote operation.



OAC1020

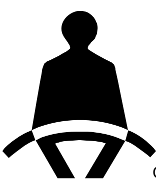
- Never permit anyone under boom, attachment or load. Rest boom or attachment on ground and stop engine before permitting anyone to work beneath boom or behind cradle.

Travel Hazards - Remote and Driving

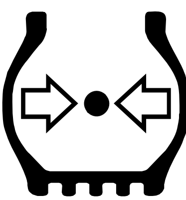


OAC0710

- Look out for and avoid other personnel, machinery and vehicles in the area. Use a spotter if you **do not** have a clear view.
- **Before moving** be sure of a clear path for undercarriage, boom and counterweight and **sound horn.**
- **Always** look in the direction of travel.
- **Before remote travel, check to be sure you are aware of orientation of upperstructure with regard to undercarriage.** Confusion could cause travel in the opposite direction you may expect.



OH20911

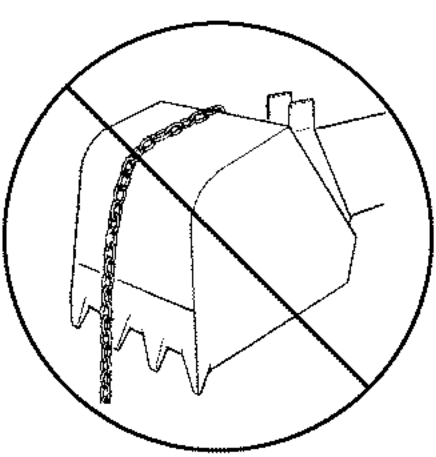


OH2291

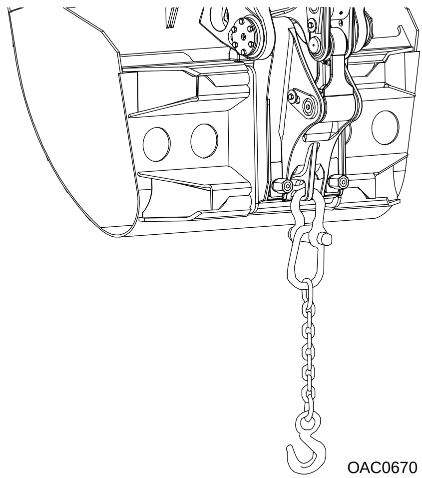
- Always wear seat belt.
- Keep head, arms and other body parts inside cab at all times.
- **Maintain proper tire pressure** at all times.
- Inspect brakes before driving undercarriage after digging. See page 3-34 for details.
- When machine is operating or driving on public roadways, **comply with all local, state and federal restrictions.**
- **When driving**, ensure boom and attachment are properly secured and positioned for maximum visibility and adequate clearances. Know the overall height of the machine.
- **Always check overhead and side boom clearances** carefully before driving. Position attachment/load to clear obstacles.
- Never drag boom or attachment while moving unit.

Tip Over Hazard

- Understand how to properly use the capacity chart located in cab. **Do not exceed rated lift capacity**. Plan the lift to be sure it can be performed safely.
- Maintain proper tire pressure at all times.
- Do not depend on machine tipping as a warning of overload. Some load ratings are based on hydraulic lift capacity, not stability.
- Do not increase hydraulic relief settings to lift a load.
- Sudden swing braking can cause unexpected movement of the load and tip the machine.
- Tether suspended loads to restrict movement.



OAC0370



OAC0670

- Never pass load line over open bucket. Relief valves in bucket circuit could cause unexpected, dangerous movement of the load. Bucket linkage could also be damaged.
- Be sure the surface excavator is on is firm enough to support unit and allows for adequate traction.
- Select low travel speed for off-highway grade travel. See *“Right Hand Arm Pod”* on page 2-34.
- Do not travel over excessively steep slopes or excessively rough terrain.
- No load in bucket, attached to boom or any other part of machine during off-highway grade travel.
- Front axle lock cylinders automatically unlock during travel. Do not travel with load over side.
- Shutting off engine will cause front axle lock cylinders to unlock. Place load on ground before shutting off engine.

Chemical Hazards

Exhaust Fumes

- **DO NOT** operate machine in an enclosed area without proper ventilation.
- **DO NOT** operate the machine in hazardous environments unless approved for that purpose by Gradall and site owner. Sparks from the electrical system and the engine exhaust can cause an explosion.
- If spark arrestors are required, be sure they are in place and in good working order.

Flammable Fuel

OW0300

- **DO NOT** fill the fuel tank or service the fuel system near an open flame, sparks or smoking materials. Engine fuel is flammable and can cause a fire and/or explosion.

⚠ WARNING

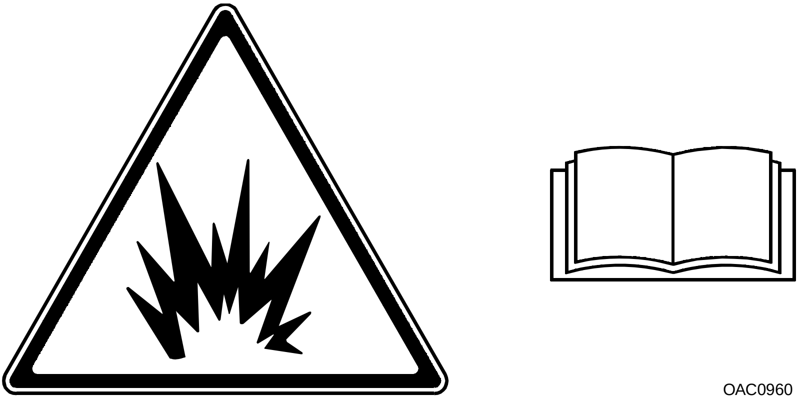
OW0021

Operating, servicing and maintaining this equipment can expose you to chemicals including gasoline, diesel fuel, lubricants, petroleum products, engine exhaust, carbon monoxide, and phthalates, which are known to the State of California to cause cancer and birth defects or other reproductive harm. To minimize exposure, avoid breathing exhaust, do not idle the engine except as necessary, service your vehicle in a well-ventilated area and wear gloves or wash your hands frequently when servicing your vehicle. Battery posts, terminals and related accessories contain lead and lead compounds, chemicals known to the state of California to cause cancer, birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov. This website, operated by California's Office of Environmental Health Hazard Assessment, provides information about these chemicals and how individuals may be exposed to them.

Hydraulic Fluid

OAC1260

- **DO NOT use your hand to check for leaks**. Use a piece of cardboard or paper to search for leaks. Wear appropriate equipment to protect yourself from spraying fluid. If fluid is injected into the skin seek medical attention immediately.
- Stop engine and relieve trapped pressure before loosening any hydraulic fitting. Hydraulic oil is under enough pressure that it can penetrate the skin.
- **DO NOT** attempt to repair or tighten any hydraulic hoses or fittings while the engine is running or when the hydraulic system is pressurized.



OAC0960

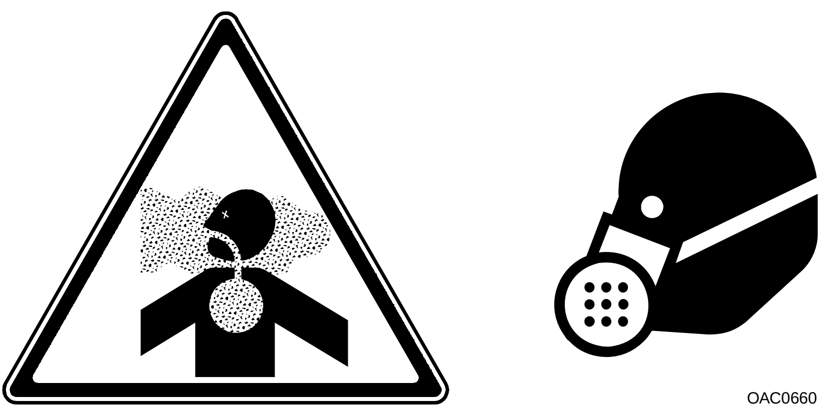
- Relieve pressure from the hydraulic reservoir using the vent valve near the reservoir breather before loosening the filter lid or cover.

Battery

OAC1270

- Keep sparks, flames and lighted material away from batteries. Explosive gases could cause death or serious injury.

Dust Hazard



OAC0660

- Repeated or substantial breathing of hazardous dusts, including crystalline silica, could cause fatal or serious respiratory disease including silicosis. Concrete, masonry, many types of rock, and various other materials contain silica sand. California lists respirable crystalline silica as a substance known to cause cancer. Operation of this equipment under certain conditions may generate airborne dust particles that could contain crystalline silica. In those conditions personal protective equipment including an appropriate respirator must be used. If excessive dust is generated, a dust collection or suppression system should also be used during operation.

1.4 PERSONAL PROTECTION EQUIPMENT

Wear all the protective clothing and personal safety devices issues to you or called for by job conditions. You may need:

- Hard hat
- Safety shoes
- Safety glasses, goggles or face shield
- Heavy gloves
- Hearing protection
- Reflective clothing
- Wet weather gear
- Respirator or filter mask

Wear adequate clothing for the job conditions.

Always know where to get assistance in the case of an emergency. Know where to find and how to use a first aid kit and fire extinguisher/fire suppression system.

NOTES:

SECTION 2 - PRE-OPERATION AND CONTROLS

2.1 PRE-OPERATION CHECKS & INSPECTION

Note: *Complete all required maintenance before operating unit.*

⚠ WARNING

OW0021

FALL HAZARD. Use extreme caution when checking items beyond your normal reach. Use an approved ladder. Failure to comply could result in death or serious injury.

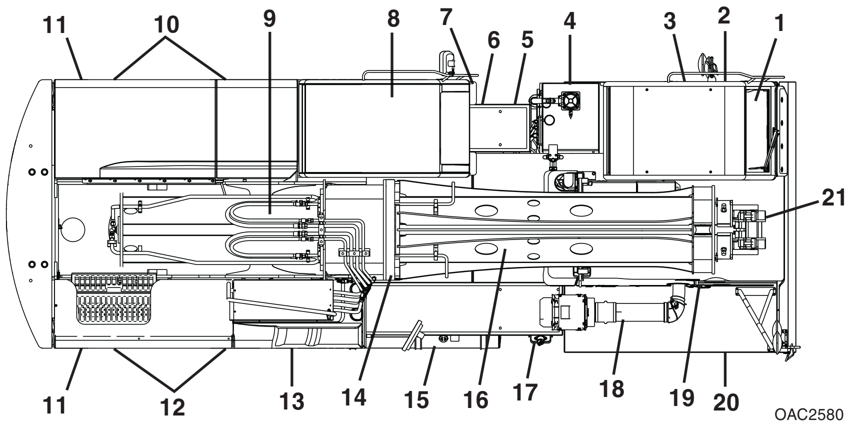
Walk around inspection must be performed at beginning of each work shift or at each change of operator.

Ensure all Safety decals are legible and in place. Clean or replace as required. Refer to pages 2-5 through 2-7.

Before removing filler caps or fill plugs, wipe all dirt and grease away from the ports. If dirt enters these ports, it can severely reduce component life.

When adding fluids, refer to *"Product Specifications"* on page 7-1 to determine proper fluid type, and *"Service & Maintenance Schedules"* on page 5-3 for intervals.

2.2 WALK-AROUND INSPECTION



Begin your walk-around inspection at item 1, as noted below. Continue to your right, checking each item in sequence.

INSPECTION NOTE: In addition to any other criteria mentioned, on all components:

- Ensure there are no loose or missing parts and that all parts are securely fastened.
- Check for visible leaks and excessive wear.
- Inspect all structural members including attachment for cracks, excessive corrosion and other damage.

1. Undercarriage Cab -
   - General appearance; no visible damage; Operator & Safety manual located in manual drawer.
   - Grab handles and steps secure and clean.
   - Window glass and mirrors clean and unobstructed. Adjust mirrors for maximum visibility, before and during operation. Be sure windows and doors are securely latched in open or closed position when operating. Replace damaged latches immediately.
   - Check seat belt for working condition damage, replace belt if frayed or cut webbing, damaged buckles or loose mounting hardware.
2. Front Axle - Drag link undamaged; steer cylinder and oscillation lock cylinders undamaged, not leaking; hydraulic hoses undamaged, not leaking; brakes undamaged.
3. Wheel/Tire Assembly - No loose or missing lug nuts; proper inflation (see page 5-26 for details). No damage to rims or tires; axle bolts torqued.

4. Hydraulic Reservoir - Recommended fluid level on sight gauge (see page 5-21 for instructions); filler/breather cap secure and working; oil is clear.

5. Air Tanks - Check for damage/leaks; open petcocks to eliminate condensation. See page 5-25 for instructions.

6. Battery Box - Battery cables tight, no visible damage or corrosion. Battery box cover properly latched. See page 5-28 for details.

7. Worklights- Clean, undamaged and aligned properly.

8. Upperstructure Cab -

    - General appearance; no visible damage; Operator & Safety manual located in manual drawer.
    - Grab handles and steps secure and clean.
    - Window glass and mirrors clean and unobstructed. Adjust mirrors for maximum visibility, before and during operation. Be sure windows and doors securely latch in open and closed position. Replace damaged latches immediately.
    - Check seat belt (if equipped) for damage, replace belt if frayed or cut webbing, damaged buckles or loose mounting hardware.

9. Center Pin - See Inspection Note.

10. Wheel/Tire Assemblies - No loose or missing lug nuts; proper inflation (see page 5-26 for details). No damage to rims or tires; axle bolts torqued.

11. Rear Axle(s)/Fenders - Check mud flaps for proper position and condition for highway operation; brakes undamaged.

12. Wheel/Tire Assemblies - No loose or missing lug nuts; proper inflation (see page 5-26 for details). No damage to rims or tires; axle bolts torqued.

13. Main Control Valve and Cover - See Inspection Note. Replace damaged latch and weak access cover support strut immediately.

14. Tilt Gear - Properly lubricated.

15. Fuel Tank - Check fuel level, refill as required (see page 5-20 for instructions); filler cap securely fastened.

16. Boom -

    - Rollers properly adjusted; no visible damage to boom hoses
    - Boom secure if machine is to be driven on highway.

17. DEF (Diesel Exhaust Fluid) Tank - Check DEF level, refill as required.

18. Air Cleaner - Air cleaner element condition indicator, check for clogged condition. Replace element as required.

19. Engine Compartment -

- Engine crankcase, check oil level & refill as required.
- Check engine coolant level at overflow bottle and refill as required.Do not remove the radiator cap. Be sure antifreeze solution is adequate for expected temperatures. Be sure radiator and oil cooler fins are clean.
- Drive belt, check condition & replace as required.
- Engine cover properly latched and secured.
- Power steering fluid at proper level.
- Transmission fluid - no leaks.

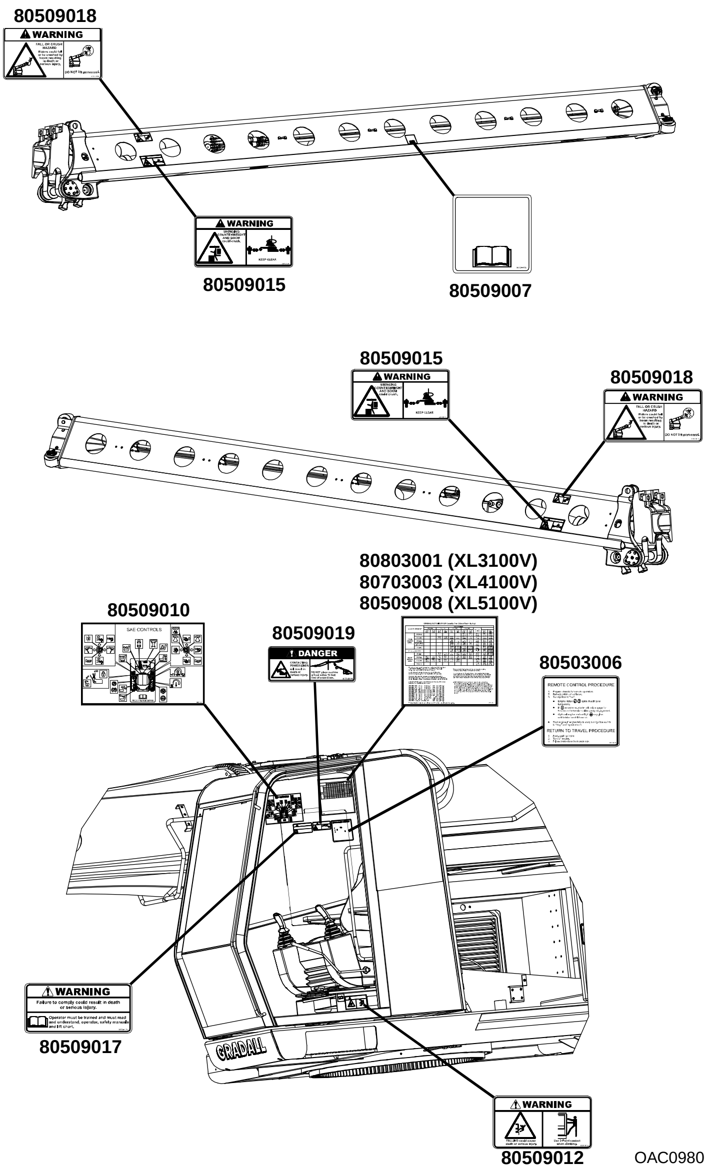
20. Wheel/Tire Assembly - No loose or missing lug nuts; proper inflation (see page 5-26 for details). No damage to rims or tires; axle bolts torqued.

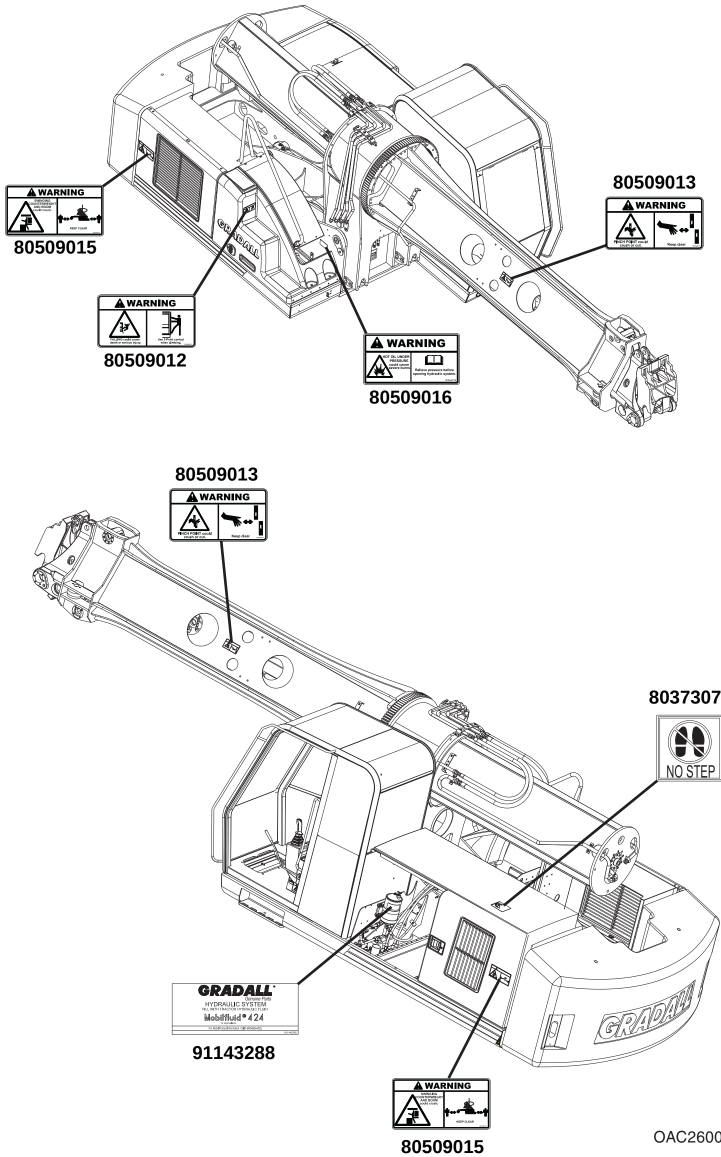
21. Attachment - Properly installed.

2.3 SAFETY DECALS

Ensure all **DANGER**, **WARNING**, **CAUTION** and instructional decals and proper capacity charts are legible and in place. Clean and replace as required.

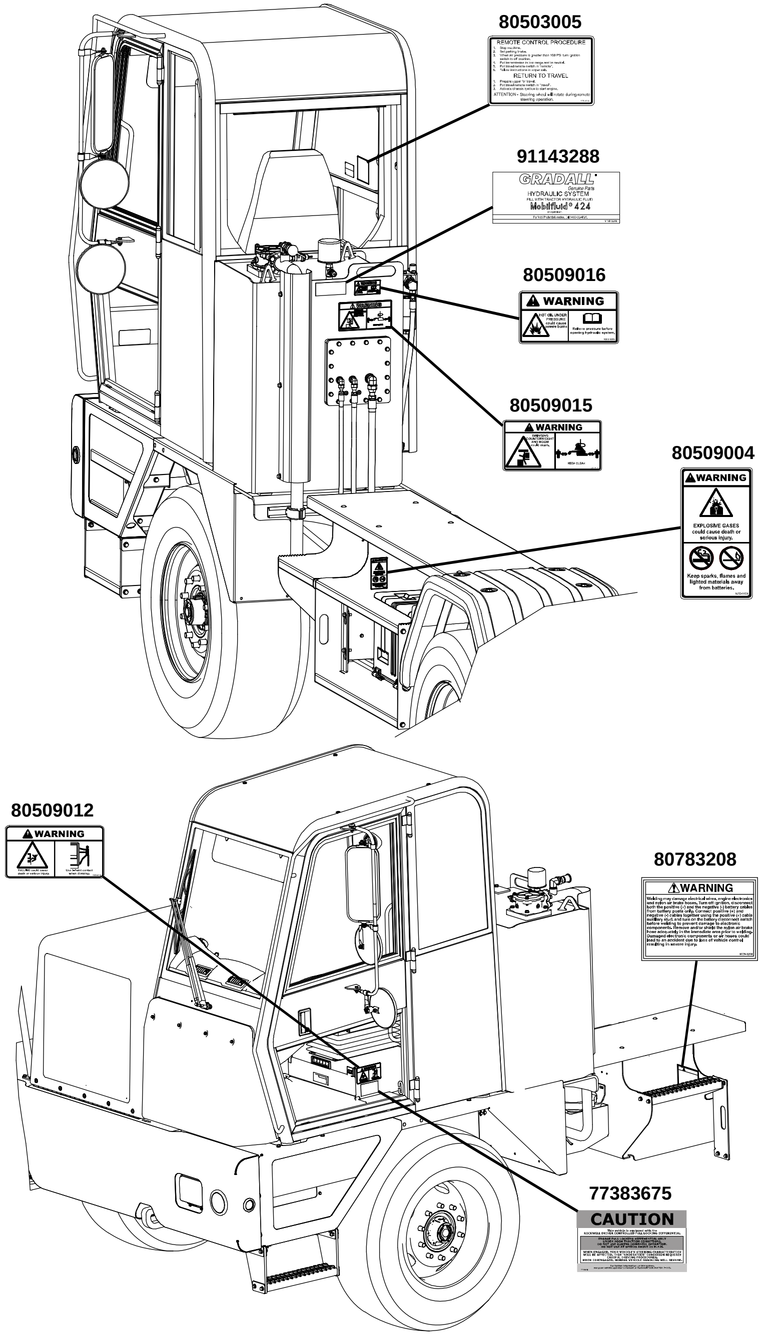
Upperstructure Decal Locations



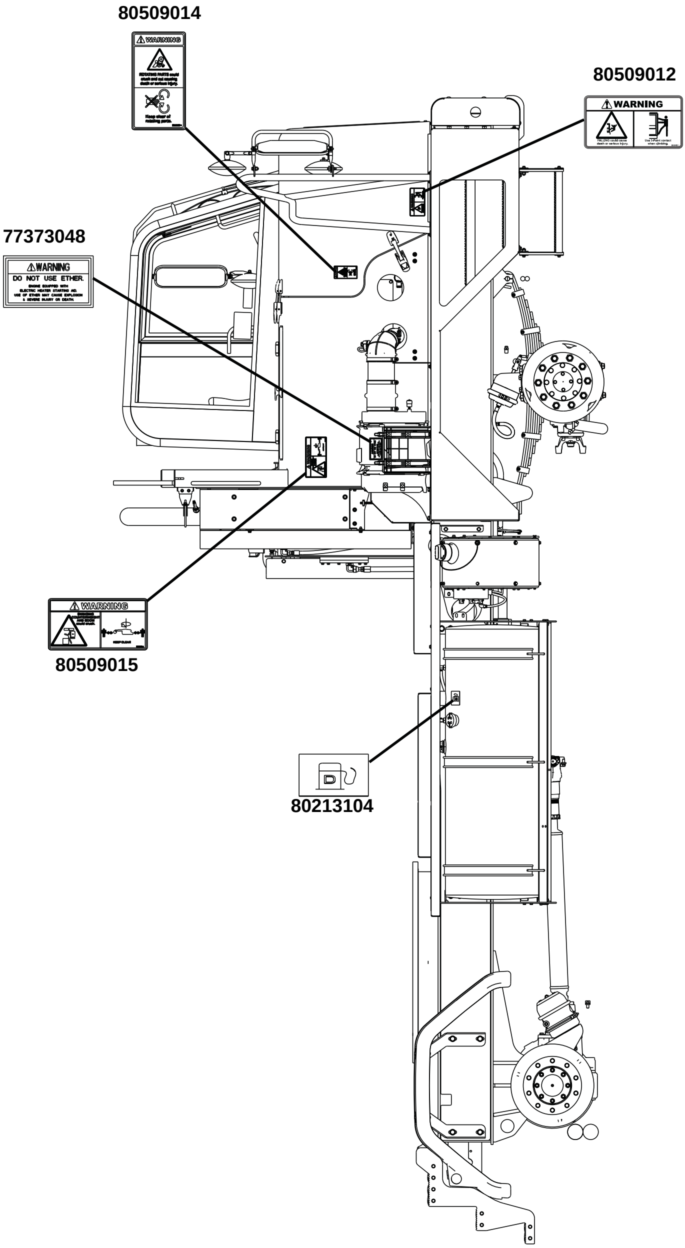

80509013
WARNING
PINCH POINT could crush or cut.
Keep clear
WARNING
80509015
WARNING
FALLING could cause death or serious injury.
80509012
WARNING
HOT OIL UNDER PRESSURE could cause severe burns.
Relieve pressure before opening hydraulic system.
80509016
GRADALL
80509013
WARNING
PINCH POINT could crush or cut.
Keep clear
80373077
NO STEP
GRADALL
HYDRAULIC SYSTEM
Mobilfluid 424
91143288
GRADALL
WARNING
KEEP CLEAR
80509015

OAC2600

Undercarriage Decal Locations

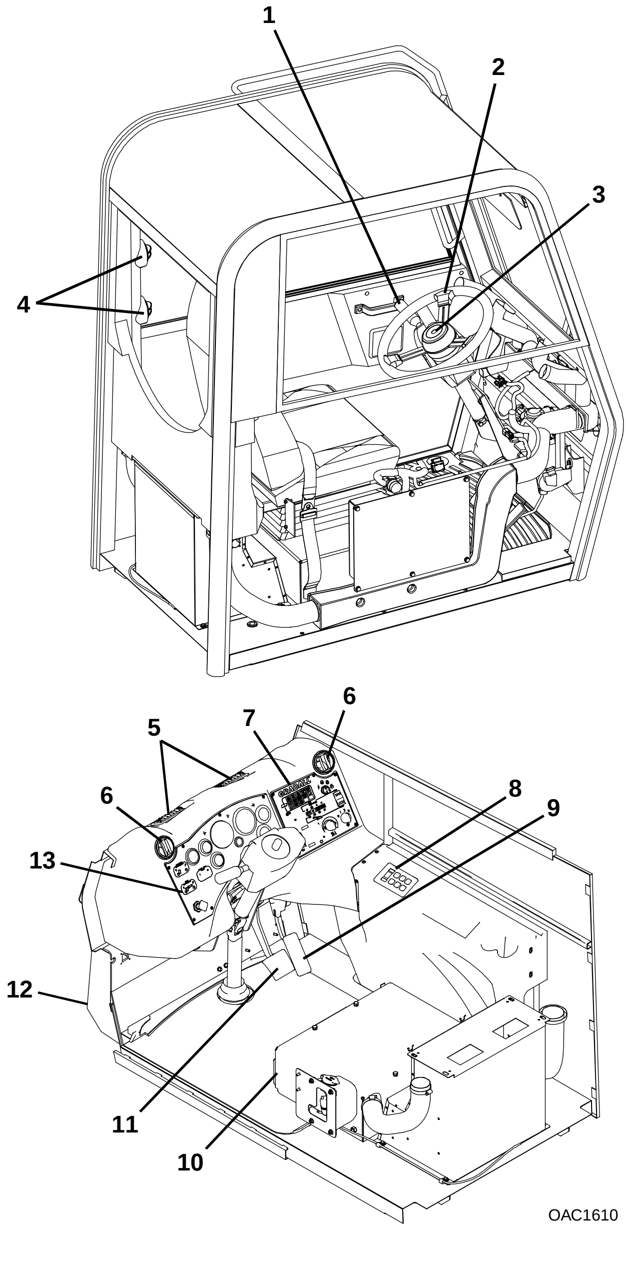


OAC1590


80509014
80509012
77373048
WARNING
DO NOT USE ETHER.
80509015
80213104

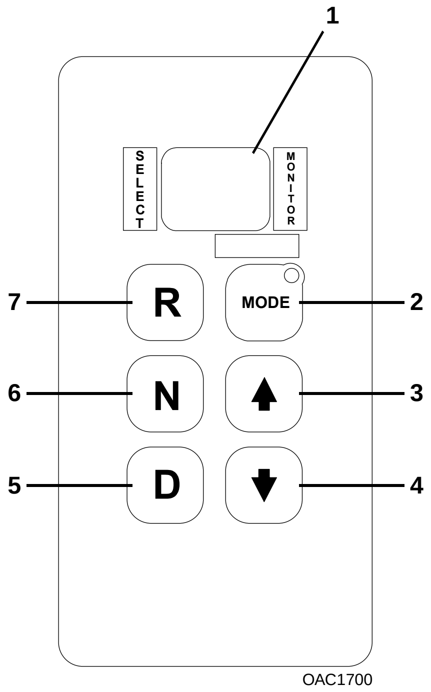
NOTES:

2.4 UNDERCARRIAGE CAB COMPONENTS



1. Turn Signal/High Beam/Hazards Lever: See page 2-28 for details.
2. Steering Wheel: Turn steering wheel to left or right to steer the machine in the corresponding direction.
3. Horn Button: Depress button to sound horn.
4. Air Diffuser Vents
5. Defroster Vents
6. Air Vents
7. Right Hand Dash Panel: See page 2-23 for details.
8. Transmission Shift Selector: See "*Shifting Gears*" on page 3-10 for detailed operating instructions.
9. Accelerator Pedal: Pressing the pedal down increases engine speed.
10. Manual Drawer: Keep Operator & Safety manual with machine at all times.
11. Brake Pedal: Depress to slow or stop machine.
12. Circuit Board and Fuse Box: See *"Fuses"* on page 7-9.
13. Dash Panel: See page 2-22 for details.

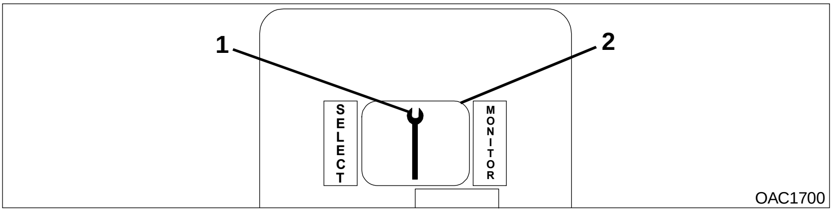
2.5 TRANSMISSION SHIFT SELECTOR



1. Digital Display
2. Mode Button: Pushbutton used to access/navigate prognostics/diagnostics.
3. Up Arrow: Pushbutton upshifts transmission when pressed. Also used to access/navigate prognostics/diagnostics.
4. Down Arrow: Pushbutton downshifts transmission when pressed. Also used to access/navigate prognostics/diagnostics.
5. Drive: Pushbutton shifts transmission to “Drive” when pressed.
6. Neutral: Pushbutton shifts transmission to “Neutral” when pressed.
7. Reverse: Pushbutton shifts transmission to “Reverse” when pressed.

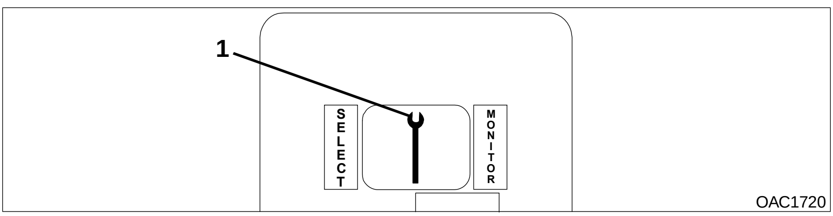
Prognostic Features

If the wrench icon **(1)** illuminates briefly in the digital display **(2)** after ignition is turned to the “RUN” position, then prognostics are enabled.



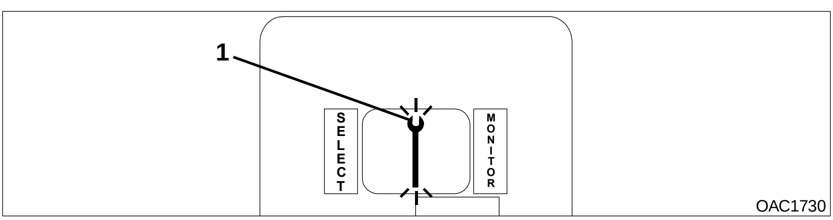
Oil Life Monitor

When fluid is due for a change, the wrench icon **(1)** is illuminated and remains solid for two minutes after “Drive” is selected.



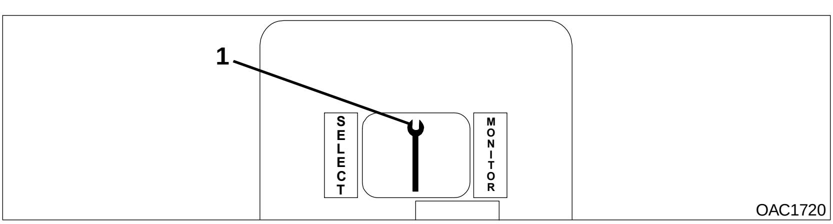
Filter Life Monitor

When the filter(s) is due for a change, the wrench icon **(1)** flashes on and off for two minutes after “Drive” is selected.



Transmission Health Monitor

When clutch maintenance is due, the wrench icon **(1)** comes on and remains solid during entire operational time of vehicle.

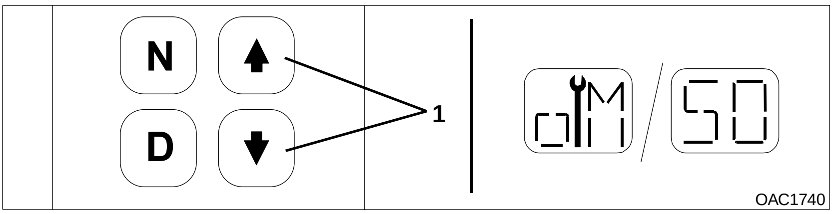


Accessing Prognostics

When you are alerted via the wrench icon on the transmission shift selector that service is due, you can check the status by toggling through the shift selector display as follows. **Be sure to park the vehicle on a level surface, shift to N (Neutral) and apply park brake before accessing prognostics through the shift selector**

Oil Life Monitor

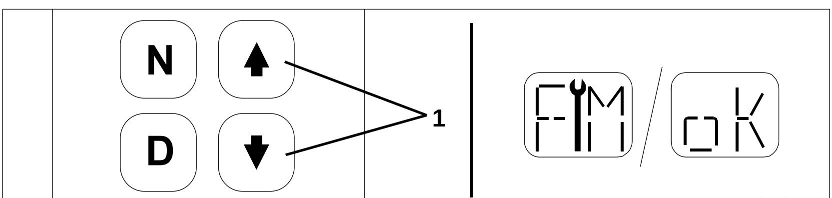
Simultaneously press the Up and Down arrows **(1)** two times. "oM" appears followed by a number from 99 to 0, which represents the percentage of oil life remaining before a fluid change is required.



OAC1740

Filter Life Monitor

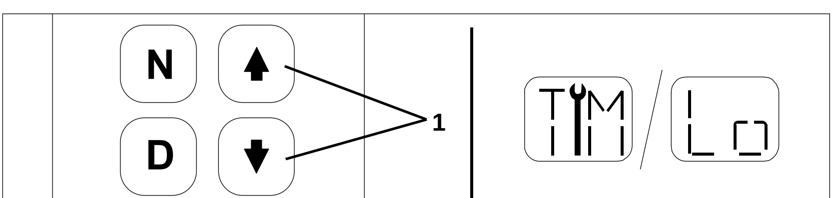
Simultaneously press the Up and Down arrows **(1)** three times. "FM" appears followed by either "oK" or "Lo". "oK" means filter(s) do not need changed and "Lo" means filter(s) need changed.



OAC1750

Transmission Health Monitor

Simultaneously press the Up and Down arrows **(1)** four times. "TM" appears followed by either "oK" or "Lo". "oK" means no clutch maintenance is required, and "Lo" means clutch maintenance is required.

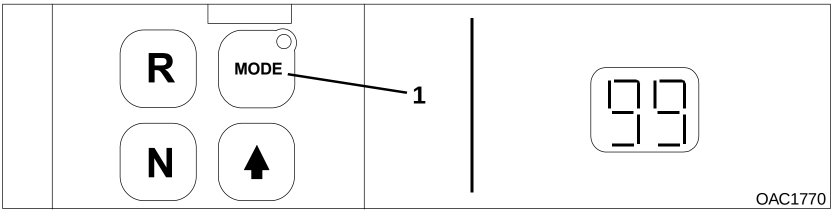


OAC1760

Resetting Prognostics

Oil Life Monitor

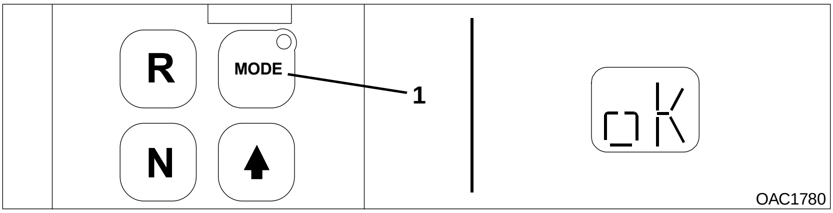
Press and hold Mode button **(1)** for approximately 10 seconds while in Oil Life Monitor mode.
-Or-
Perform the following shift sequence **with the ignition on but the engine off**. Do not stop the sequence for more than three seconds once you have started:
N-D-N-D-N-R-N.



Note: *A "99" will display verifying that Oil Life Monitor has been reset.*

Filter Life Monitor

Press and hold Mode button **(1)** for approximately 10 seconds while in Filter Life Monitor mode.
-Or-
Perform the following shift sequence **with the ignition on but the engine off**. Do not stop the sequence for more than three seconds once you have started:
N-R-N-R-N-D-N.



Note: *The wrench icon will illuminate briefly and "oK" will display verifying Filter Life Monitor has been reset.*

Transmission Health Monitor

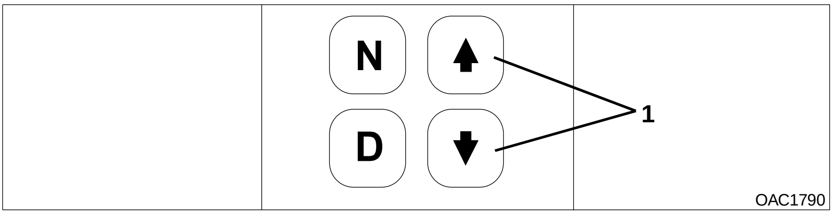
The wrench icon clears automatically when appropriate conditions are detected. Transmission Health Monitor must be reset manually using Allison DOC™ after correcting a clutch system issue.

Checking Fluid Levels

Use the following procedure to display oil level information.

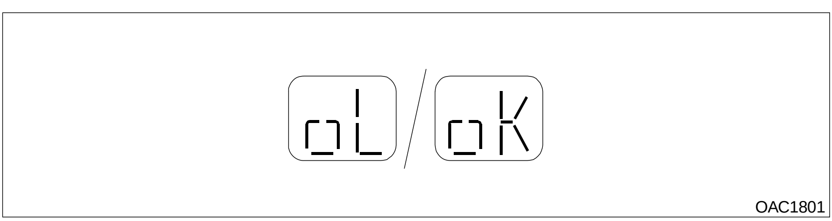
To enter the oil level function:

1. Park vehicle on a level surface, shift to N (Neutral) and apply the parking brake.
2. Simultaneously press the Up and Down arrows **(1)** one time.

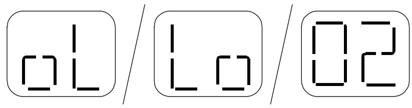


3. The fluid level reading may be delayed until the following conditions are met:
   Note: *The indication of a delayed fluid level check is a flashing display and a numerical countdown.*
   - Engine is at idle.
   - The fluid temperature is between 60°C (140°F) and 104°C (220°F).
   - Transmission is in N (Neutral)
   - The vehicle has been stationary for approximately two minutes to allow the fluid to settle.
   - The engine is at idle (below 1000 rpm - not “fast” idle).
4. The shift selector displays the oil level data as follows:

- **Correct Fluid Level** - “oL” is displayed (“oL” represents “Fluid (Oil) Level Check”) followed by “oK”. The “oK” display indicates the fluid is within the correct fluid level zone. The sensor display and the transmission dipstick may not agree exactly because the oil level sensor compensates for fluid temperature.



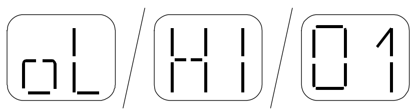
- **Low Fluid Level** - “oL” is displayed (“oL” represents “Fluid (Oil) Level Check”) followed by “Lo” (“Lo” represents “Low Oil Level”) and the number of quarts the transmission fluid is low.



OAC1810

Example: *“*oL Lo 02” indicates that 2 additional quarts of fluid will bring the fluid level within the middle of the “oK” zone.

- **High Fluid Level** - “oL” is displayed (“oL” represents “Fluid (Oil) Level Check”) followed by “HI” (“HI” represents “High Oil Level”) and the number of quarts the transmission fluid is overfilled.



OAC1820

Example: *“*oL HI 01” indicates 1 quart of fluid above the full transmission level.

- **Invalid For Display** - If any of the previous conditions are not met, the shift selector will display “oL” (“oL” represents “Fluid (Oil) Level Check”) followed by **“--”** and a numberical display. The numerical display is a fault code and indicates conditions are not proper to recieve the fluid level information or there is a system malfunction. The fault codes that may be encountered are shown below:

DISPLAY FAULT CODE	FLUID LEVEL FAULT CODE DESCRIPTION
oL, - -, OX*	**Setting time too short**
oL, - -, 50 or, EL	**Engine speed too low**
oL, - -, 59 or, EH	**Engine speed too high**
oL, - -, 65 or, SN	**Neutral must be selected**
oL, - -, 70 or, TL	**Sump fluid temperature too low**
oL, - -, 79 or, TH	**Sump fluid temperature too high**
oL, - -, 89 or, SH	**Output speed high**
oL, - -, 95 or, FL	**Oil level sensor failed****

OAC1830

*A number between 8 and 1 that flashes during countdown period.
**Report sensor failure display to a distributor or dealer in your area.

CAUTION

OW0031

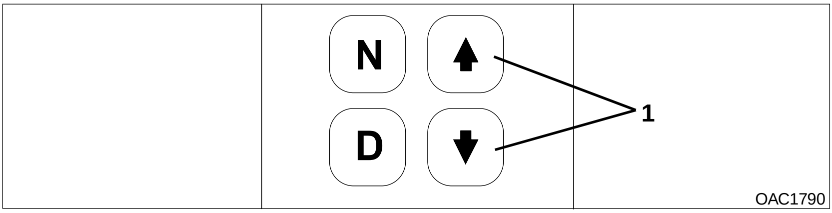
TRANSMISSION DAMAGE. A low or high fluid level can cause overheating and irregular shift patterns. Incorrect fluid level can damage the transmission.

- **To exit Oil Level Function, press any range button (R, N, D).**

Diagnostic Codes

To enter the diagnostic code function:

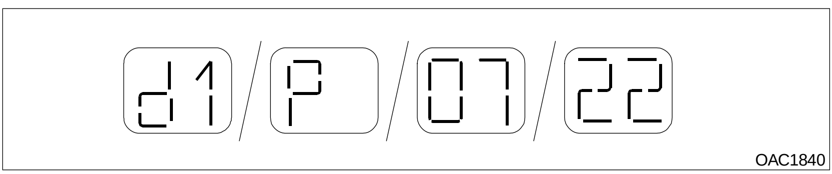
1. Bring the vehicle to a complete stop and apply the parking brake.
2. Simultaneously press the Up and Down arrows **(1)** five times.



To read diagnostic codes in the digital display:

Diagnostic codes will appear two characters at a time. When the diagnostic function is entered, the first code (position “d1”) is displayed as follows:

Example Code: **P 07 22** *Displayed as:* **d1, P, 07, 22**



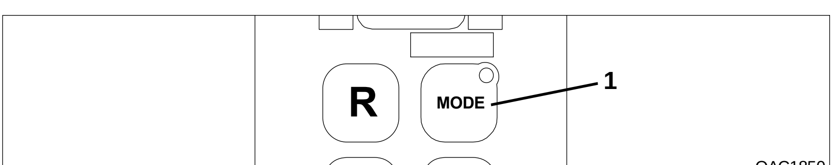
The Code Position (d1) is the first item displayed, followed by the Diagnostic Trouble Code (DTC),** P, 07, 22. Each item is displayed for about one second. The display cycles continuously until the next code list position is accessed by pressing the “MODE” button.

For a detailed list of Diagnostic Transmission Codes, see page 2-19.

***Diagnostic Trouble Code (DTC) - The diagnostic trouble code number referring to the general condition or area of fault detected by the TCM.*

To clear diagnostic codes:

Press and hold the “MODE” button **(1)** for 10 seconds to clear both active and inactive codes.



Note: *Be sure to record all codes displayed before they are cleared. This is essential for troubleshooting. Begin operating as normal.*

Diagnostic Transmission Codes

DIAGNOSTIC CODE	CODE DESCRIPTION
C1312	RETARDER REQUEST SENSOR, FAILED LOW
C1313	RETARDER REQUEST SENSOR, FAILED HIGH
P0122	PEDAL POSITION SENSOR, LOW VOLTAGE
P0123	PEDAL POSITION SENSOR, HIGH VOLTAGE
P0218	TRANSMISSION FLUID OVER TEMPERATURE
P0602	TCM NOT PROGRAMMED
P0610	TCM VEHICLE OPTIONS (TRANSID) ERROR
P0613	TCM PROCESSOR
P0614	TORQUE CONTROL DATA MISMATCH - ECM/TCM
P0634	TCM INTERNAL TEMPERATURE TOO HIGH
P063E	AUTO CONFIGURATION THROTTLE INPUT NOT PRESENT
P063F	AUTO CONFIGURATION ENGINE COOLANT TEMP INPUT NOT PRESENT
P0658	ACTUATOR SUPPLY VOLTAGE1 (HSD1), LOW
P0659	ACTUATOR SUPPLY VOLTAGE1 (HSD1), HIGH
P0701	TRANSMISSION CONTROL SYSTEM PERFORMANCE
P0702	TRANSMISSION CONTROL SYSTEM ELECTRICAL (TRANSID)
P0703	BRAKE SWITCH CIRCUIT MALFUNCTION
P0708	TRANSMISSION RANGE SENSOR, HIGH
P070C	TRANSMISSION FLUID SENSOR, LOW
P070D	TRANSMISSION FLUID SENSOR, HIGH
P0711	TRANSMISSION FLUID TEMPERATURE SENSOR PERFORMANCE
P0712	TRANSMISSION FLUID TEMPERATURE SENSOR, LOW
P0713	TRANSMISSION FLUID TEMPERATURE SENSOR, HIGH
P0716	TURBINE SPEED SENSOR PERFORMANCE
P0717	TURBINE SPEED SENSOR, NO SIGNAL
P0719	BRAKE SWITCH ABS, INPUT LOW
P071A	RELS INPUT, FAILED ON
P071D	GENERAL PURPOSE FAULT
P0721	OUTPUT SPEED SENSOR PERFORMANCE
P0722	OUTPUT SPEED SENSOR, NO SIGNAL
P0726	ENGINE SPEED SENSOR PERFORMANCE
P0727	ENGINE SPEED SENSOR, NO SIGNAL
P0729	INCORRECT 6TH GEAR RATIO
P0731	INCORRECT 1ST GEAR RATIO
P0733	INCORRECT 2ND GEAR RATIO
P0734	INCORRECT 3RD GEAR RATIO
P0735	INCORRECT 4TH GEAR RATIO
P0736	INCORRECT 5TH GEAR RATIO

OAC1860

Diagnostic Transmission Codes, (cont'd)

P0741	TORQUE CONVERTER CLUTCH SYSTEM, STUCK OFF
P0776	PRESSURE CONTROL SOLENOID 2, STUCK OFF
P0777	PRESSURE CONTROL SOLENOID 2, STUCK ON
P0796	PRESSURE CONTROL SOLENOID 3, STUCK OFF
P0797	PRESSURE CONTROL SOLENOID 3, STUCK ON
P0842	TRANSMISSION PRESSURE SWITCH 1, LOW
P0843	TRANSMISSION PRESSURE SWITCH 1, HIGH
P088A	DETERIORATED FILTER
P088B	VERY DETERIORATED FILTER
P0880	TCM POWER INPUT SIGNAL
P0881	TCM POWER INPUT SIGNAL PERFORMANCE
P0882	TCM POWER INPUT SIGNAL, LOW
P0883	TCM POWER INPUT SIGNAL, HIGH
P0884	TRANSMISSION COMPONENT SLIPPING
P0897	TRANSMISSION FLUID AT LIMIT
P0960	PRESSURE CONTROL SOLENOID MAIN MOD CONTROL, OPEN
P0962	PRESSURE CONTROL SOLENOID MAIN MOD CONTROL, LOW
P0963	PRESSURE CONTROL SOLENOID MAIN MOD CONTROL, HIGH
P0964	PRESSURE CONTROL SOLENOID 2 CONTROL, OPEN
P0966	PRESSURE CONTROL SOLENOID 2 CONTROL, LOW
P0967	PRESSURE CONTROL SOLENOID 2 CONTROL, HIGH
P0968	PRESSURE CONTROL SOLENOID 3 CONTROL, OPEN
P0970	PRESSURE CONTROL SOLENOID 3 CONTROL, LOW
P0971	PRESSURE CONTROL SOLENOID 3 CONTROL, HIGH
P0973	SHIFT SOLENOID 1 CONTROL, LOW
P0974	SHIFT SOLENOID 1 CONTROL, HIGH
P0975	SHIFT SOLENOID 2 CONTROL, OPEN
P0976	SHIFT SOLENOID 2 CONTROL, LOW
P0977	SHIFT SOLENOID 2 CONTROL, HIGH
P0989	RETARDER PRESSURE SENSOR, FAILED LOW
P0990	RETARDER PRESSURE SENSOR, FAILED HIGH
P1739	INCORRECT LOW GEAR RATIO
P1891	THROTTLE POSITION SENSOR PWM SIGNAL, LOW
P1892	THROTTLE POSITION SENSOR PWM SIGNAL, HIGH
P2184	ENGINE COOLANT TEMPERATURE SENSOR, LOW
P2185	ENGINE COOLANT TEMPERATURE SENSOR, HIGH
P2637	TORQUE MANAGEMENT FEEDBACK SIGNAL (SEM)
P2641	TORQUE MANAGEMENT FEEDBACK SIGNAL (LRTP)
P2670	ACTUATOR SUPPLY VOLTAGE 2 (HSD2), LOW
P2671	ACTUATOR SUPPLY VOLTAGE 2 (HSD2), HIGH
P2685	ACTUATOR SUPPLY VOLTAGE 3 (HSD3), LOW
P2686	ACTUATOR SUPPLY VOLTAGE 3 (HSD3), HIGH

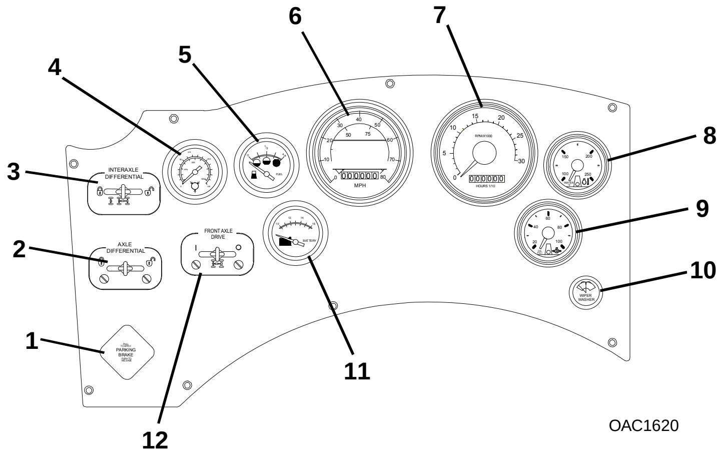
OAC1870

P2714	PRESSURE CONTROL SOLENOID 4, STUCK OFF
P2715	PRESSURE CONTROL SOLENOID 4, STUCK ON
P2718	PRESSURE CONTROL SOLENOID 4, STUCK OPEN
P2720	PRESSURE CONTROL SOLENOID 4 CONTROL, LOW
P2721	PRESSURE CONTROL SOLENOID 4 CONTROL, HIGH
P2723	PRESSURE CONTROL SOLENOID 1, STUCK OFF
P2724	PRESSURE CONTROL SOLENOID 1, STUCK ON
P2727	PRESSURE CONTROL SOLENOID 1 CONTROL, OPEN
P2729	PRESSURE CONTROL SOLENOID 1 CONTROL, LOW
P2730	PRESSURE CONTROL SOLENOID 1 CONTROL, HIGH
P2736	PRESSURE CONTROL SOLENOID 5 CONTROL, OPEN
P2738	PRESSURE CONTROL SOLENOID 5 CONTROL, LOW
P2739	PRESSURE CONTROL SOLENOID 5 CONTROL, HIGH
P2740	RETARDER OIL TEMPERATURE, HOT
P2742	RETARDER OIL TEMPERATURE SENSOR, LOW
P2743	RETARDER OIL TEMPERATURE SENSOR, HIGH
P2761	TCC PCS CONTROL, OPEN
P2763	TCC PCS CONTROL, HIGH
P2764	TCC PCS CONTROL, LOW
P278A	KICKDOWN INPUT, FAILED ON
P2789	CLUTCH ADAPTIVE LEARNING AT LIMIT
P2793	GEAR SHIFT DIRECTION
P2808	PRESSURE CONTROL SOLENOID 6, STUCK OFF
P2809	PRESSURE CONTROL SOLENOID 6, STUCK ON
P2812	PRESSURE CONTROL SOLENOID 6 CONTROL, OPEN
P2814	PRESSURE CONTROL SOLENOID 6 CONTROL, LOW
P2815	PRESSURE CONTROL SOLENOID 6 CONTROL, HIGH
U0001	HIGH SPEED CAN BUS RESET COUNTER OVERRUN (IESCAN)
U0010	CAN BUS RESET COUNTER OVERRUN
U0100	LOST COMMUNICATION WITH ECM/PCM (J1587)
U0103	LOST COMMUNICATION WITH GEAR SHIFT MODULE (SHIFT SELECTOR) 1
U0115	LOST COMMUNICATION WITH ECM
U0291	LOST COMMUNICATION WITH GEAR SHIFT MODULE (SHIFT SELECTOR) 2
U0304	INCOMPATIBLE GEAR SHIFT MODULE 1 (SHIFT SELECTOR ID)
U0333	INCOMPATIBLE GEAR SHIFT MODULE 2 (SHIFT SELECTOR ID)
U0404	INVALID DATA RECIEVED FROM GEAR SHIFT MODULE (SHIFT SELECTOR) 1
U0592	INVALID DATA RECIEVED FROM GEAR SHIFT MODULE (SHIFT SELECTOR) 2

OAC1880

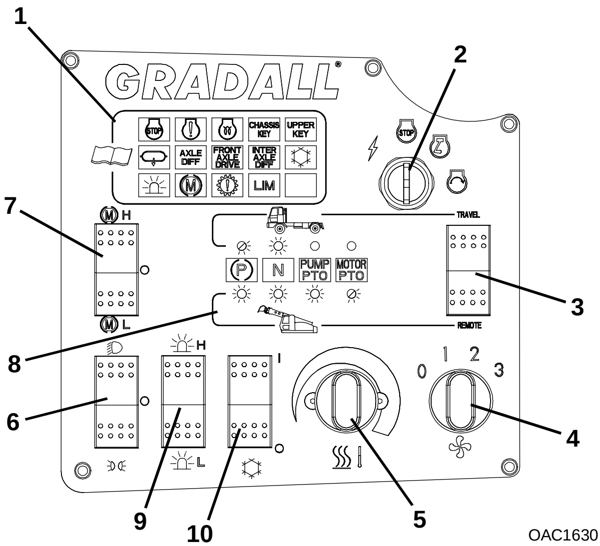
2.6 UNDERCARRIAGE CAB CONTROLS & INDICATORS

Dash Panel



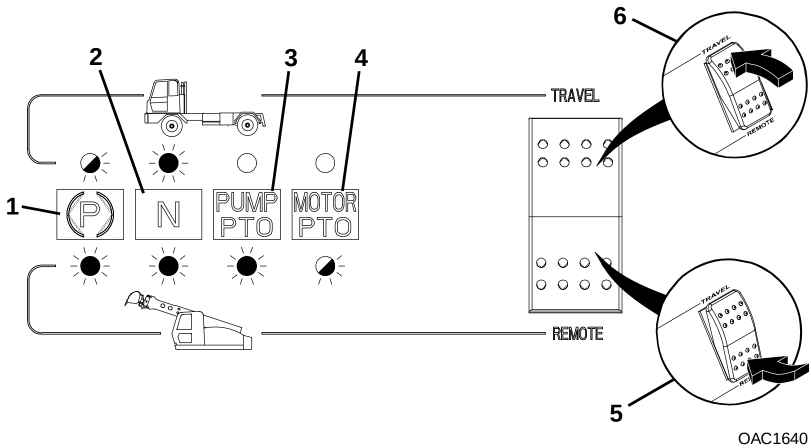
1. Parking Brake: See page 3-8 for details.
2. Differential Lock Switch: See page 3-11 for details.
3. Interaxle Differential Lock Switch (XL4100V & XL5100V only): See page 3-11 for details.
4. Dual Air Pressure Gauge: See *"Service Brake"* on page 3-5.
5. Fuel Gauge/DEF Level Indicator: Gauge for the fuel tank. LED indicator for Diesel Exhaust Fluid (DEF) level. A low DEF warning light will illuminate red and a pulsing alarm is activated to indicate Diesel Exhaust Fluid (DEF) level is less than 14%. Light will begin to blink 30 minutes after DEF level reaches less than 10% and engine torque will begin to derate.
6. Speedometer: Indicates undercarriage speed in miles per hour (mph).
7. Tachometer w/Engine Hourmeter: Tachometer indicates engine speed in revolutions per minute (rpm). Hourmeter indicates total time of engine operation in hours and tenths of hours.
8. Engine Coolant Temperature Gauge: Gauge for engine coolant temperature.
9. Engine Oil Pressure Gauge: Gauge for engine oil pressure.
10. Wiper/Washer Switch: Rotate switch clockwise to activate wiper. Press and hold switch to activate washer. Rotate switch counterclockwise to turn off wiper.
11. Voltmeter: Gauge indicating battery voltage.
12. Front Axle Drive Switch (if equipped): See page 3-13 for details.

Right Hand Dash Panel



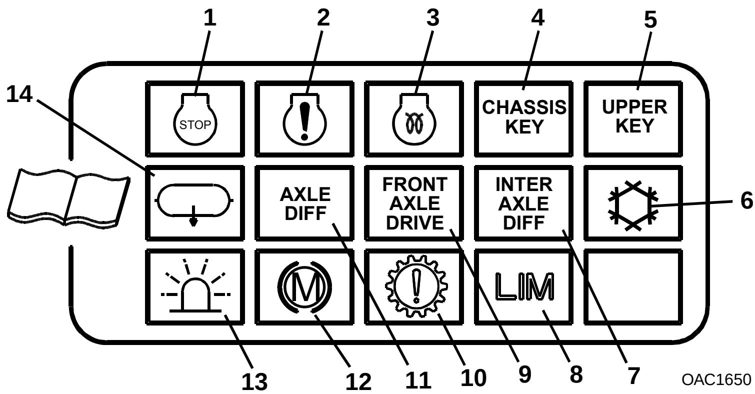
1. Information Display Area: See page 2-25 for details.
2. Ignition: Key Activated. See page 2-27 for details.
3. Travel/Remote Switch: See *"Travel/Remote Display Area"* on page 2-24.
4. Fan Speed: Rotary switch for heater and air conditioner (if equipped).
5. Temperature Control: Adjustable rotary switch.
6. Light Switch: 3-position rocker switch. Depress top of switch to activate headlights; depress bottom of switch to activate marker lights. Middle position is 'OFF'.
7. Engine Brake Switch (if equipped): 3-position rocker switch. Depress top of switch to activate compression brake; depress bottom of switch to activate compression/exhaust brake. Middle position is 'OFF'.
8. Travel/Remote Display Area: See page 2-24 for details.
9. Rotating Beacon Switch (if equipped): 3-position rocker switch. Depress top of switch to activate high-pulse strobe; depress bottom of switch to activate low-pulse strobe. Middle position is 'OFF'.
10. A/C Switch (if equipped): On/Off switch.

Travel/Remote Display Area



1. Parking Brake Indicator: Illuminates red to indicate parking brake is activated (See page 3-8). Parking brake must be applied to start engine while in remote control mode.
2. Neutral Gear Indicator: Illuminates green to indicate unit is in neutral gear. Transmission must be in neutral gear to start engine in either remote control mode or travel mode.
3. Pump PTO Indicator: Illuminates green to indicate main PTO (pump) is engaged. PTO (pump) must be off to start engine in travel mode. PTO (pump) must be engaged to start engine in remote control mode.
4. Motor PTO Indicator: Illuminates green to indicate PTO travel motor is engaged. PTO must be engaged to propel machine in remote control mode.
5. Remote Control Active: Depress bottom of switch for remote (upperstructure) operation.
6. Travel Mode Active: Depress top of switch for travel (undercarriage) operation.

Information Display Area



Note: *When ignition is turned to the "RUN" position (see page 2-27 for details), the engine stop, check engine, and optional engine preheat displays illuminate for approximately two seconds and then go off. At lower temperatures, the optional engine preheat light may continue to illuminate until the intake manifold warms to proper temperature.*

1. Engine Stop Indicator: Illuminates red and a pulsing alarm is activated to indicate excessive engine temperature or low engine oil pressure. Stop engine immediately and repair before continued use.
2. Check Engine Indicator: Illuminates yellow to indicate an engine malfunction. Stop engine and repair before continued use.
3. Engine Preheat Indicator (if equipped): Illuminates yellow to indicate grid heaters are warming intake manifold to proper starting temperature.
4. Undercarriage Key Indicator: Illuminates green to indicate undercarriage ignition key is in the "RUN" position (see page 2-27 for details).
5. Upperstructure Key Indicator: Illuminates green to indicate upperstructure ignition key is in the "RUN" position (see page 2-44 for details).
6. Air Conditioning Indicator (if equipped): Illuminates green to indicate air conditioner is activated.
7. Interaxle Differential Indicator (XL4100V & XL5100V only): Illuminates green to indicate interaxle differential lock is engaged.
8. Torque Limiter Indicator: Illuminates yellow and an alarm is activated to indicate Diesel Exhaust Fluid (DEF) level is low enough to begin engine torque deration. If light is solid, engine torque is greater than 50%. If light is blinking, engine torque is less than 50%.
9. Front Axle Drive Indicator (if equipped): Illuminates green if front axle drive is activated.

10. Check Transmission Indicator: Illuminates yellow to indicate a problem has been detected in the transmission and shifting may be restricted.

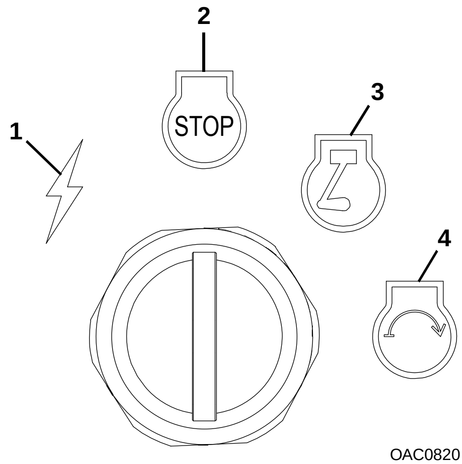
11. Axle Differential Lock Indicator: Illuminates green to indicate rear axle differential lock is engaged (XL3100V). Illuminates green to indicate front rear tandem axle differential lock is engaged (XL4100V & XL5100V).

12. Engine Brake Indicator (if equipped): Illuminates green if engine brake is activated.

13. Rotating Beacon Indicator (if equipped): Illuminates green if beacon is activated.

14. Low Air Indicator: Illuminates red to indicate air system pressure is below minimum operating pressure. An audible alarm is also activated. Do not move undercarriage while illuminated.

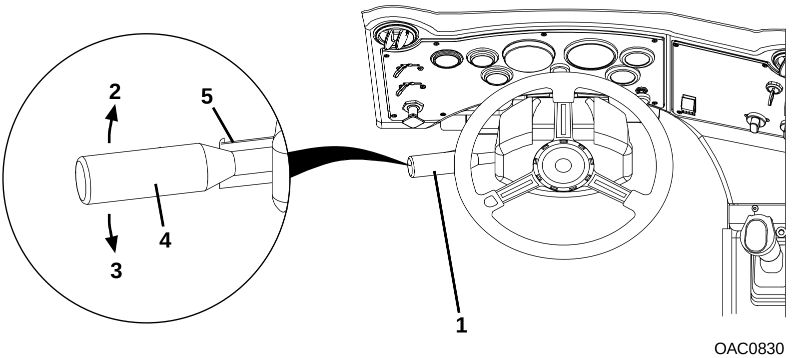
Ignition



1. ACC: Voltage is available for all electrical functions.
2. OFF: Engine off.
3. RUN: Prohibits rotating key switch to position 4 in the event the engine does not start. Rotate the key to position 2 then back to position 4 to re-engage the starter.
4. START: Engine start.

Turn Signal/High Beam/Hazards Lever

The turn signal/high beam/hazards lever **(1)** operates the turn signals, hazards and low beam/high beam function for the headlights.



Turn Signal/Hazards

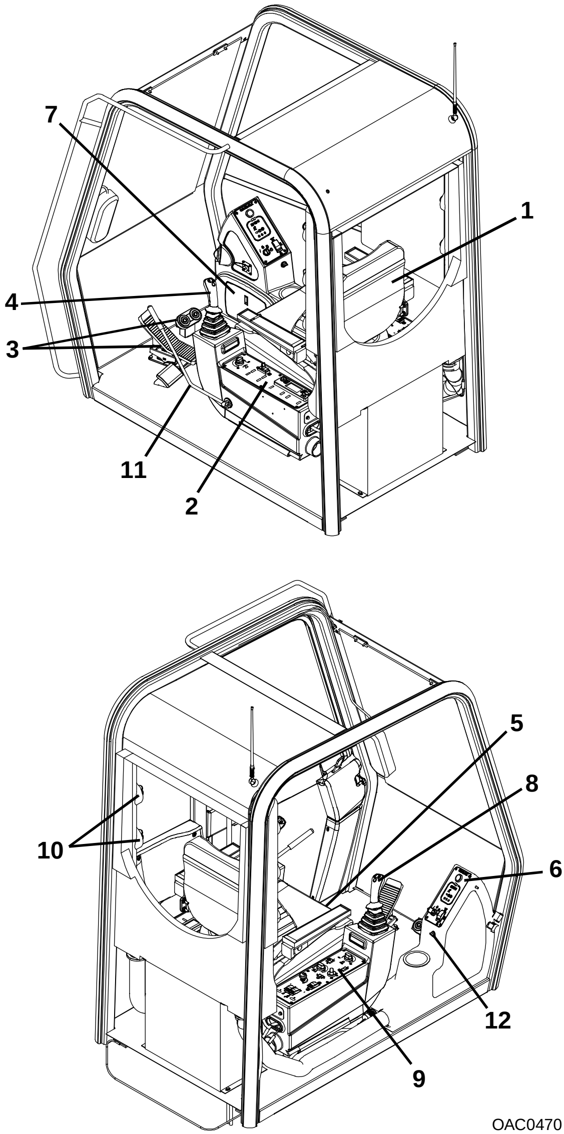
- Push the lever forward **(2)** to activate the right turn signal.
- Pull the lever back **(3)** to activate the left turn signal.
- Pull hazard switch **(5)** to activate hazards. Push lever **(1)** forward or back to deactivate hazards.

Low Beam/High Beam

- Raise/lower the lever **(1)** to switch between low beam and high beam.

NOTES:

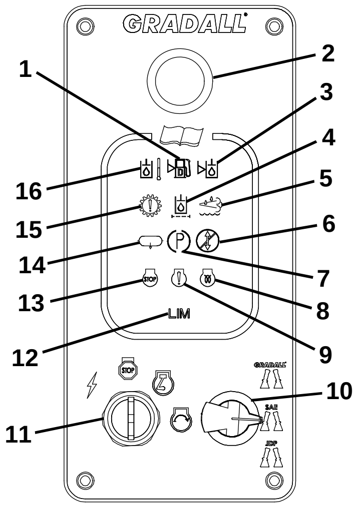
2.7 UPPERSTRUCTURE CAB COMPONENTS



1. Operator Seat: See *“Operator Seat Adjustments”* on page 2-43.
2. Left Hand Arm Pod: See page 2-36 for details.
3. Foot Pedals: See *“Driving Undercarriage from Upperstructure Cab”* on page 3-19.
4. Left Hand Joystick: See *“Joystick Controls”* on page 2-39.
5. Manual Drawer (located under operator seat): Keep Operator & Safety manual with machine at all times.
6. Electronic Monitoring Unit: See page 2-32 for details.
7. Circuit Board and Fuse Box: See *“Fuses”* on page 7-9.
8. Right Hand Joystick: See *“Joystick Controls”* on page 2-39.
9. Right Hand Arm Pod: See page 2-34 for details.
10. Air Vents
11. Control Cut Out Lever: See *“Activating the Joysticks”* on page 2-39.
12. 12-Volt Accessory Outlet: A cigarette lighter is provided. The receptacle can be used to power an auxiliary 12 VDC device equipped with the appropriate adapter.

2.8 UPPERSTRUCTURE CAB CONTROLS & INDICATORS

Electronic Monitoring Unit

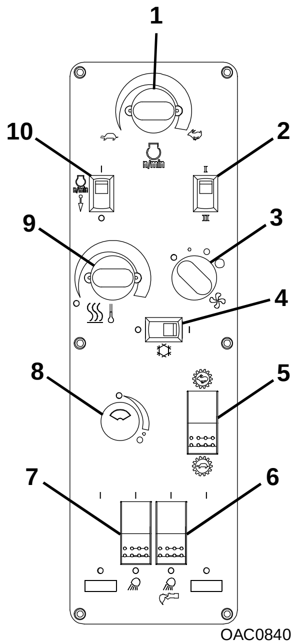


***Note:** When key is turned to the "RUN" position (see page 2-44 for details), the engine stop, check engine, and optional engine preheat displays illuminate for approximately two seconds and then go off. Depending on the temperature, the optional engine preheat light may continue to illuminate until the intake manifold warms to proper temperature.*

1. Fuel Level Indicator: Illuminates red if fuel level falls below 25% of capacity.
2. Mini Siren: Pulsing sound indicates engine shutdown has been initiated - Steady sound indicates low air system pressure or a travel lockout condition.
3. Hydraulic Oil Level Indicator: Illuminates red if oil level falls below acceptable operating level.
4. Hydraulic Filter Indicator: Illuminates red to indicate hydraulic reservoir filter needs replaced. See page 5-23 for details.
5. DEF Level Indicator: Illuminates red to indicate Diesel Exhaust Fluid (DEF) level is less than 14%. Light will begin to blink 30 minutes after DEF level reaches less than 10% and engine torque will begin to derate.
6. Travel Lockout Indicator: Illuminates yellow if travel motor or range gear is not engaged. An audible alarm is also activated.
7. Parking Brake Indicator: Illuminates red to indicate the parking brake is applied.
8. Engine Preheat Indicator (if equipped): Illuminates yellow to indicate grid heaters are warming intake manifold to proper starting temperature.

9. Check Engine Indicator: Illuminates yellow to indicate a malfunction. Stop engine and repair before continued use.
10. Joystick Control Pattern Selection Switch: See *"Joystick Control Pattern Selection"* on page 2-38.
11. Ignition: Key Activated. See page 2-44 for details.
12. Torque Limiter Indicator: Illuminates yellow to indicate Diesel Exhaust Fluid (DEF) level is low enough to begin engine torque deration. If light is solid, engine torque is greater than 50%. If light is blinking, engine torque is less than 50%.
13. Engine Stop Indicator: Illuminates red and a pulsing alarm is activated to indicate excessive engine temperature or low engine oil pressure. Stop engine immediately and repair before continued use.
14. Low Air Indicator: Illuminates red to indicate air system pressure is below minimum operating pressure. An audible alarm is also activated. Do not move undercarriage while illuminated.
15. Check Transmission Indicator: Illuminates red to indicate a problem has been detected in the transmission and shifting may be restricted.
16. Hydraulic Oil Temperature Indicator:
    - Flashes red to indicate below normal hydraulic oil operating temperature. Operate machine at reduced engine rpm & pump flow until display no longer flashes.
    - Illuminates red if hydraulic oil temperature is above safe operating temperature.

Right Hand Arm Pod



1. Engine Speed: Rotary switch. Rotate switch clockwise to increase engine rpm; rotate counterclockwise to decrease engine rpm.
2. Mode Select Switch: Depress front of switch (I) for fine grade mode. Depress back of switch (II) for dig mode.
3. Fan Speed: Rotary switch for heater and air conditioner fan.
4. Air Conditioning Switch: On/Off switch.
5. Travel Speed Switch: Depress front of switch for high travel speed. Depress back of switch for low (creeper) travel speed.

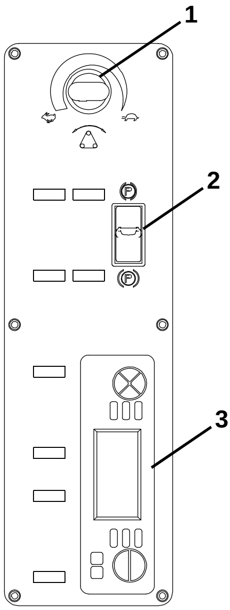
Note: *If travel speed is switched while unit is in motion, the machine will not shift to selected travel speed until the travel pedal is released and digging brake is set.*

6. Boom Lights Switch: On/Off switch.
7. Work Lights Switch: On/Off switch.
8. Intermittent Wiper/Washer Switch: See *"Intermittent Wiper/Washer"* on page 2-45.
9. Temperature Control: Adjustable rotary switch.

10. Auto Idle Override Switch: Depress front of switch (I) to activate auto idle. Depress back of switch (II) to deactivate auto idle.

- With auto idle activated, engine speed will return to low idle after 7 seconds of hydraulic control inactivity. Once controls are activated, engine resumes speed set by the operator.
- With auto idle deactivated, engine speed remains as set by the operator.

Left Hand Arm Pod



OAC0850

1. Boom Tilt Speed Switch: Rotary switch. Rotate switch clockwise to decrease boom tilt speed; rotate counterclockwise to increase boom tilt speed.
2. Park Brake Switch: See page 2-46 for details.
3. AM/FM Radio

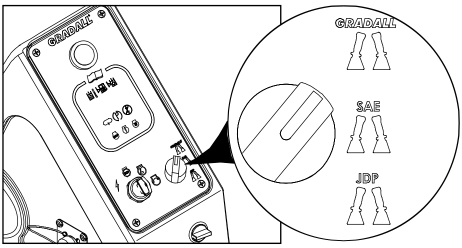
NOTES:

Joystick Control Pattern Selection

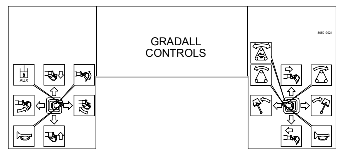
The control pattern selection switch allows the operator to select from three joystick control patterns; GRADALL, SAE and JOHN DEERE. The pattern must be selected with the ignition key in the “OFF” position. If a new pattern is selected while the engine is running, it will not change until the engine is turned off then restarted.

When a control pattern is changed, the corresponding control decal must be displayed in the cab.

GRADALL Control Pattern

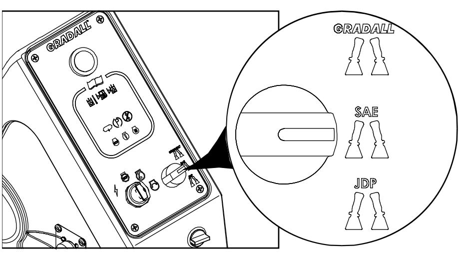


GRADALL CONTROL DECAL OVERLAY 80509021

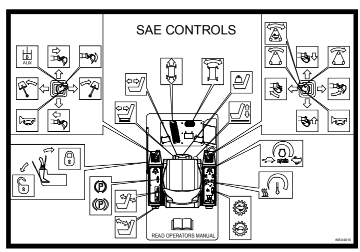


OAC1670

SAE Control Pattern

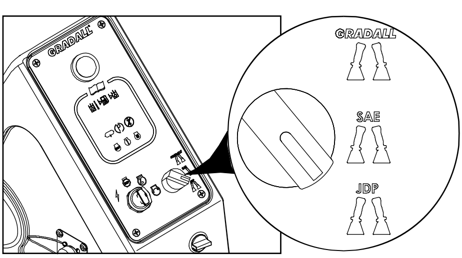


SAE CONTROL DECAL 80509010

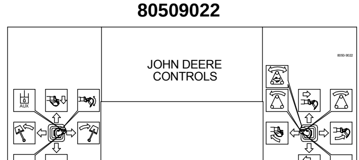


OAC1680

JOHN DEERE Control Pattern



JOHN DEERE CONTROL DECAL OVERLAY 80509022

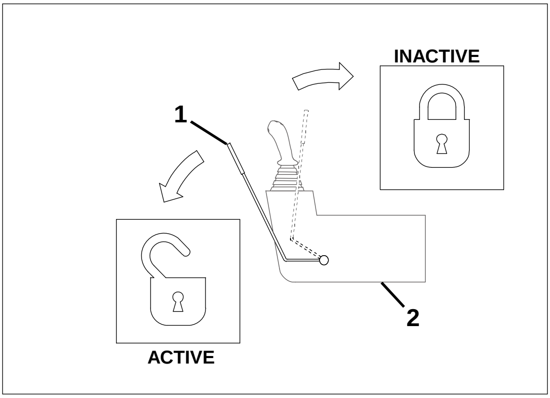


OAC1690

Joystick Controls

Activating the Joysticks

The joysticks will remain locked/inactive until the control cut out lever **(1)** located on the left hand arm pod **(2)** is moved to the unlocked/active position.

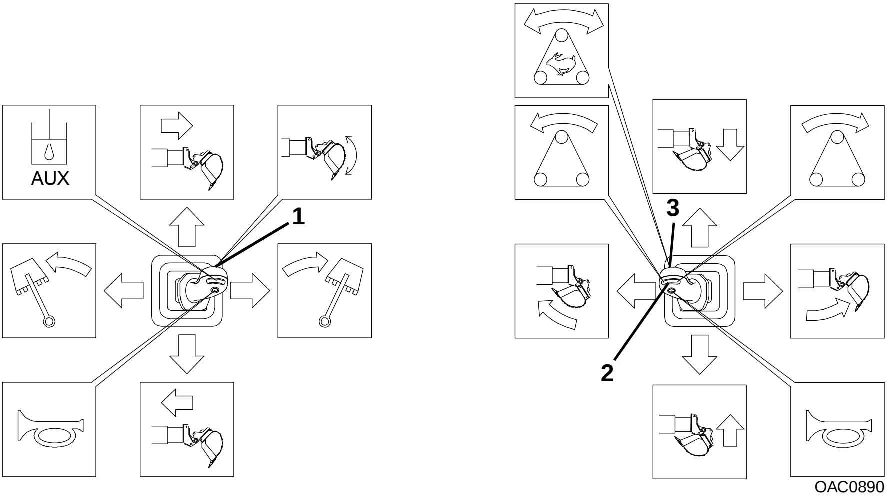


OAC0920

Joystick Control Patterns

Before operating, refer to the position of the joystick control pattern switch located on the electronic monitoring unit to verify control pattern setting. Ensure the joystick decal matches the machine controls before operating.

SAE Joystick Controls



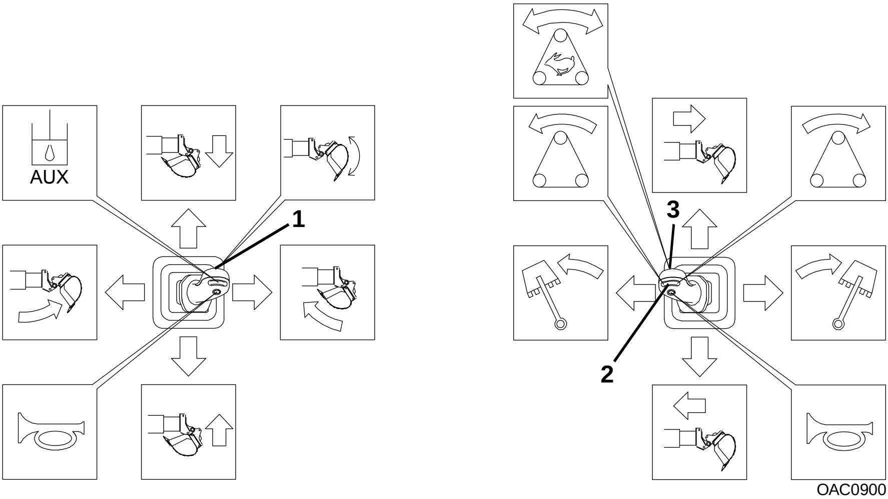
Left Hand Joystick Functions

- Move the joystick back to retract boom; move joystick forward to extend boom. Move joystick right to swing boom right; move joystick left to swing boom left.
- Attachment shake button **(1)** allows excess dirt or debris to be removed from the boom attachment.
- For two simultaneous boom functions, move the joystick between quadrants. For example, moving the joystick forward and to the left will extend and swing the boom left simultaneously.

Right Hand Joystick Functions

- Move the joystick back to raise boom; move joystick forward to lower boom. Move joystick right to open tool; move joystick left to close tool.
- Left-click boom tilt button **(2)** to tilt boom counterclockwise; right-click boom tilt button **(2)** to tilt boom clockwise.
- Use fast tilt button **(3)** simultaneously with boom tilt button **(2)** to momentarily increase boom tilt speed.
- For two simultaneous boom functions, move the joystick between quadrants. For example, moving the joystick forward and to the left will lower the boom and close the tool simultaneously.

GRADALL Joystick Controls



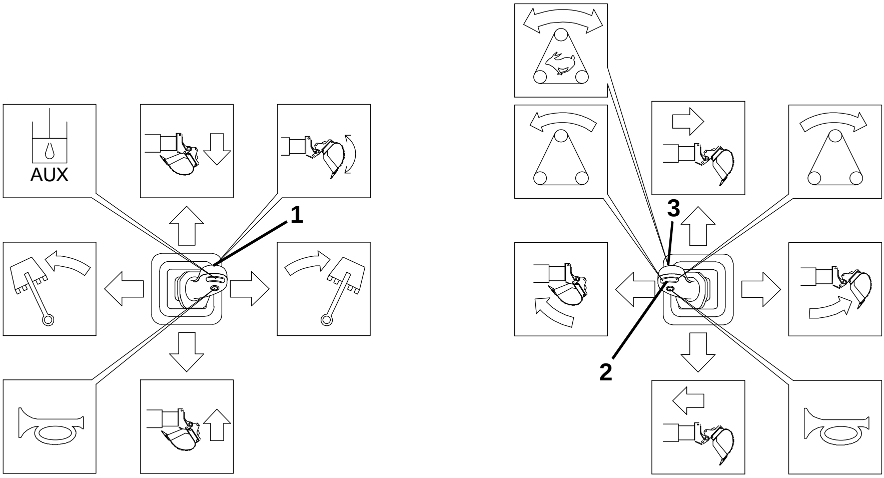
Left Hand Joystick Functions

- Move the joystick back to raise boom; move joystick forward to lower boom. Move joystick right to close tool; move joystick left to open tool.
- Attachment shake button **(1)** allows excess dirt or debris to be removed from the boom attachment.
- For two simultaneous boom functions, move the joystick between quadrants. For example, moving the joystick forward and to the left will lower boom and open tool simultaneously.

Right Hand Joystick Functions

- Move the joystick back to retract boom; move joystick forward to extend boom. Move joystick right to swing boom right; move joystick left to swing boom left.
- Left-click boom tilt button **(2)** to tilt boom counterclockwise; right-click boom tilt button **(2)** to tilt boom clockwise.
- Use fast tilt button **(3)** simultaneously with boom tilt button **(2)** to momentarily increase boom tilt speed.
- For two simultaneous boom functions, move the joystick between quadrants. For example, moving the joystick forward and to the left will extend and swing the boom left simultaneously.

JOHN DEERE Joystick Controls



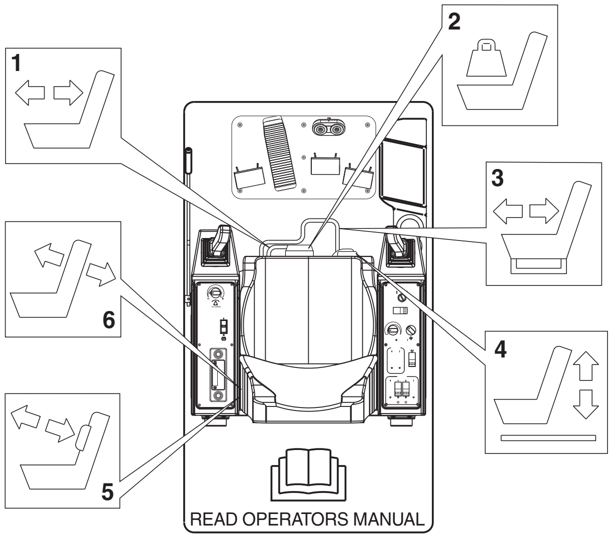
Left Hand Joystick Functions

- Move the joystick back to raise boom; move joystick forward to lower boom. Move joystick right to swing boom right; move joystick left to swing boom left.
- Attachment shake button **(1)** allows excess dirt or debris to be removed from the boom attachment.
- For two simultaneous boom functions, move the joystick between quadrants. For example, moving the joystick forward and to the left will lower and swing boom left simultaneously.

Right Hand Joystick Functions

- Move the joystick back to retract boom; move joystick forward to extend boom. Move joystick right to open tool; move joystick left to close tool.
- Left-click boom tilt button **(2)** to tilt boom counterclockwise; right-click boom tilt button **(2)** to tilt boom clockwise.
- Use fast tilt button **(3)** simultaneously with boom tilt button **(2)** to momentarily increase boom tilt speed.
- For two simultaneous boom functions, move the joystick between quadrants. For example, moving the joystick forward and to the left will extend boom and close the tool simultaneously.

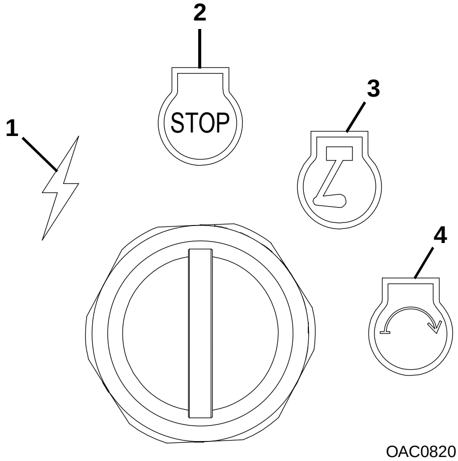
Operator Seat Adjustments



Prior to starting engine adjust seat for position and comfort.

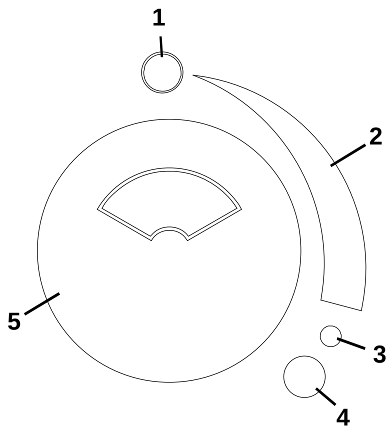
1. Upper Seat Fore and Aft Adjustment Control
2. Weight Adjustment Control
3. Lower Seat Fore and Aft Adjustment Control
4. Height Adjustment Control
5. Lumbar Adjustment Control
6. Seat Back Adjustment

Ignition



1. ACC: Voltage is available for all electrical functions.
2. OFF: Engine off.
3. RUN: Prohibits rotating key switch to position 4 in the event the engine does not start. Rotate the key to position 2 then back to position 4 to re-engage the starter.
4. START: Engine start.

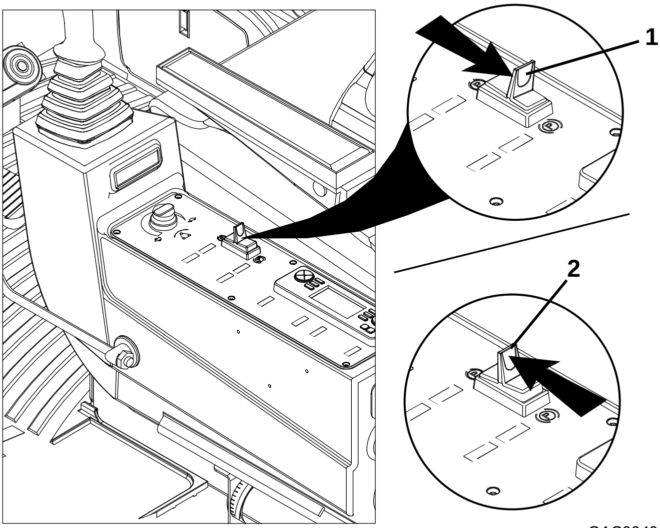
Intermittent Wiper/Washer



OAC0930

1. OFF
2. DELAY: Rotating knob clockwise decreases delay.
3. LOW: Low wiper speed. No delay.
4. HIGH: High wiper speed. No delay.
5. WASHER: Press and hold switch to activate washer.

Park Brake Switch



- Park Brake Switch: This switch controls the application and release of the park brake. Indicator light on electronic monitoring unit illuminates to indicate brake is applied.
- With the engine running and the park brake switch in “OFF” position **(1)**, park brakes are disengaged. With switch in “ON” position **(2)**, park brake is engaged and transmission will not engage forward or reverse.

SECTION 3 - OPERATION

3.1 TRAVEL MODE ENGINE OPERATION

Starting Engine from Undercarriage Cab

1. Perform walk-around inspection on page 2-2
2. Apply the parking brake. Put transmission in neutral. Using the travel/remote switch, select the travel position.
3. With throttle pedal in idle position, turn ignition to “ON” position. The Engine Stop, Check Engine, and optional Preheat lights will illuminate for approximately two seconds and go out.
4. Disengage interaxle differential lock (XL4100V & XL5100V only) and differential lock for highway travel (refer to page 3-11 for procedure).
5. Verify PTO lights are not illuminated (drive motor disengaged).
6. When Optional Preheat light goes out, turn ignition switch clockwise to “START” position. **Notice!:** The engine must not start or crank with the transmission in gear. Release key immediately when engine starts. If engine does not start after three attempts, check fuel supply system.
7. After engine starts, observe oil pressure gauge. If gauge remains on zero for more than 15 seconds, stop engine and determine cause. Correct before restarting engine.
8. Operate engine at idle speed for three to five minutes before operating with a load. Increase engine speed slowly.

Normal Engine Operation

- Observe gauges frequently to be sure all engine systems are functioning properly.
- **Be alert for unusual noises or vibration.** When an unusual condition is noticed, park machine in a safe position and perform shut-down procedure. See *“Travel Mode Engine Shutdown”* on page 3-14 or *“Remote Mode Engine Shutdown”* on page 3-33. Report condition to your supervisor or maintenance personnel.
- **Avoid prolonged idling.** If the engine is not being used, turn it off.

Cold Weather Starting Aids

- It is the **owners responsibility** to determine proper use of starting aid with regard to engine and starting aid manufacturer's instruction.
- An ether starting aid may be used with this engine **only** if it **does not** have the optional **grid heater**.

CAUTION

OW0031

ENGINE EXPLOSION. If your excavator is equipped with a cold start aid, do not spray additional ether into air cleaner. If machine is not equipped with cold start aid, follow instructions listed in the engine manual **supplied** with the excavator. Failure to comply may result in death or serious injury.

3.2 CHECKS BEFORE UNDERCARRIAGE OPERATION

This section outlines the checks to be performed at the beginning of each work shift or at each change of operator. Refer to page 3-34 for procedure to check brakes after remote control operation and digging. Repair any deficiencies before driving or operating the equipment.

1. Check all lights and turn signals, defroster, windshield wiper and washer for proper operation.
2. Check park brake and service brakes to ensure they are working properly.
3. Check operation of steering while moving slowly in first gear. Be alert for any increase in effort needed to turn wheels and any unusual steering response to normal steering effort.
4. Check operation of horn, back-up alarm, and any other signal devices. Must be audible from inside operator’s cab with the engine running.
5. Observe oil pressure gauge with engine running at operating temperature and speed.
6. Observe voltmeter indication of alternator output. Proper output is approximately 24 V. with engine running at 2000 RPM (without optional grid heaters active).
7. Observe water temperature gauge. Proper operating temperature is approximately 160-210°F (71-104°C).
8. Observe low air warning light. Light should continue to illuminate and an audible alarm will sound until brake system pressure reaches approximately 60 psi. Proper brake system pressure is 60-125 psi. Do not release parking brake or move undercarriage while low air warning light is illuminating.

3.3 TRAVEL MODE BRAKE SYSTEM

The air brake system includes service brakes, emergency brakes, parking brakes and digging brakes.

⚠ CAUTION

OW0031

NEW BRAKES. New brakes need increased stopping distance. Brake capability will improve after several stops. Failure to stop may result in death or serious injury.

⚠ WARNING

OW0021

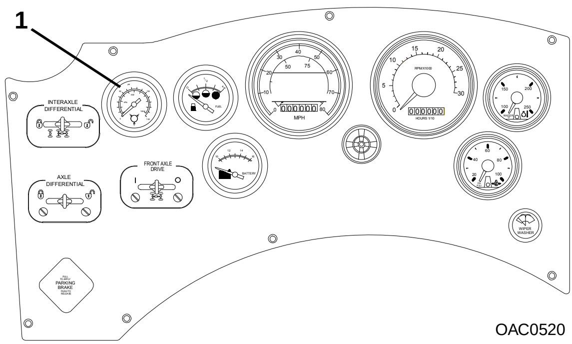
BRAKING HAZARDS. Always wear seat belt to avoid being thrown from driver's seat during braking emergency.

Do not "fan" the brake valve pedal. A long series of rapid brake applications could reduce system pressure to a point where effective service braking will be lost until brake pressure is restored.

Do not operate undercarriage or upperstructure while low air indicator is illuminated. If light comes on while undercarriage is moving, stop in a safe area as soon as possible. If undercarriage will not maintain the proper brake pressure, notify maintenance personnel immediately for repair of condition.

Service Brake

- The operating pressure range for service brakes is 60-125 psi (414/862 kpa).
- A dual air pressure gauge **(1)** is furnished to indicate pressure in front and rear portions of the system.



- The red needle indicates pressure in tank #1 which supplies the front axle brakes.
- The white needle indicates pressure in tank #2 which supplies the rear axle brakes.
- If pressure in either portion of the system falls below safe operating range, the low air indicator light will illuminate and an audible alarm will sound.

Emergency Brake

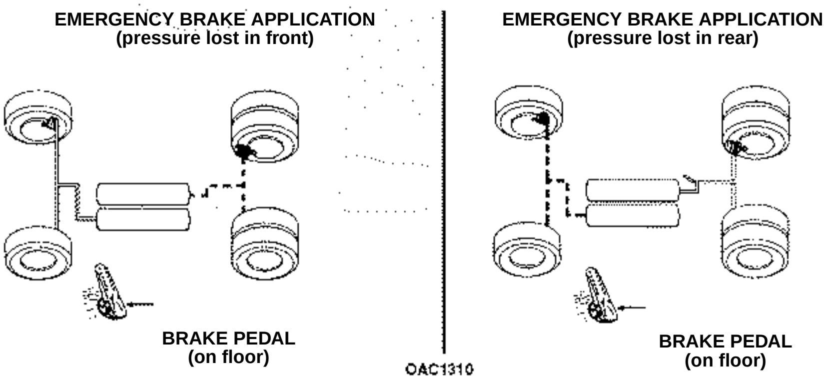
The emergency brake functions only when air pressure has been lost from the brake system.

⚠ WARNING

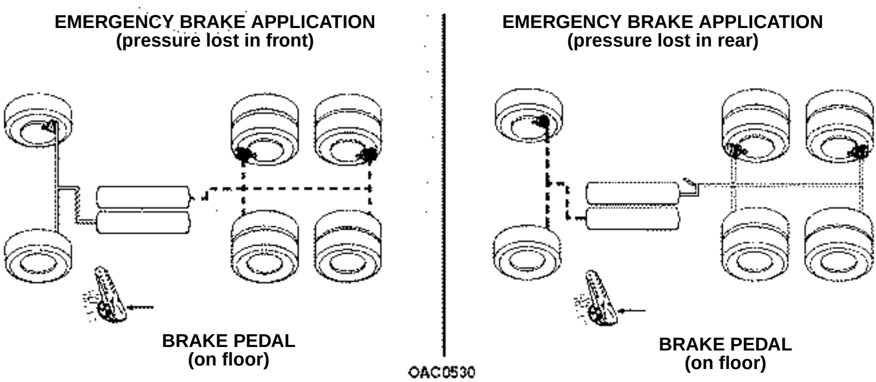
OW0021

EMERGENCY BRAKE. Emergency brake will not stop undercarriage in as short a distance as the service brakes.

XL3100V



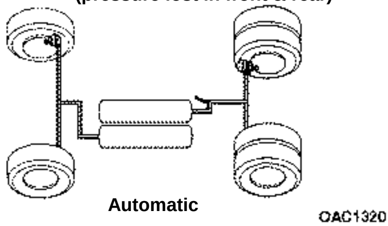
XL4100V & XL5100V



- If air pressure is lost from the front portion of the dual brake system, normal actuation of the brake pedal will apply service brakes to the wheels of rear axle. There will be no braking of the wheels of the front axle.
- If air pressure is lost from the rear portion of the dual brake system, normal actuation of the brake pedal will apply service brakes to the wheels of the front axle and apply the spring brakes to the wheels of the rear axle.

XL3100V

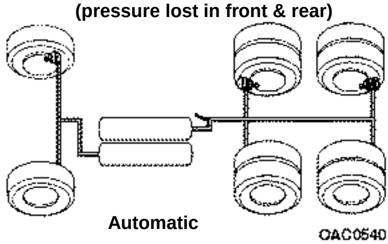
EMERGENCY BRAKE APPLICATION
(pressure lost in front & rear)



Automatic

XL4100V & XL5100V

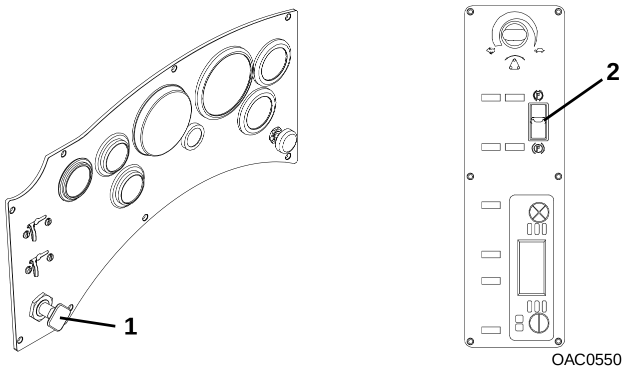
EMERGENCY BRAKE APPLICATION
(pressure lost in front & rear)



Automatic

- In the event air pressure is lost from the system, the spring brakes will begin to apply as pressure drops to 60 psi (414 kpa) and there will be a complete application when pressure decreases to 40 psi (276 kpa).
- Air pressure is required to release the spring brakes, therefore they will remain ON until pressure can be restored.

Parking Brake



- Two parking brake controls are provided; one on undercarriage dashboard **(1)** and another on left hand pod panel in the upperstructure **(2)**. The switch in the upperstructure cab is inoperative when in travel mode. Undercarriage park brake must remain applied when in remote mode.
- Apply parking brake in undercarriage cab by raising parking brake control knob. Knob will raise automatically if air pressure is lost from the system.
- Release parking brake by depressing parking brake control knob (system must be pressurized to release parking brake).

NOTES:

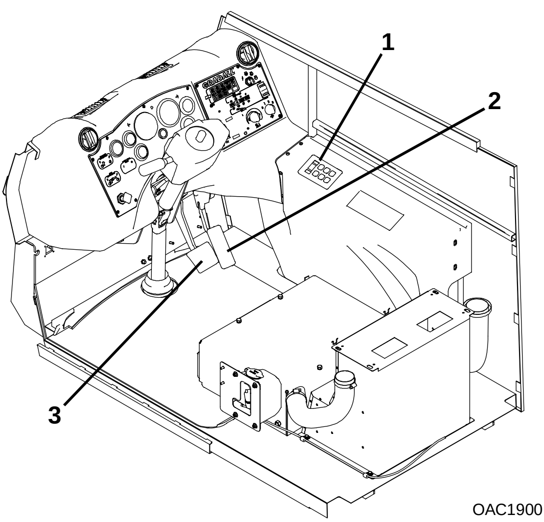
3.4 TRAVEL MODE POWER TRAIN

Shifting Gears

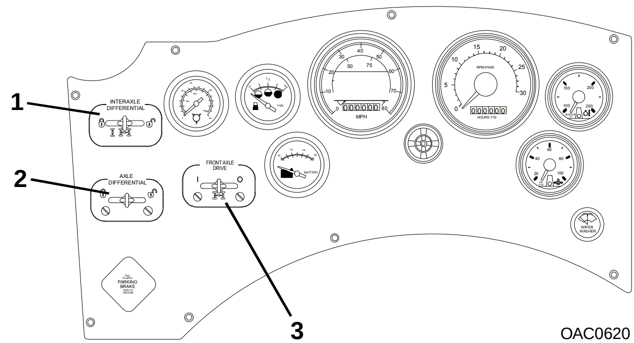
The transmission is automatically shifted with 6 forward speeds plus reverse. Ranges are selected by pressing and releasing the button for the desired range on the Transmission Shift Selector. For example, press and release the “N” button to select Neutral, the “D” button to select Drive, and the “R” button to select Reverse. As vehicle speed increases, the transmission upshifts automatically through each range. As the vehicle speed decreases, the transmission automatically downshifts to the correct range.

You may also manually select a lower forward gear below the “D” position by pushing the Down Arrow after selecting the Drive gear. The first number displayed in the digital display is the highest forward range available and second number is range attained in selected position.

Manual shifting can also be done by pressing the up and down arrow pushbuttons on Transmission Shift Selector.



1. Transmission Shift Selector
2. Accelerator Pedal
3. Brake Pedal



1. Interaxle Differential Lock Switch (XL4100V & XL5100V only): The interaxle differential is controlled by a toggle lever mounted on the dashboard in the undercarriage cab.

    - With toggle in unlocked position, the front and rear tandem axles are permitted to rotate at different speeds.
    - Keep toggle in unlocked position when driving on good tractive conditions.
    - With toggle in locked position, there is positive drive to the front and rear tandem axles.
    - Keep toggle in locked position when driving in poor tractive conditions (mud, ice, snow or off-road travel). Use lock position for remote control travel.
    - The interaxle differential may be locked when traveling but NEVER when the wheels have lost traction and are spinning.
    - If shifting interaxle differential while traveling, release accelerator first.

.

CAUTION

OW0031

DIFFERENTIAL DAMAGE. Serious damage will occur if interaxle differential is shifted while wheels are spinning.

2. Differential Lock Switch: The differential lock can be engaged (locked) ONLY when the interaxle differential has been engaged.

Differential Lock

Normally, differential lock will engage and disengage immediately in response to lock/unlock toggle; however, differential “wind-up”, or misalignment can delay engagement/disengagement. In this event, reversing direction of travel and/or operation of steering while traveling may relieve differential “wind-up”. Indicator light shows actual state of lock engagement/disengagement.

- The differential can be locked or unlocked when the vehicle is standing still or at a constant low speed when wheels are not slipping. **Notice!:** Engaging the differential lock while the wheels are slipping may cause damage to the differential.
- Lock the differential and operate the vehicle only at low speeds on poor road or highway surfaces or when digging over the side.
- When differential is locked, the turning radius will increase.
- Unlock the differential when need for maximum traction has passed or when traveling on good surface.
- Do not lock differential when the vehicle is traveling down steep grades and traction is minimal. Potential loss of stability can result.

Locking the Differential: When encountering poor traction conditions, perform the following:

1. While stopped or traveling straight at a constant speed and no wheels slipping, move differential lock toggle to locked position.
2. Let up momentarily on accelerator allowing differential to fully lock.
3. When differential is fully engaged, the indicator light will illuminate.

Unlocking the Differential: After poor conditions have passed, perform the following:

1. Move differential toggle to unlock position.
2. Let up momentarily on accelerator allowing the differential to fully unlock.
3. When differential lock is fully disengaged, the indicator light will no longer illuminate.

3. Front Axle Drive Switch (if equipped):

To Engage:

- Stop machine.
- Move toggle lever on dash to the “I” position.

Notice!: Engaging front axle drive while undercarriage is moving will damage transfer case. Stop undercarriage before engaging front axle drive.

To Disengage:

- Stop machine
- Move toggle lever on dash to the “O” position.

Notice!: Do not drive on improved/hard surfaces with front axle engaged. Drive line damage may occur.

3.5 TRAVEL MODE ENGINE SHUTDOWN

MACHINE ROLL-AWAY HAZARD. Always move park brake switch to "ON" position and stop engine before leaving cab.

WARNING

OW0021

When parking the excavator, park in a safe location on flat level ground and away from other equipment and/or traffic lanes.

From Undercarriage Cab:

1. Apply the park brake.
2. Shift transmission to neutral.
3. Operate engine at low idle for 3 to 5 minutes. **DO NOT** rev engine.
4. Turn key to “OFF” position and remove.
5. Exit excavator maintaining 3-point contact.
6. Chock wheels (if necessary).

3.6 REMOTE CONTROL PREPARATION

Preparing Undercarriage for Remote Control Operation

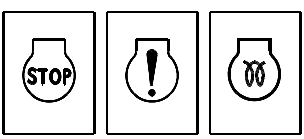
Remote travel is to be used for positioning unit at job site, not for over-the-road driving. After reaching job site, perform the following to prepare undercarriage for remote control operation:

1. Stop the machine in a safe level area.
2. Apply the parking brake.
3. Engage axle and interaxle differential lock (refer to page 3-11 for procedure; interaxle differential lock applies to XL4100V & XL5100V only). Front axle drive may be selected (if equipped).
4. Put transmission in neutral.
5. When both sections of air system reach at least 100 psi, stop engine. Key must be in "OFF" position for remote operation.
6. Depress remote portion of travel/remote switch.
7. Proceed to upperstructure cab.

Preparing Upperstructure for Remote Control Operation

All instructions on undercarriage cab remote control decal must be followed before starting machine in remote operation.

1. Place control cut out lever in locked/inactive position (refer to page 2-39).
2. Turn ignition switch to "RUN" position.



OAC0700

3. The three monitor lights shown above should illuminate and then go out.
4. Turn ignition switch to "START" position to start engine and/or engage hydraulic pump. If engine fails to start, turn ignition switch to "OFF" position and repeat steps 2 through 4. If starter will not engage to crank engine, check for proper park brake and gearshift positions in the undercarriage cab and verify that the joystick activation lever is in the locked/inactive position.
5. Operate engine at full throttle for upperstructure operation.
6. Position control cut out lever in the unlocked/active position to activate and engage joystick controls and pedals in remote operation.

3.7 CHECKS BEFORE REMOTE CONTROL OPERATION

This section outlines the checks to be performed at the beginning of each work shift or at each change of operator. Repair any deficiencies before driving or operating the equipment. During warm-up period, check the following:

- Ensure digging brakes and park brake function properly before moving undercarriage in remote control.
- Be sure travel alarm and horn function properly. Both must be audible from the cab with engine running.
- Check to ensure control pattern decal matches joystick controls.
- Make sure all boom and attachment functions operate smoothly and correctly.
- Forward and reverse travel, digging brakes, and steering operate correctly.
- Swing the upperstructure left and right and ensure the swing brake functions properly.
- Make sure the engine does not start with the control cut out lever in the lowered position.
- Check to ensure the engine functions properly and the lights and indicators located in the upperstructure cab are functioning.

3.8 REMOTE MODE BRAKE SYSTEM

Remote Control Braking

WARNING

OW0021

REMOTE CONTROL BRAKING. Allow sufficient time for full brake system pressure 125 psi (862 kpa) to develop before operating unit in remote control. Low air light indicator will turn off when pressure reaches 60 psi.

Always apply upperstructure parking brake before leaving upperstructure cab.

- With the travel/remote switch in remote position, the digging brake will set and release as travel pedal in upperstructure is actuated and released.
- Under certain circumstances the upperstructure park brake switch doubles as an emergency brake. If the automatic digging brake fails to apply when travel pedal is released, move upperstructure park brake switch to apply brakes. Notify maintenance personnel immediately for repair of digging brakes before continued operation.

Digging Brake

When in remote mode, the digging brakes are automatically applied upon releasing the travel pedal.

- When activated, the digging brake is applied to all wheels to hold the undercarriage stationary while the excavator is digging.
- Apply digging brake by moving travel/remote switch to remote position and turning on upperstructure ignition key.
- Release digging brake by moving travel/remote switch to travel position and turning undercarriage ignition key to “ON” position.

3.9 REMOTE MODE POWER TRAIN

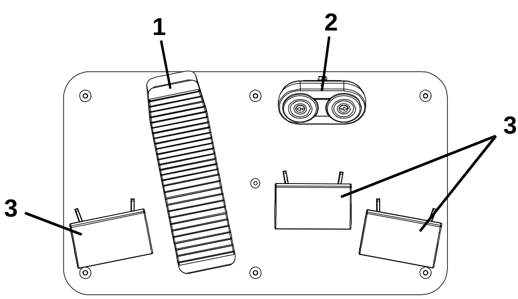
Driving Undercarriage from Upperstructure Cab

Remote travel is possible at all times except when indicated by an audible alarm and the travel lockout symbol being illuminated on the monitor. When this condition exists, the directional travel pedal must be slowly and carefully activated in both directions until the light and alarm turn off. This allows proper gear mesh within the transmission. The dig brakes will not release while this light is on.

Note: *Abrupt engagement of the remote travel pedal while this light is on will damage the transmission!*

Never tow a load using remote control drive.

Operate the engine at full throttle. Undercarriage speed is controlled by travel speed switch position and amount of travel pedal actuation.



OAC0630

1. Travel Pedal: The travel pedal **(1)** controls undercarriage travel; with boom positioned over front of machine, depress front of pedal to travel forward or rear of pedal to travel in reverse. Undercarriage travel alarms and back-up lights will activate when travel pedal is depressed. The digging brake is automatically released when the pedal is depressed and applied when the pedal is released. Release pedal gently for a smooth stop. Pedal returns to a neutral position when released. Keep in mind the position of upperstructure in relation to undercarriage.

WARNING

OW0021

UNEXPECTED DIRECTION OF TRAVEL. Before remote travel, check to be sure you are aware of orientation of upperstructure with regard to undercarriage. Confusion could cause travel in the opposite direction you are expecting.

Note: *Engage park brake to stop undercarriage if automatic digging brake fails.*

2. Steering Pedal: The steering pedal **(2)** controls right and left turns; with boom positioned over front of machine, depress left side of pedal to turn left or right side of pedal to turn right. Pedal returns to neutral position when released. Keep in mind the position of upperstructure in relation to undercarriage. Undercarriage travel alarms and back-up lights will activate when steer pedal is depressed. **NOTE:** Due to varying conditions of front axle load and ground conditions, steering may be restricted until unit is in motion.
3. Foot Rests: The foot rests **(3)** are located in the cab as shown in illustration.

Shifting Gears While in Remote Control

Using the travel speed switch on the right hand pod panel (see page 2-34 for location), it is possible to shift between low and high range from the upperstructure cab. If travel speed is switched while unit is in motion, the machine will not shift to selected travel speed until the travel pedal is released and digging brake is set.

To Shift Gears:

- Stop Machine
- Toggle the travel speed switch to the desired gear range. Refer to page 3-19 if an audible alarm sounds and the travel lockout symbol illuminates.

3.10 STEERING SYSTEM

Notice!: Use of power steering while undercarriage is stopped causes unnecessary stress on system components and may cause serious damage to system. Holding steering wheel or remote steering pedal in full turn position will cause system to overheat. This may cause steering pump to fail.

WARNING

OW0021

POWER STEERING FAILURE. In the event power steering fails, stop as soon as possible. Do not drive unit until problem has been corrected.

When differential lock is engaged (rear axle shafts locked together), the turning radius will become greater.

3.11 TYPICAL DIG CYCLE

Standard SAE Boom and Attachment Functions

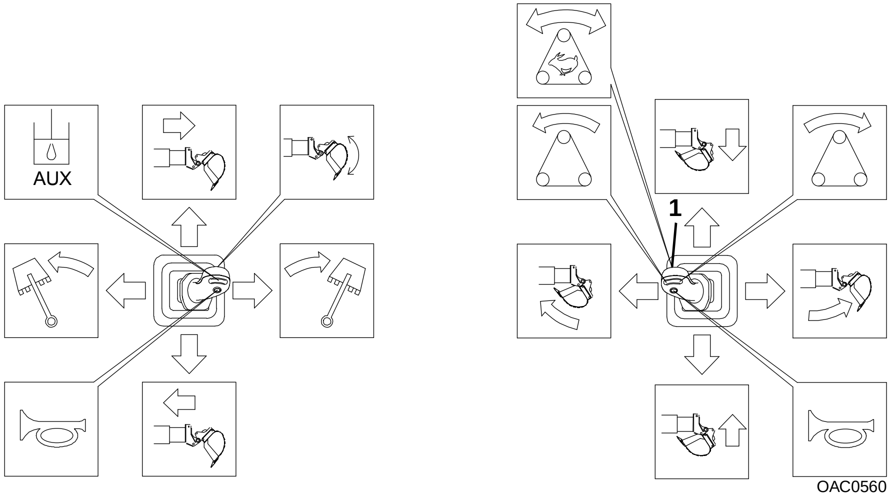
Prepare for boom and attachment function:

1. Position unit for efficient attachment usage. **Notice!:** While digging, pay close attention to boom position in relation to undercarriage components. In certain instances it is possible for the boom to come into contact with the undercarriage.
2. Stop engine and secure door and windows in desired position for ventilation. Remove boom tie down chain from boom.
3. Perform checks before remote control operation located on page 3-16. Set engine to full throttle position.
4. Be certain control cut out lever is in down position to energize joysticks and foot pedals.

WARNING

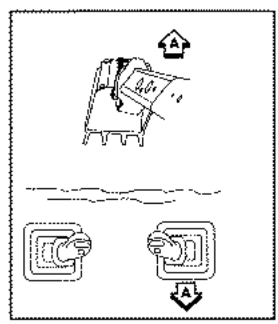
OW0021

UNEXPECTED MOVEMENT. Test your controls before operating. If controls have been changed to another pattern, be sure you are familiar with the functions and ensure that the diagram in the cab shows the actual pattern in use. Alternate patterns are located in the operator cab in the manual compartment. If you do not have the proper control decal, do not change the control pattern.



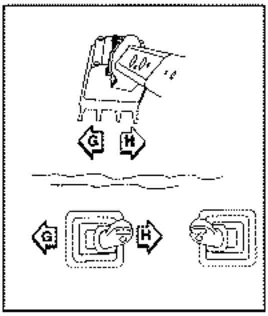
Joystick controls standard SAE control pattern. If tilt speed has been reduced for conditions, speed can be temporarily increased by depressing fast tilt button **(1)**.

Note: *Practice with controls in a safe, open area. Joysticks and pedals return to neutral position when released.*

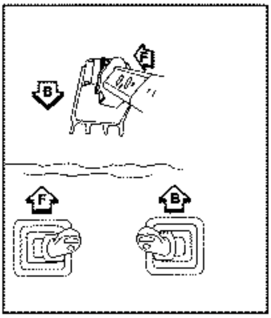


1. Pull back on right joystick **(A)** to raise boom far enough to clear all obstructions.

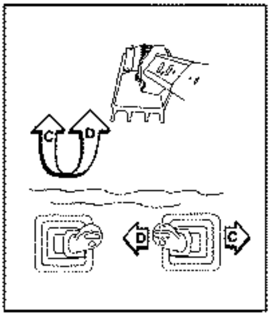
2. Move left joystick to left **(G)** to swing left or to right **(H)** to swing right.



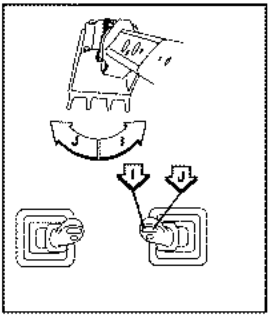
3. While pushing left joystick forward **(F)** to extend boom, push right joystick forward **(B)** to lower boom into position for start of cut.



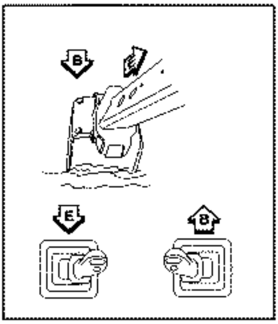
4. Move right joystick to right **(C)** to open bucket or to left **(D)** to close bucket for correct penetration. Teeth should angle downward slightly (about 5 degrees). Angle may be greater for soft digging.



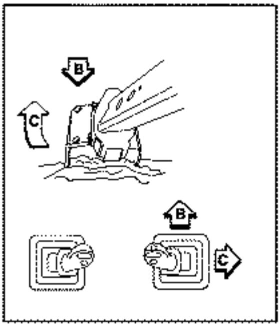
5. If required, press left side of tilt switch **(I)** to tilt counterclockwise or right side of switch **(J)** to tilt clockwise. If necessary, use fast tilt button to return to fast tilt.



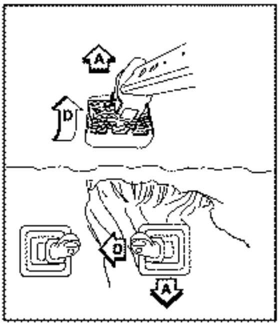
6. While pushing forward on right joystick **(B)** to lower boom and force bucket into ground, pull back on left joystick **(E)** to retract boom and fill bucket.



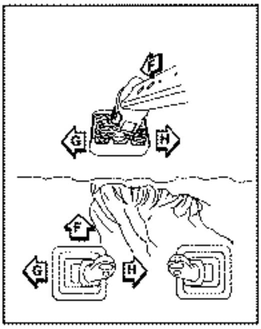
7. As bucket is filling, jog right joystick forward **(B)** to lower boom and maintain depth of cut. At same time jog right joystick to right **(C)** to open bucket and maintain proper bucket angle.



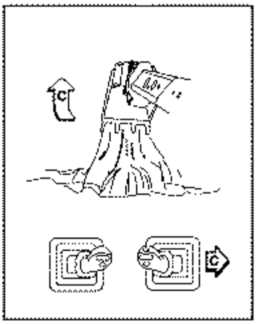
8. When bucket is full, or when boom is fully retracted, move right joystick to left **(D)** to close bucket. At same time pull right joystick back **(A)** to raise boom far enough to clear obstructions.



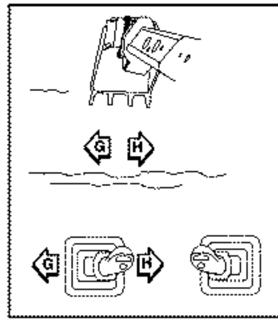
9. Move left joystick to right **(H)** to swing right or to left **(G)** to swing left to dump site. If necessary, extend boom by pushing left joystick forward **(F)**.



10. Move right joystick to right **(C)** to open bucket and dump load.



11. Move left joystick to left **(G)** or right **(H)** to align boom for next cut. Repeat steps 3 through 11.



3.12 LIFTING & PLACING A LOAD

WARNING

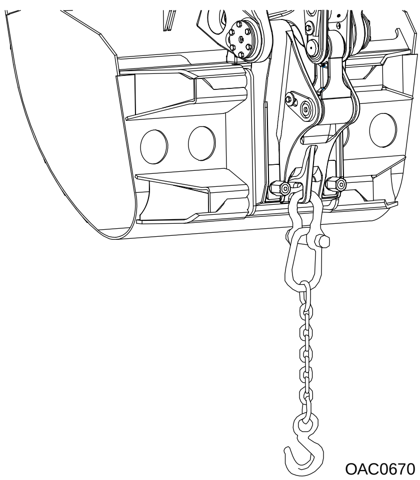
OW0021

LIFTING & POSITIONING LOADS. Failure to plan a lift properly could result in death or serious injury.

The automatic boom tilt brake will not prevent boom from tilting in response to an external load. Load must be centered under bucket adapter with boom level from side to side.

Precautions

- Use the lift capacity chart to calculate maximum load. Keep in mind, the attachment weight and rigging must be added to the load, then compared to the value on the lift capacity chart.
- If it becomes necessary to shut the engine off while positioning a load, place load on the ground prior to shutting off engine.
- Be thoroughly familiar with excavator hand signals shown at the end of the manual.
- Operate machine at full throttle and do not shut off engine with suspended load.
- Do not travel with suspended load positioned over the side of the machine.



OAC0670

- Suspend loads only as shown above. Passing load line over open bucket can cause uncontrolled movement of load.
- To lift loads, level boom from side to side and close adapter fully against stops. Pass through adapter as shown and be certain chain is locked on itself.

General

There is a lift capacity difference between the excavator's best and worst lift positions. Just because it can lift a load from one point does not mean it can safely deliver the load to any other point.

Prior to lifting and placing a load, map out the lift, swing, and lower path to ensure that capacity, both hydraulic and stability tipping limits, are not exceeded. The best lifting position is over the rear with the excavator level and the boom fully retracted.

You must plan the lift based on the worst condition of the lift and delivery, not the best. The worst condition can only be determined by performing an UNLOADED TEST AND DELIVERY of the load.

Loads shown on chart in cab are hydraulic lift capacities with those in shaded area indicating tipping limits. Exceeding these capacities can cause a relief valve to open allowing the load to fall or in some cases, the machine to tip over.

Positioning Machine For A Lift

The machine must be on a firm, level surface when making a lift.

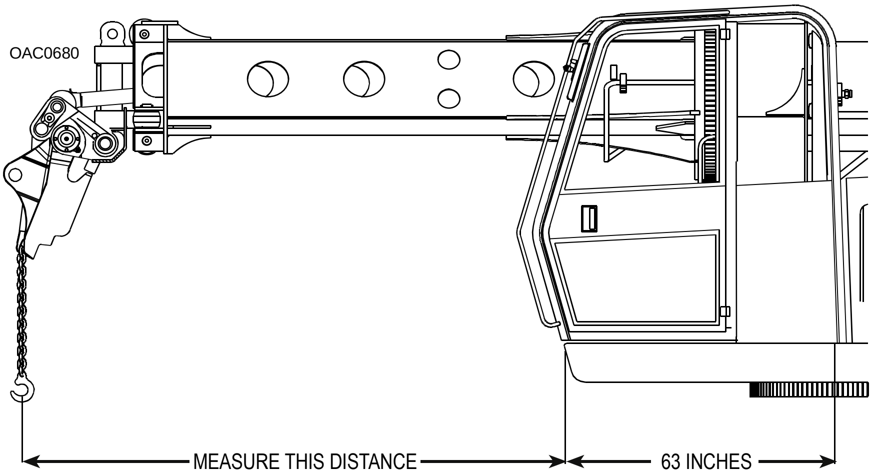
The shorter the load radius, the greater the lift capacity. Position the unit to minimize boom extension and swing while keeping adequate distance from obstructions and excavations.

Position machine to gain maximum visibility of load and delivery point. If conditions do not permit a clear view, use a signal person.

Planning A Lift

Note: *Lift capacities are based on machine being on a firm, level surface and also no load being suspended beneath bucket adapter.*

1. Determine the weight of the load including weight of slings, chains, bucket/ attachment (tool), and auxiliary lifting devices. Refer to lift capacity chart for weight adjustment required for bucket.
2. Move the machine to the best position for making the lift.
3. Perform an unloaded trial run of lift to determine maximum boom height/depth and load radius required to complete the lift.
4. Measure boom height/depth from hole in adapter to ground level (same level as bottom of tire). Be sure to allow for length of chain and height of load.



5. Measure load radius from inner corner of frame at front of cab to vertical load line (as shown above) and add distance to center of rotation (63 inches).
6. Refer to lift capacity chart column for required load radius. If required radius is between columns, use column for next larger radius.
7. Check the appropriate capacities for required boom height/depth. The smaller of these capacities is the maximum load permitted for lift conditions.

Note: *To determine working load limits the operator must also consider wind, hazardous conditions, experience of personnel and proper load handling.*

3.13 LIFT CAPACITY

LOAD POINT HEIGHT		LOAD RADIUS 10' (3.0m) OVER END	10' (3.0m) OVER SIDE	15' (4.6m) OVER END	15' (4.6m) OVER SIDE	20' (6.1m) OVER END	20' (6.1m) OVER SIDE	25' (7.6m) OVER END	25' (7.6m) OVER SIDE	MAXIMUM RADIUS	OVER END	OVER SIDE
ABOVE GROUND LEVEL	20' (6.1m)							5715 (2590)	5715 (2590)	27' 4" (8.3m)	5070 (2300)	5070 (2300)
	15' (4.6m)			12425 (5635)	12425 (5635)	8795 (3990)	8795 (3990)	6515 (2955)	6515 (2955)	29' 5" (9m)	5120 (2320)	5120 (2320)
	10' (3.0m)					9880 (4480)	9880 (4480)	7140 (3240)	7140 (3240)	30' 6" (9.3m)	5230 (2370)	5230 (2370)
	BOOM LEVEL 8' 7" (2.4m)					10080 (4570)	10080 (4570)	7255 (3290)	7255 (3290)	30' 7" (9.3m)	5265 (2390)	5265 (2390)
	5' (1.5m)					10290 (4665)	10030 (4550)	7415 (3365)	7175 (3255)	30' 7" (9.3m)	5375 (2440)	5195 (2355)
AT GROUND LEVEL						9815 (4450)	9800 (4445)	7265 (3295)	7035 (3190)	29' 11" (9.1m)	5550 (2515)	5310 (2410)
BELOW GROUND LEVEL	5' (1.5m)			11090 (5030)	11090 (5030)	8705 (3950)	8705 (3950)	6745 (3060)	6745 (3060)	28' 3" (8.6m)	5740 (2605)	5725 (2595)
	10' (3.0m)	8500 (3855)	8500 (3855)	8630 (3915)	8630 (3915)	7365 (3340)	7365 (3340)	6010 (2725)	6010 (2725)	25' 5" (7.7m)	5910 (2680)	5910 (2680)
	15' (4.6m)	5840 (2650)	5840 (2650)	6640 (3010)	6640 (3010)	6075 (2755)	6075 (2755)			20' 11" (6.4m)	5930 (2690)	5930 (2690)
	20' (6.1m)									12' 10" (3.9m)	4875 (2210)	4875 (2210)

The above loads are in compliance with the SAE standard J1097 DEC2005. They do not exceed 87% of hydraulic lifting capacity or 75% of tipping capacity.

Loads shown in shaded areas indicate the load is limited by tipping rather than hydraulic lift capacity.

The rated lift capacity is based on the machine being equipped with 15,500 lb (7030 kg) counterweight, standard boom, standard tires, no auxiliary hydraulics, and no bucket.

Adjust the listed rated capacities by subtracting the value listed for bucket/attachment used:

8065-6007 60" (1.5 m)	Ditching -	807	lbs.	(366 kg)
8065-6006 66" (1.7 m)	Ditching -	892	lbs.	(405 kg)
8065-6002 72" (1.8 m)	Ditching -	944	lbs.	(428 kg)
8045-6020 24" (610 mm)	Excavating -	603	lbs.	(274 kg)
8045-6021 30" (762 mm)	Excavating -	660	lbs.	(300 kg)
8045-6022 36" (914 mm)	Excavating -	741	lbs.	(336 kg)
8045-6023 42" (1.1 m)	Excavating -	841	lbs.	(382 kg)
8045-6024 48" (1.2 m)	Excavating -	957	lbs.	(434 kg)
8065-6013 72" (1.8 m)	Dredging -	1114	lbs.	(505 kg)
8065-6102 40" (1.0 m)	Pavement -	1262	lbs.	(573 kg)
8065-6024 8' (2.4 m)	Blade -	630	lbs.	(285 kg)
8065-6009 Single Tooth	Ripper -	557	lbs.	(253 kg)

- **Note: Bucket adjustment values are 87% of the actual bucket weights.**

The load point is located on the bucket pivot point, including loads listed for maximum radius.

Do not attempt to lift or hold any load greater than these rated values at specified load radii and heights. The weight of slings and any auxiliary devices must be deducted from the rated load to determine the net load that may be lifted.

ATTENTION: All rated loads are based on the machine being stationary and level on a firm supporting surface. The user must make allowance for particular job conditions such as soft or uneven ground, out of level conditions, side loads, hazardous conditions, experience of personnel, etc. The operator and other personnel must read and understand the operator manual before operating this machine. Rules for safe operation of equipment must be adhered to at all times.

OAC0690

Note: *This is a sample capacity chart* ***only! DO NOT*** *use this chart, use the one located in your operator cab.*

The rated lift capacity is based on the machine being on flat, level ground and equipped with standard boom and no bucket. Adjust the listed rated capacities on capacity chart located in operator cab according to each bucket as shown:

Part Number	Size	Description	Weight Adjustment
80656007	60"	(1.5m) Ditching	-807lbs. (366kg)
80656006	66"	(1.7m) Ditching	-892lbs. (405kg)
80656002	72"	(1.8m) Ditching	-943lbs. (428kg)
80456020	24"	(610mm) Excavating	-560lbs. (255kg)
80456021	30"	(762mm) Excavating	-660lbs. (300kg)
80456022	36"	(914mm) Excavating	-741lbs. (336kg)
80456023	42"	(1.1m) Excavating	-841lbs. (382kg)
80456024	48"	(1.2m) Excavating	-957lbs. (434kg)
80656013	72"	(1.8m) Dredging	-1114lbs. (505kg)
80656102	40"	(1.0m) Pavement	-1262lbs. (573kg)
80656024	8’	(2.4m) Blade	-630lbs. (285kg)
80656009	24"	Single Tooth Ripper	-557lbs. (253kg)

Note: *Bucket adjustment values are 87% of the actual bucket weights. Any weight adjustment for Gradall buckets not shown can be calculated by multiplying actual bucket weight by .87.*

- The load point is located on the bucket pivot point, including load listed for maximum radius.
- Do not attempt to lift or hold any load greater than the rated values at specified load radii and heights. The weight of slings and any auxiliary devices must be deducted from the rated load to determine the net load that may be lifted.

ATTENTION: All rated loads are based on the machine being stationary and level on a firm supporting surface. The user must make allowance for particular job conditions such as soft or uneven ground, out of level conditions, side loads, hazardous conditions, experience of personnel, etc. The operator and other personnel must be fully trained and understand this Operator Manual and Safety Manuals furnished by the manufacturer before operating this machine. Rules for safe operation of equipment must be adhered to at all times.

3.14 REMOTE MODE ENGINE SHUTDOWN

To shutdown the excavator, park in a safe location on flat level ground and away from other equipment and/or traffic lanes.

From Upperstructure Cab:

1. Stop machine by removing pressure from foot pedals.
2. Swing the machine to align upperstructure with undercarriage
3. Lower attachment/boom to ground or stow boom in boom rest. See *“Boom Stow Procedure”* on page 3-35.
4. Operate engine at low idle for 3 to 5 minutes. **DO NOT** rev engine.
5. Turn key to “OFF” position and remove key.
6. Exit excavator maintaining 3-point contact.
7. Chock wheels (if necessary).

WARNING

OW0021

MACHINE ROLL-AWAY HAZARD. Lower boom to ground or boom rest and stop engine before leaving cab.

3.15 RETURN TO TRAVEL MODE

Preparing Upperstructure for Undercarriage Operation

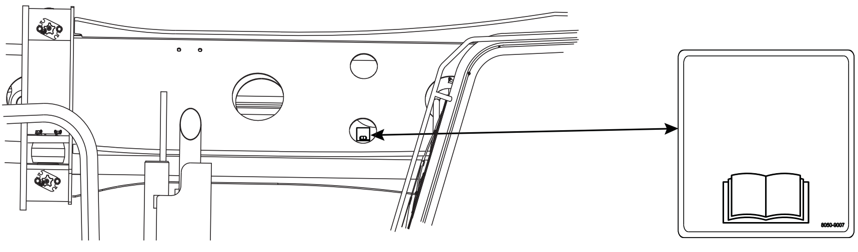
1. Check operation of brakes after remote operation and digging.
2. Position unit on level surface, apply digging brake and stop engine. Check the following for damage; brake actuator chambers and rods, brake actuator brackets, and slack adjusters. With brake applied, actuator rod should form an approximate right angle with slack adjuster. Do not drive unit until any damage or malfunction has been repaired. Check for proper slack adjuster operation in accordance with the procedure shown on page 5-30.
3. Position boom over rear of undercarriage and embed bucket in ground or against a solid object.
4. Apply down pressure with boom and pull and push with boom while a helper watches for rotation of each wheel.
5. Rotation of any wheel during step 3 indicates brake failure on that wheel. Have any failure corrected before driving the unit.
6. Position boom in rest, allowing clearance for attachment. See *"Boom Stow Procedure"* on page 3-35. Secure boom using boom hold-down device. See *"Securing Unit for Driving"* on page 3-35.
7. Idle engine to remove heat from critical areas.
8. Shut down engine from upperstructure cab.
9. Proceed to undercarriage cab.

Preparing Undercarriage for Conventional Operation

- See *"Starting Engine from Undercarriage Cab"* on page 3-1.

Boom Stow Procedure

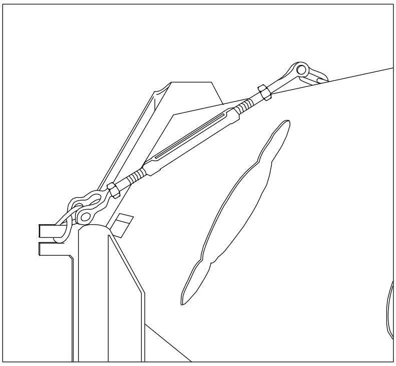
1. With teleboom extended, stow boom in boom rest.
2. Retract telescope boom until the boom position decal is visible in the bottom smaller hole in the main boom, as illustrated:



OAC2690

Securing Unit for Driving

Drive to and from job site only under the following conditions:



OAC0640

- Position boom in boom rest and secure boom as shown above.
- Mirrors are clean and properly adjusted for visibility.
- Doors and upperstructure windows secured in closed position.
- No load attached to any part of machine.
- Tires inflated to proper pressure.
- Seat belt buckled across lap.
- Drive in accordance with Federal, State, and Local requirements.
- Plan your route.

3.16 PARKING THE EXCAVATOR

Precaution

If the machine is in remote and must be shut down for an extended period of time, return the machine to conventional undercarriage operation.

Avoid parking on roads or highways. If it cannot be avoided, or in case of emergency, display warning flags, flares or flashing lights.

Parking Procedure

1. Perform *"Travel Mode Engine Shutdown"* on page 3-14 or *"Remote Mode Engine Shutdown"* on page 3-33.
2. Fill fuel tank to minimize condensation.

ATTENTION!: Prior to step 3, wait a MINIMUM of five minutes after shutting off engine before disconnecting battery. Failure to do so can cause severe damage to the engine after-treatment system.

3. Disconnect battery.
4. Lock all doors and covers and install protective window covers if available.

3.17 PRESERVATION & STORAGE

- Park the machine following the procedure on page 3-36.
- If it is impractical to activate functions regularly, and if freezing temperatures are expected, remove batteries and store in a warm location.
- Tape a note inside cab window indicating the person to be called in an emergency.
- If machine is on an unpaved surface, be sure tires are resting on sturdy boards to prevent them from being frozen in soft ground.
- Periodically cycle hydraulic functions until normal operating temperature is reached, then apply Boeshield *T9 (part number 1440-4645) to exposed cylinder rods.

Maintenance

- Take a sample of hydraulic fluid for analysis. ***Note**: Not all analysis methods are compatible with all hydraulic fluids (e.g., laser particle counters <u>do not</u> record accurate cleanliness levels in Mobil 424 due to some of the oil additives being interpreted as contaminants). Consult with your analysis lab as to oil type and test method.*
- Thoroughly clean all mud and debris from the machine to help protect surfaces from corrosion.
- Lubricate all grease fittings until fresh lube is expelled from the lube point.
- Check the hourmeter and the lubrication and maintenance schedule. If you are close to any lubricant change period, make the change before storage.
- Check level of anti-freeze protection, drain and refill if necessary to obtain proper protection.

This Page Intentionally Left Blank

SECTION 4 - ATTACHMENTS

4.1 APPROVED ATTACHMENTS

To determine if an attachment is approved for use on the hydraulic excavator you are using, perform the following prior to installation.

- Use only Gradall approved attachments.
- Before selecting specific attachments for specific models, consult the load chart on the model literature and consult either an authorized Gradall distributor or Gradall.

If any of the above conditions are not met, do not use the attachment.

4.2 UNAPPROVED ATTACHMENTS

⚠ WARNING

OW0021

Use only approved attachments. Attachments which have not been approved for use with your excavator could cause machine damage or an accident resulting in death or serious injury.

Do not use unapproved attachments for the following reasons:

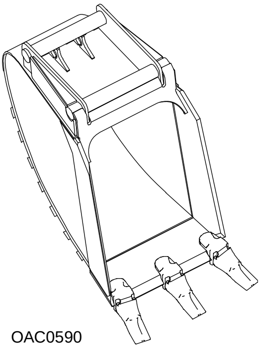
- Gradall cannot establish range and capacity limitations for “will fit,” homemade, altered, or other non-approved attachments.
- An overextended or overloaded excavator can tip over with little or no warning and cause death or serious injury to the operator and/or those working nearby.
- Gradall cannot assure the ability of a non-approved attachment to perform its intended function safely.

4.3 ATTACHMENT OPERATION

- Capacities and range limits for the excavator change depending on the attachment being used.
- Separate attachment instructions (if applicable) must be kept in Manual Holder in cab with this Operator & Safety Manual. An additional copy must be kept with the attachment if it is equipped with a manual holder.
- Window guards must be in place when using powered attachments such as hammers, augers or mowers capable of producing flying debris.

Excavating Buckets

Size	Cu. Yd.	m3
24" (610mm)	3/8	.31
30" (762mm)	1/2	.41
36" (914mm)	5/8	.54
42" (1.07m)	3/4	.64
48" (1.22m)	1	.76

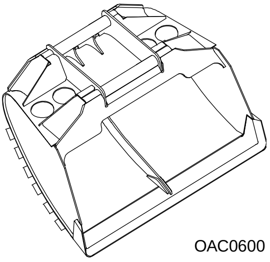


Installation Procedure

- Refer to *"Adapter Attachment Installation"* beginning on page 4-4.

Ditching Buckets

Size	Cu. Yd.	m3
30" (.80m)	1/4	.20
60" (1.52m)	7/8	.73
66" (1.68m)	1	.76
72" (1.83m)	1-1/8	.87

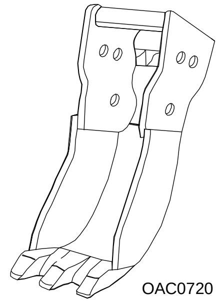


Installation Procedure

- Refer to *"Adapter Attachment Installation"* beginning on page 4-4.

Trenching Buckets

Size	Cu. Yd.	m3
15" (381mm)	1/5	.15
21" (533mm)	1/4	.19



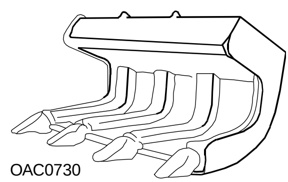
OAC0720

Installation Procedure

- Refer to *"Adapter Attachment Installation"* beginning on page 4-4.

Pavement Removal Bucket

Size	Cu. Yd.	m3
18" (.50m)	N/A	N/A
24" (.60m)	N/A	N/A
28" (.70m)	N/A	N/A
40" (1.02m)	N/A	N/A



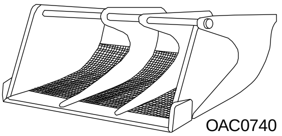
OAC0730

Installation Procedure

- Refer to *"Adapter Attachment Installation"* beginning on page 4-4.

Dredging Bucket

Size	Cu. Yd.	m3
72" (1.83m)	1-1/8	.87

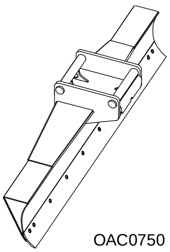

OAC0740

Installation Procedure

- Refer to *"Adapter Attachment Installation"* beginning on page 4-4.

Grading Blade

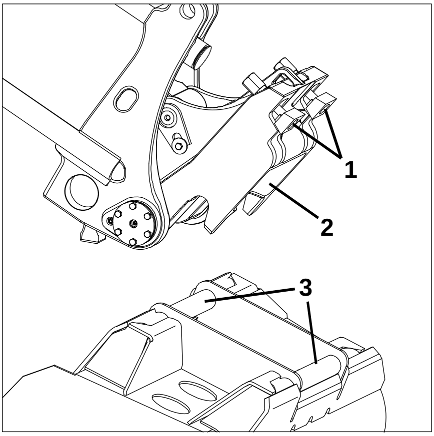
Size	Cu. Yd.	m3
8' (2.4m)	N/A	N/A


OAC0750

Installation Procedure

- Refer to *"Adapter Attachment Installation"* beginning on page 4-4.

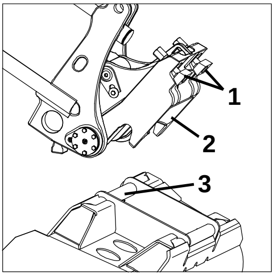
4.4 ADAPTER ATTACHMENT INSTALLATION



OAC0760

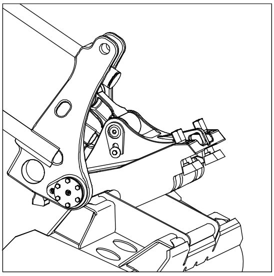
1. Wedge Bolts
2. Bucket Adapter
3. Bucket Bars

Installation Procedure:



OAC0770

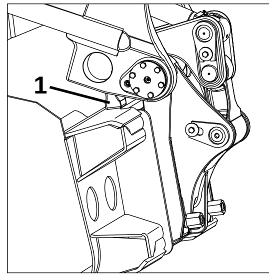
1. Be sure wedge bolts **(1)** are secured in storage position (toward rear) and position bucket adapter **(2)** above bucket bar **(3)** as shown.



OAC0780

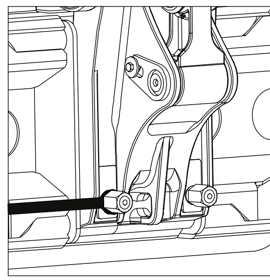
2. Lower boom until concave section of adapter contacts bucket bar.

3. Move adapter toward "bucket close" position until outer end of adapter contacts bucket. Ensure proper alignment and continue to close until adapter contacts stops **(1)**.



OAC0790

4. Only use the nuts to move wedge bolts forward to position wedge between adapter and bucket bar. Do not use fingers to slide wedges forward or to keep wedges from turning when tightening nuts. Be certain wedge surfaces are flush between adapter and bar and tighten fully. Jog tool control a few times and re-tighten. Check often to be sure bolts remain tight.



OAC0800

WARNING

OW0021

CRUSH HAZARD. Keep boom in fully extended position while installing bucket. Stay clear until bucket adapter has been fitted to bucket as shown in step 3.

Digging with a loose or improperly fitted bucket may cause excessive wear, shear adapter bolts or cause loss of bucket.

SECTION 5 - LUBRICATION & MAINTENANCE

5.1 INTRODUCTION

Service the product in accordance with the maintenance schedule on the following pages. Complete all required maintenance before operating unit.

Service intervals are based on machine usage of 1500 hours annually. Use of your product may vary significantly and you must adjust service frequency for your usage to obtain maximum service life.

Always check hourmeter and date at beginning of shift to be certain services are performed at proper intervals. Perform service at whichever interval comes first.

Note: *Failure To Use Gradall Hydraulic Filter Elements Could Void Warranty.*

⚠ WARNING

OW0021

FALL HAZARD. Use extreme caution when checking items beyond your normal reach. Use an approved ladder. Failure to comply could result in death or serious injury.

If guards are removed for service, replace them before operating machine.

Do not step or stand on engine cover or upperstructure heater cover when performing checks and services in the area of the main boom and cradle.

Before removing filler caps or fill plugs, wipe all dirt and grease away from the ports. If dirt is allowed to enter ports, it can shorten the life of major hydraulic components along with o-rings, seals, packing and bearings.

⚠ CAUTION

OW0031

ELECTRICAL COMPONENT DAMAGE. Do not pressure wash or steam clean under the valve cover on the upperstructure or behind the front external cover on the undercarriage cab.

When adding fluids, refer to *“Product Specifications”* on page 7-1 to determine proper fluid type, and *“Service & Maintenance Schedules”* on page 5-3 for intervals.

Clothing and Safety Gear

Wear all the protective clothing and personal safety devices issued to you or called for by job conditions. **DO NOT** wear loose clothing or jewelry that can get caught on controls or moving parts. Refer to page 1-13 for more detail.

5.2 GENERAL MAINTENANCE INSTRUCTIONS

Prior to performing any service or maintenance on the excavator, follow the shutdown procedure on page 3-14 or page 3-33 unless otherwise instructed and place "Do Not Operate" tag on steering wheel in associated cab.

WARNING

OW0021

CUT/CRUSH/BURN HAZARD. Do not perform service or maintenance on the machine with the engine running. Failure to comply could cause death or serious injury.

- Ensure excavator is level for proper fluid readings.
- For boom service, extend boom, close bucket and lower onto flat ground.
- Clean lubrication fittings before lubricating.
- After greasing excavator, cycle all functions several times to distribute lubricants.
- Apply a light coating of engine oil to all linkage pivot points.
- Drain engine and gear cases after operating when oil is hot.
- Check all lubricant and coolant levels when cool.

WARNING

OW0021

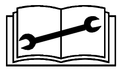
MACHINE DAMAGE. Contact Gradall before welding on machine. Welding could damage wires, electronic processors, hoses, and tubes. Prior to welding, turn off ignition, unplug all electronic processors and disconnect positive (+) and negative (-) battery cables from battery posts only. Do not disconnect cable leads from studs on battery box panel. Connect positive (+) and negative (-) cables together. Remove or adequately shield all components, hoses, tubes, and wires in the area. Component damage could cause an accident resulting in death or serious injury.

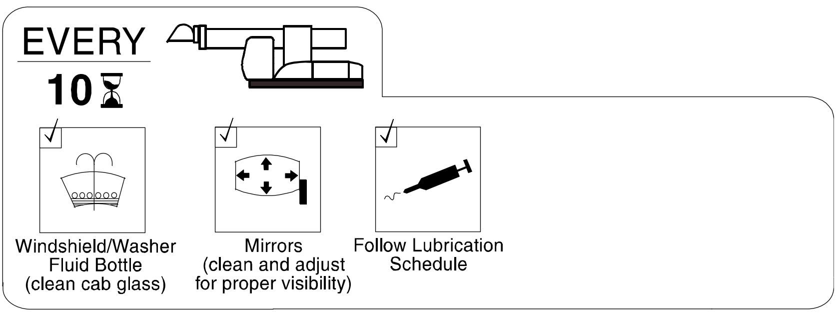
Tire Service

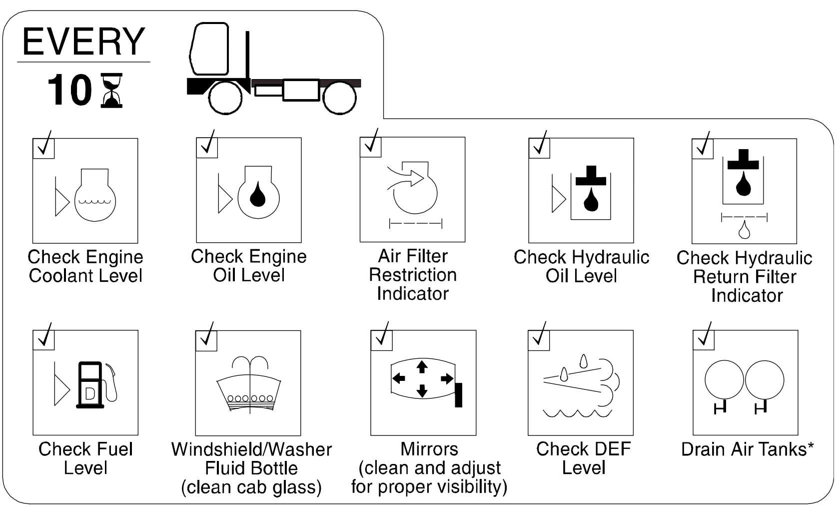
Tire service must be performed by a qualified tire service center or an authorized person that is properly trained in procedures and use of safety equipment designed for tire service.

5.3 SERVICE & MAINTENANCE SCHEDULES

Daily or Shift (10 Hour Maximum) Maintenance Schedule



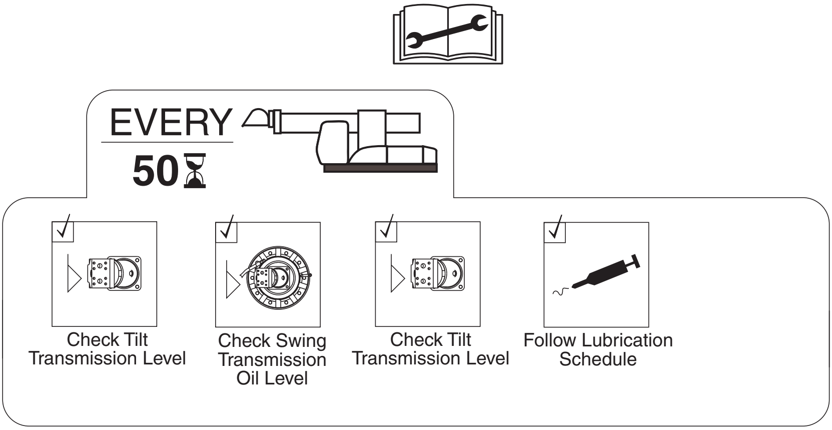


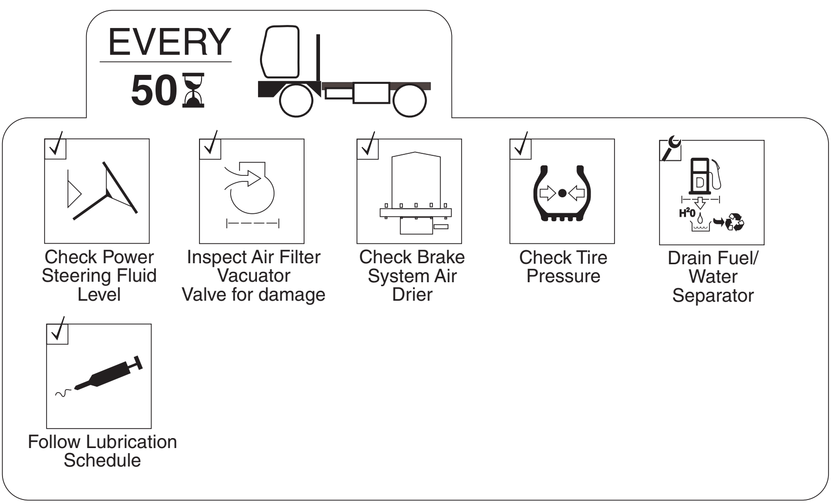


OAC1991

** Drain air tanks daily. To prevent possible damage to emission controls components, wait a **minimum** of 10 minutes after shutting off engine before draining air tanks.*

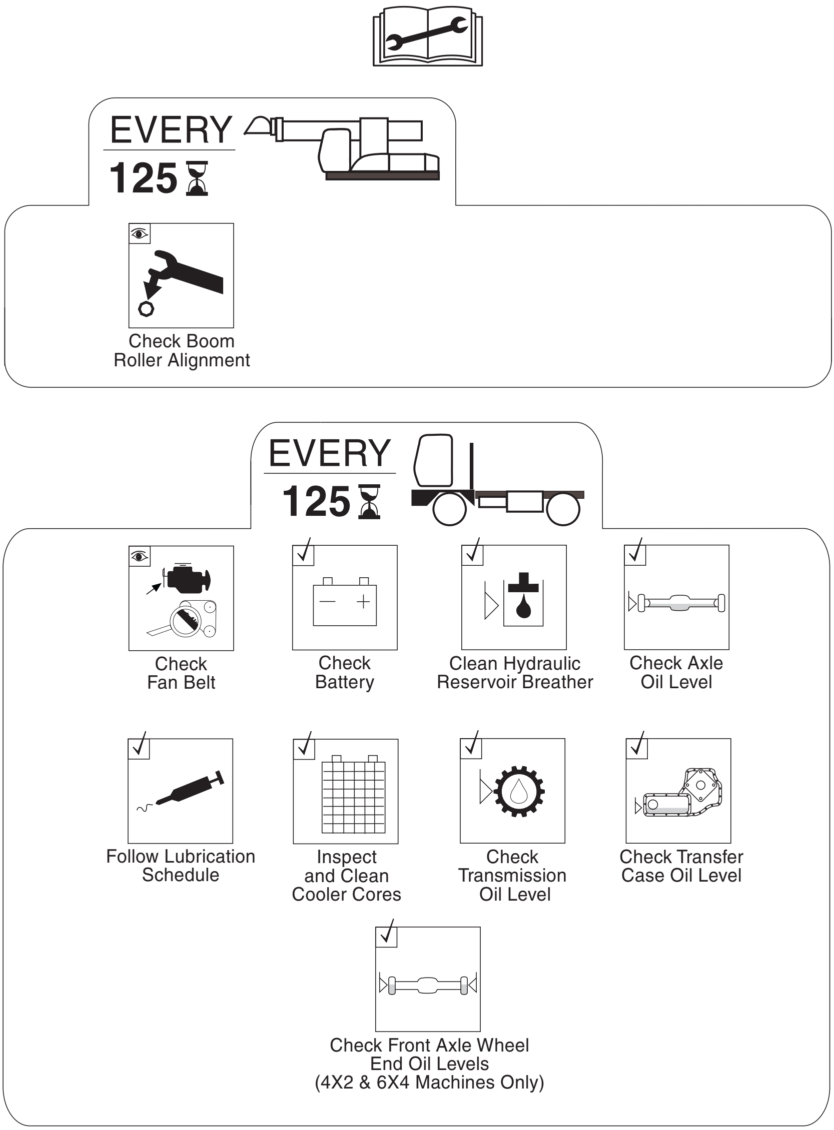
Weekly (50 Hour Maximum) Maintenance Schedule





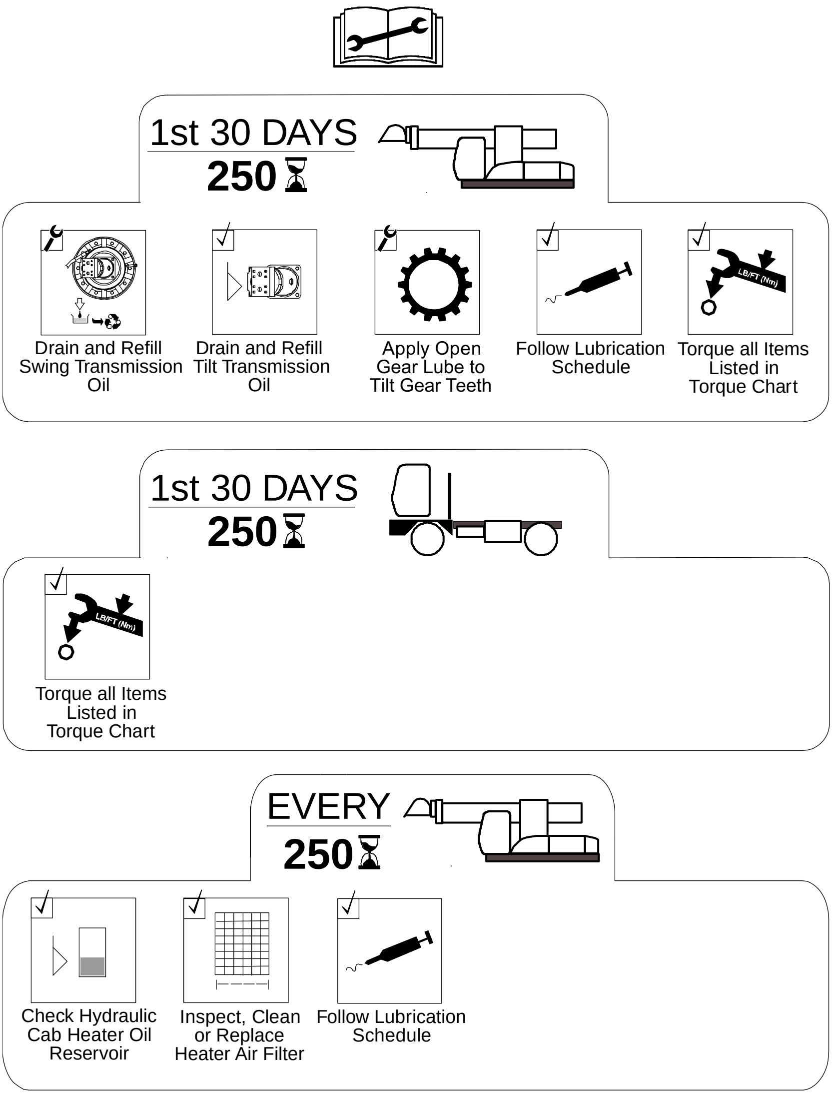
OAC2431

Monthly (125 Hour Maximum) Maintenance Schedule



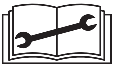
OAC2440

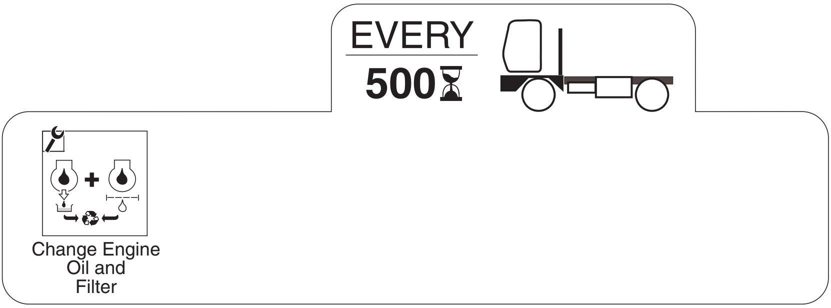
1st 30 Days (250 hrs Max) & 250 Hour Maintenance Schedule



OAC2021

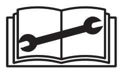
500 Hour Maintenance Schedule

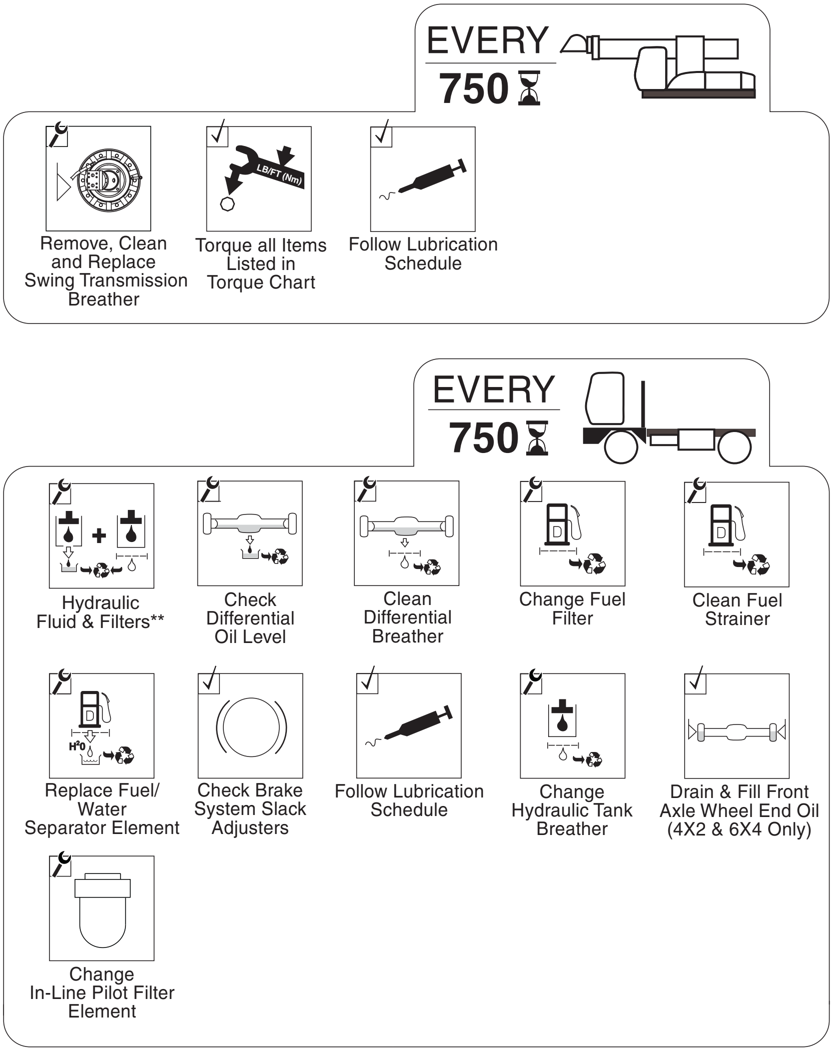




OAC2451

Semi-Annual (750 Hour Maximum) Maintenance Schedule

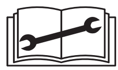


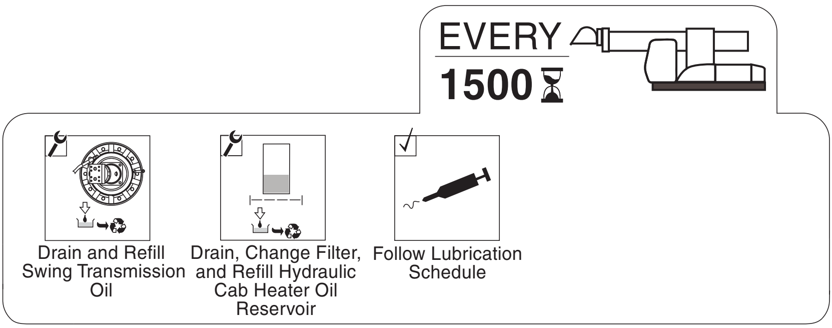


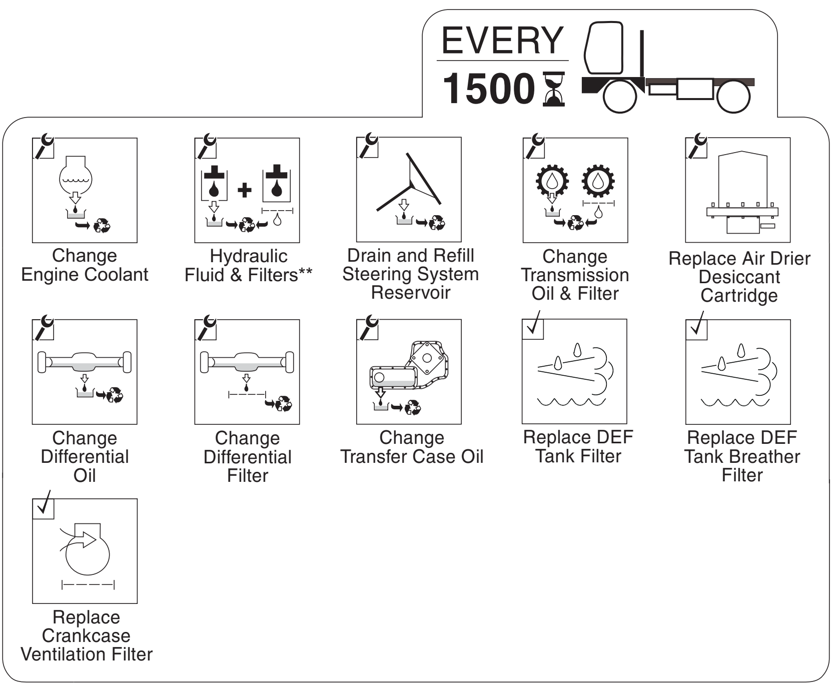
OAC2460

** - Have hydraulic fluid analyzed to determine condition.
Use test port mini-check in pump line to obtain sample.
Drain, flush and replenish system if required.

Annual (1500 Hour Maximum) Maintenance Schedule





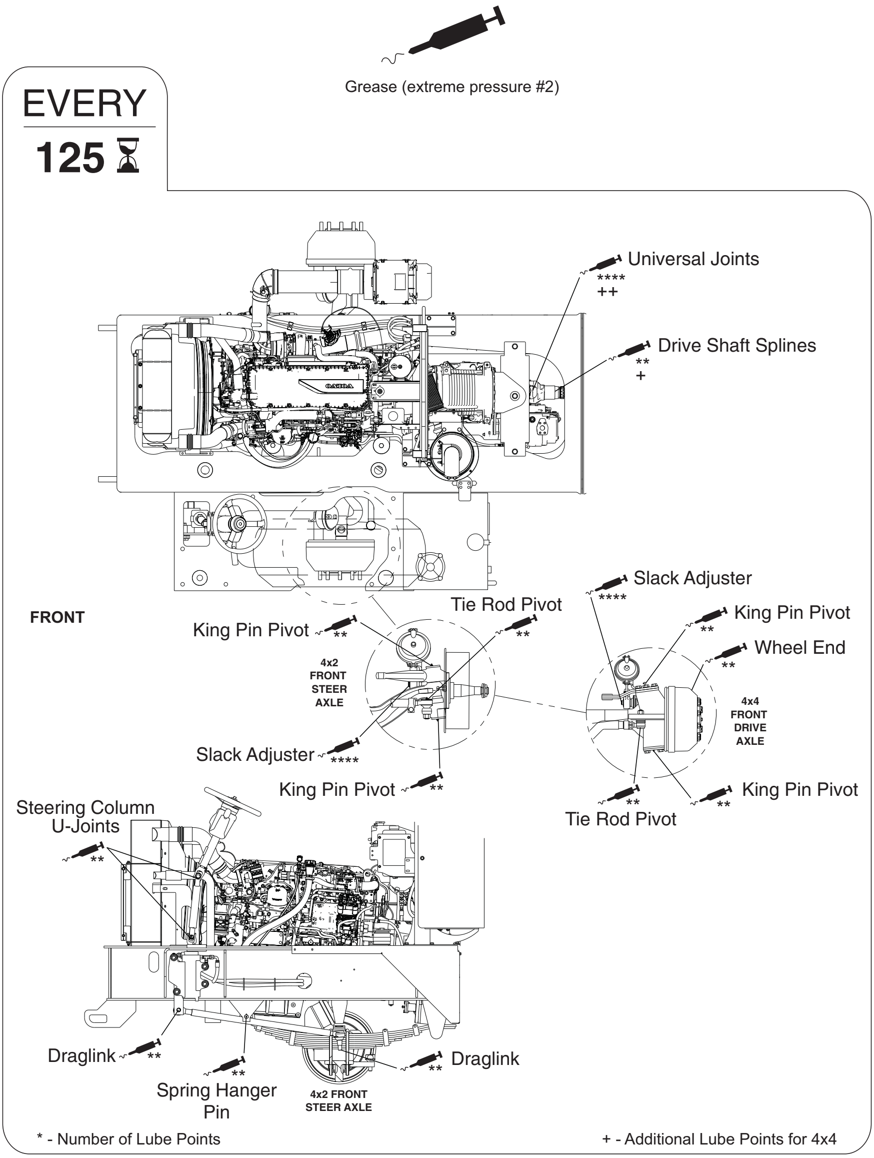


OAC2470

** - Unless hydraulic fluid is analyzed semi-annually to determine level of contamination, system must drained, flushed and replenished on an annual basis.

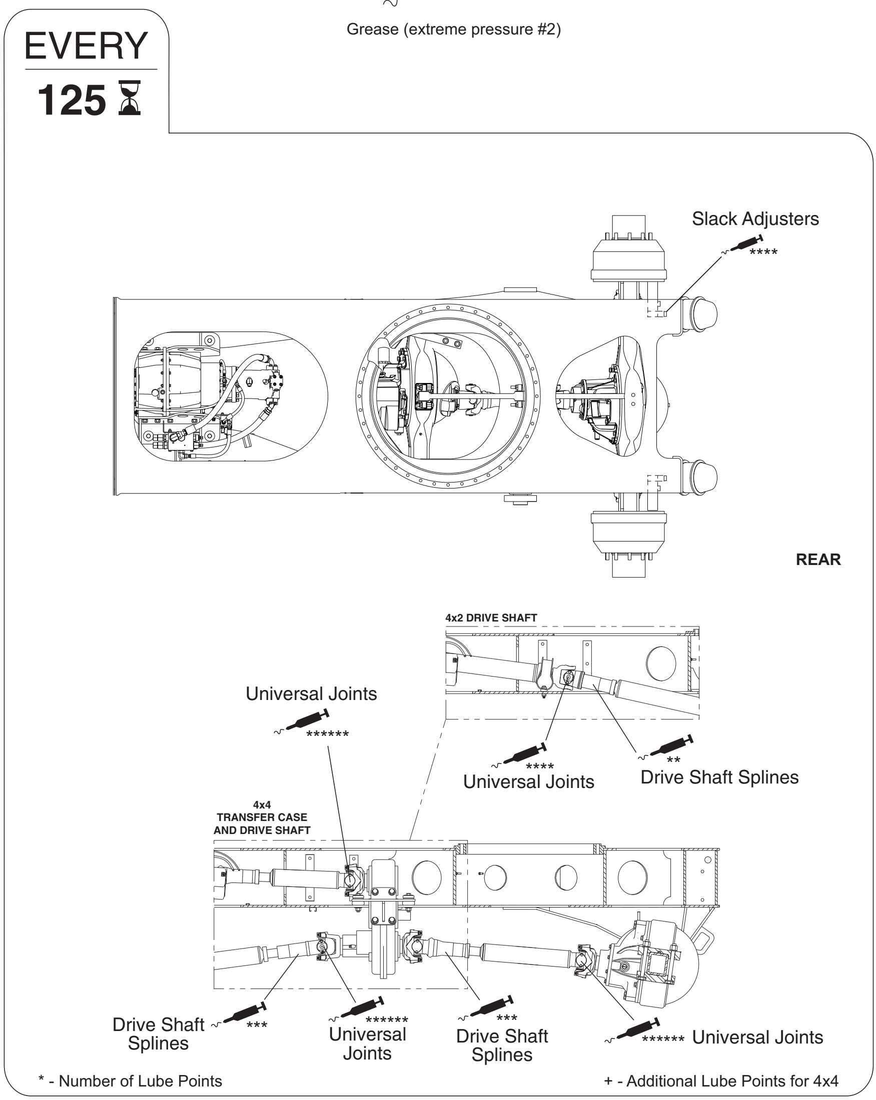
5.4 UNDERCARRIAGE LUBRICATION SCHEDULES

Monthly (125 Hour Maximum) Lubrication Schedule - XL3100V



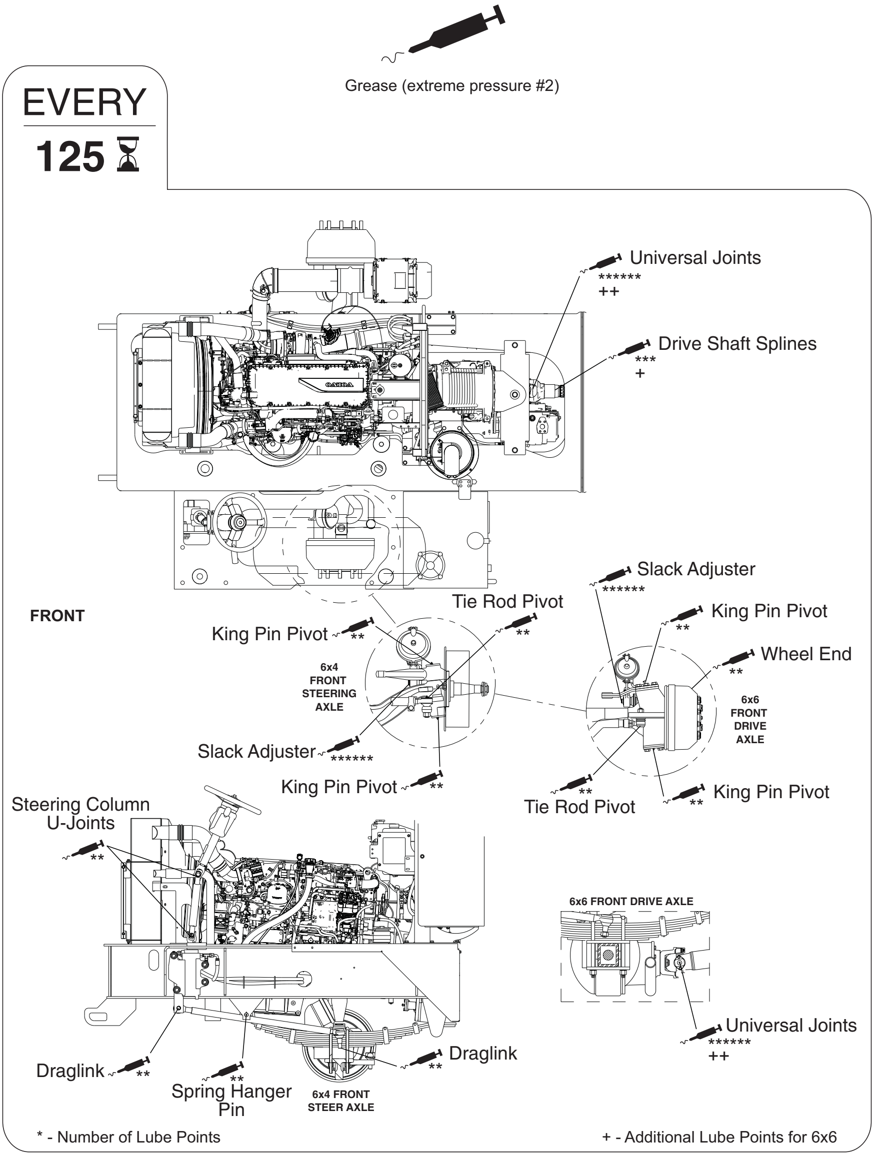
OAC2501

Grease (extreme pressure #2)



OAC2561

Monthly (125 Hour Maximum) Lubrication Schedule - XL4100V & XL5100V

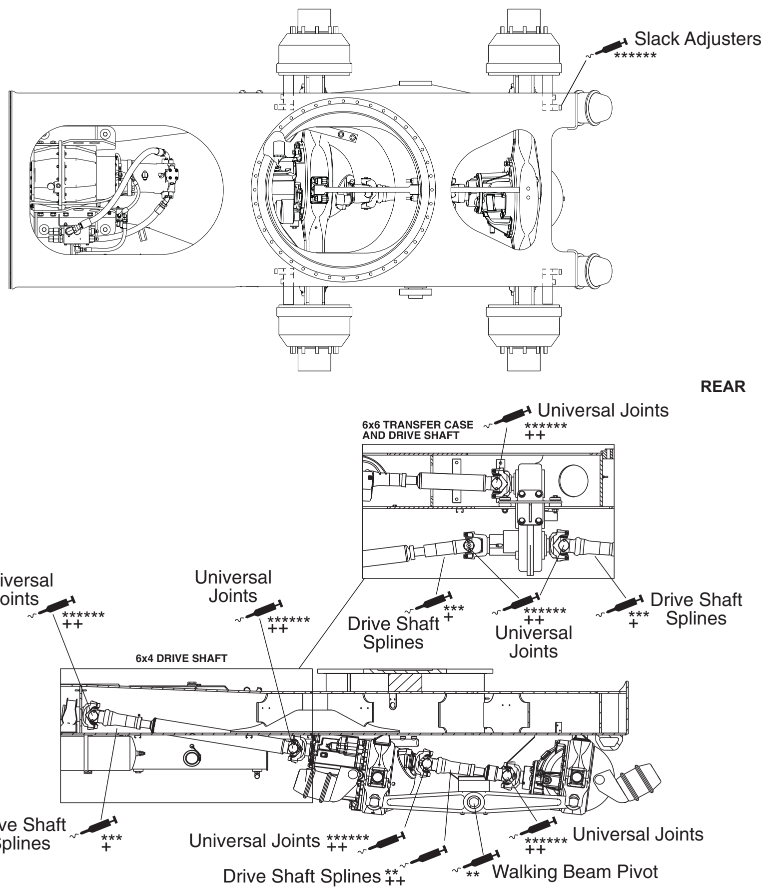


OAC2511

Grease (extreme pressure #2)

EVERY

125

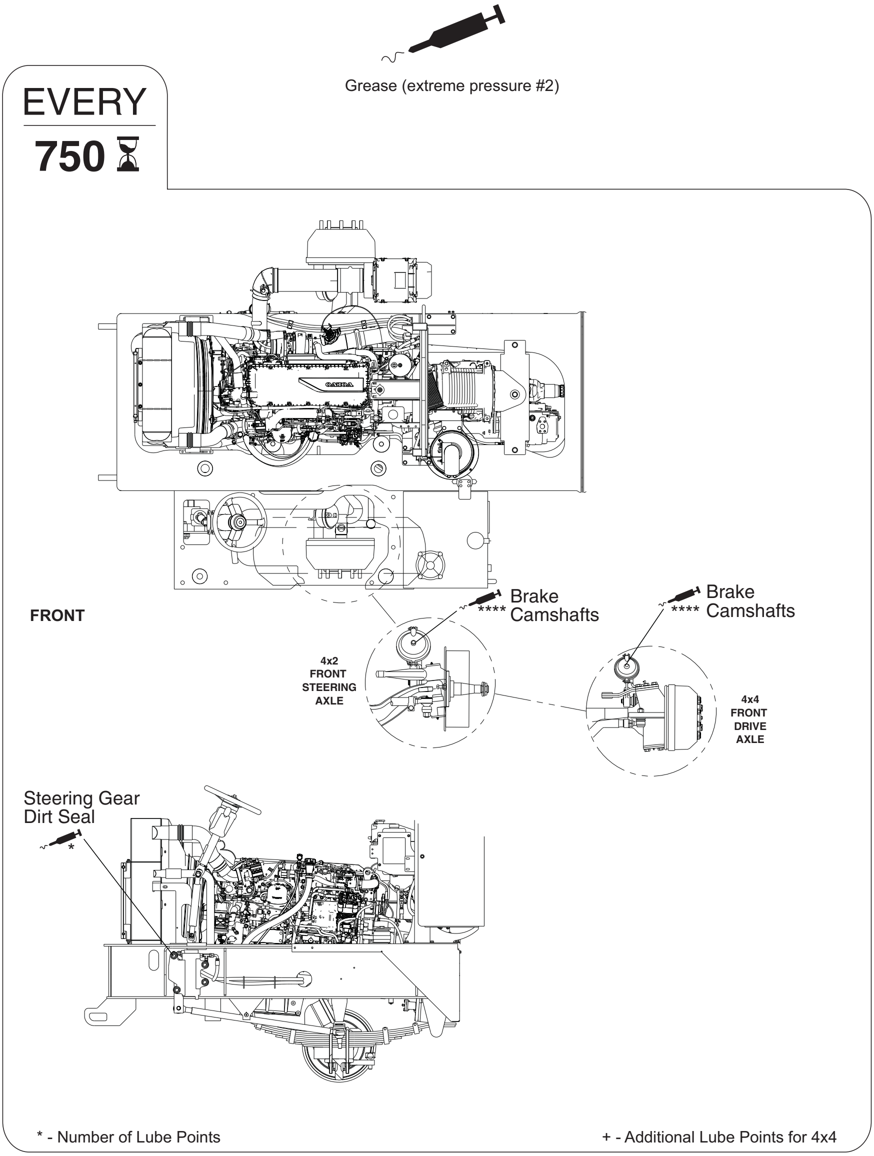


* - Number of Lube Points

\+ - Additional Lube Points for 6x6

OAC2571

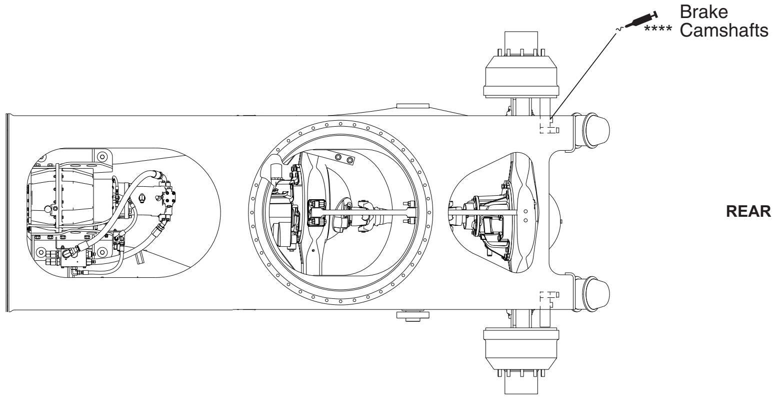
Semi-Annual (750 Hour Maximum) Lubrication Schedule - XL3100V



OAC2521

EVERY

750

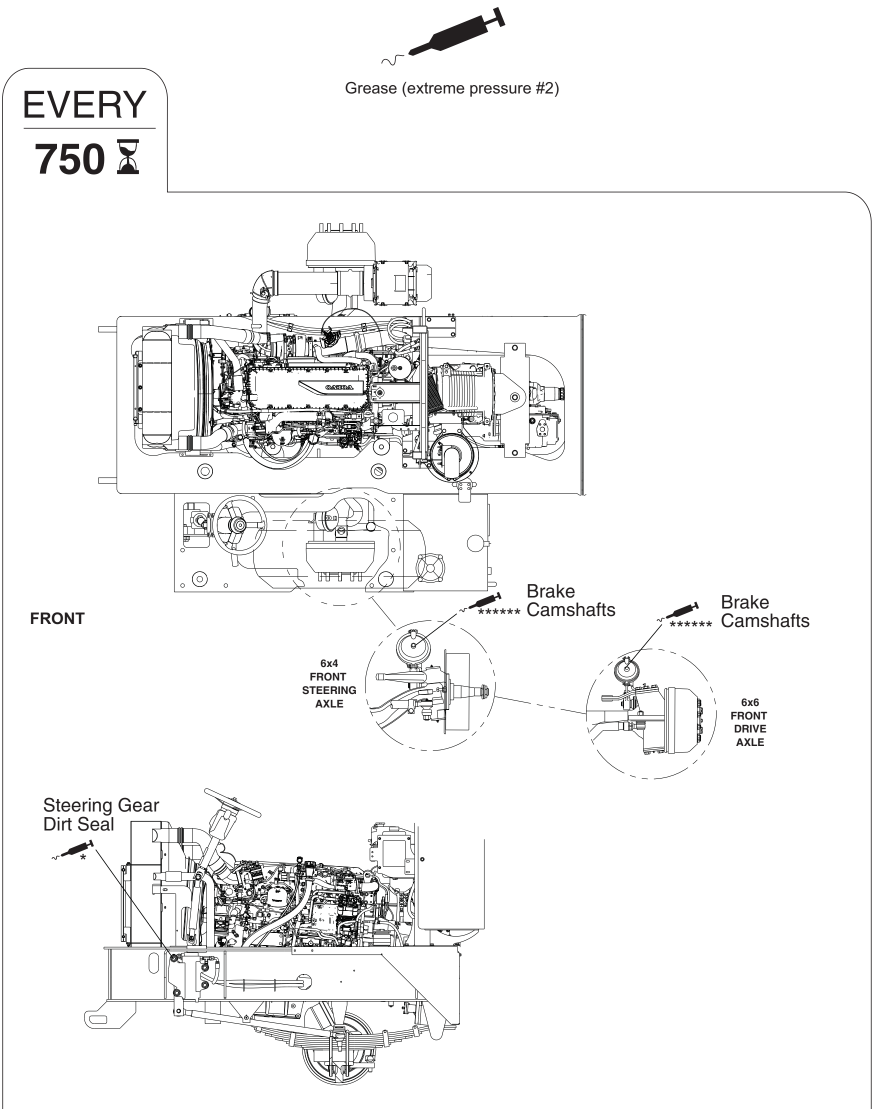


* - Number of Lube Points

\+ - Additional Lube Points for 4x4

OAC2531

Semi-Annual (750 Hour Maximum) Lubrication Schedule - XL4100V & XL5100V



* - Number of Lube Points

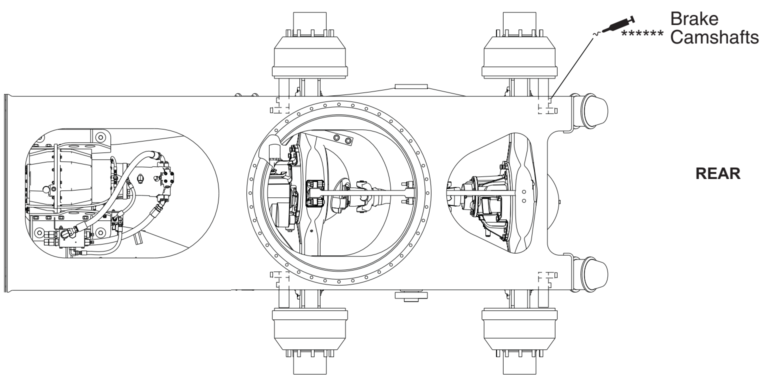
\+ - Additional Lube Points for 6x6

OAC2541

Grease (extreme pressure #2)

EVERY

750



* - Number of Lube Points

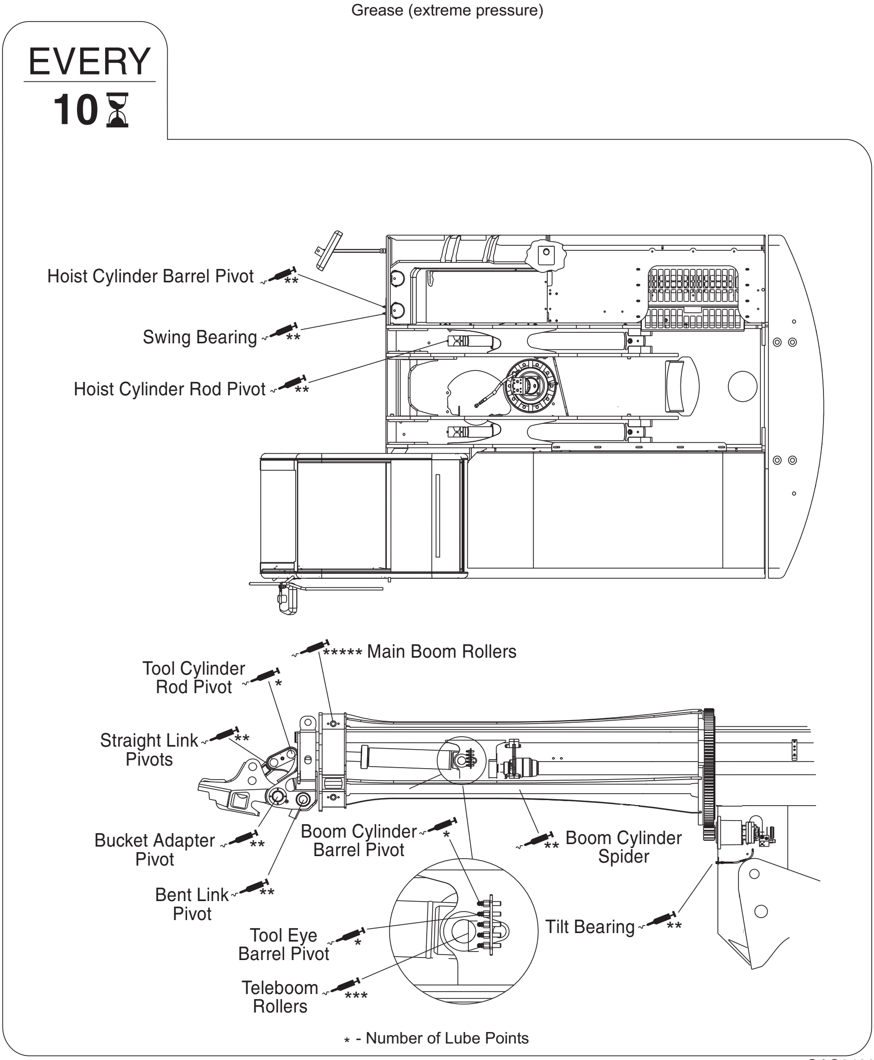
+ - Additional Lube Points for 6x6

OAC2551

5.5 UPPERSTRUCTURE LUBRICATION SCHEDULES

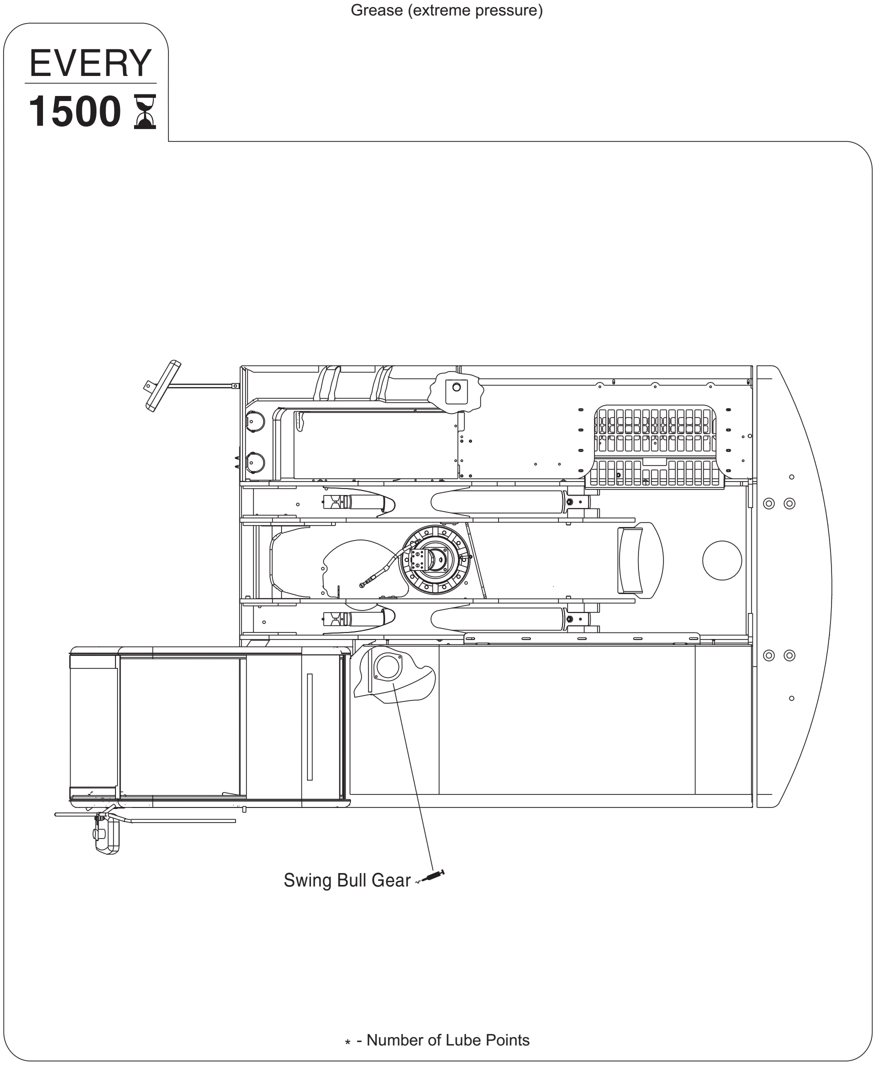
Daily or Shift (10 Hour Maximum) Lubrication Schedule

Grease (extreme pressure)



OAC2480

Annual (1500 Hour Maximum) Lubrication Schedule



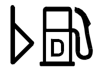
OAC2490

5.6 OPERATOR MAINTENANCE INSTRUCTIONS

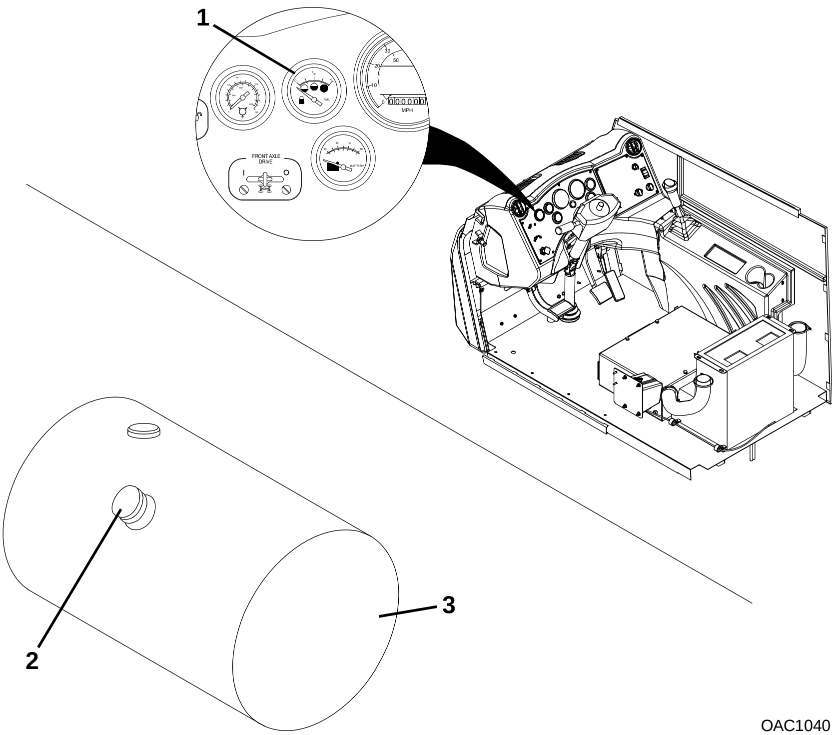
10 Hours

Fuel Level Check

OAC1030



OW0990

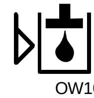


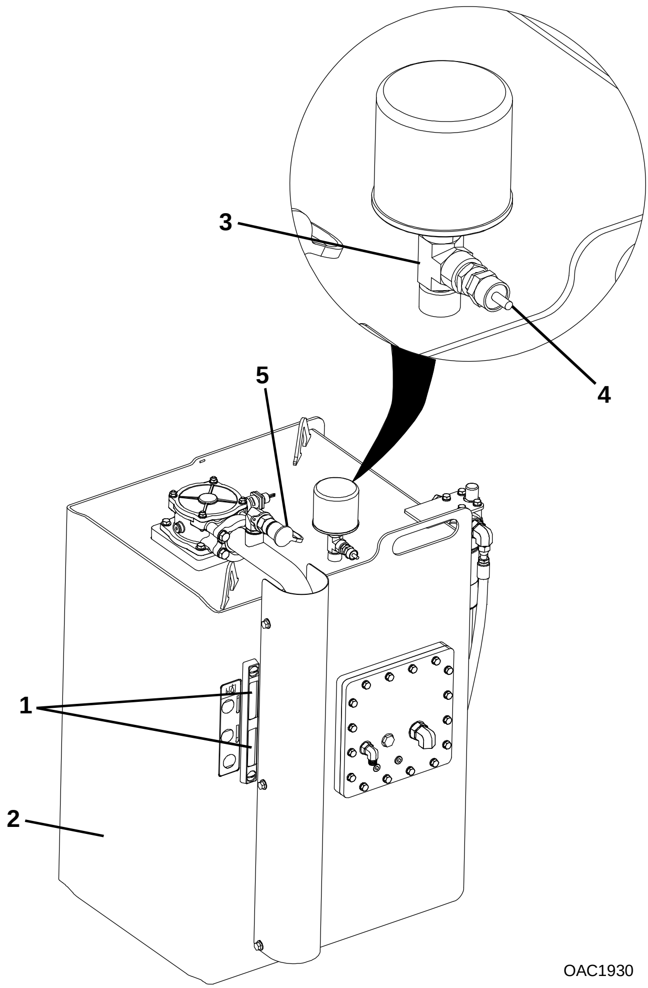
OAC1040

1. Check fuel gauge **(1)** located on dash panel in undercarriage cab.
2. If fuel is low, perform shutdown procedure on page 3-14 or page 3-33 and proceed to fuel tank **(3)**.
3. Turn fuel tank cap **(2)** and remove from fuel tank **(3)**. Add diesel fuel as needed. Replace fuel tank cap.

Replenish diesel fuel at end of each work shift to minimize condensation.

Hydraulic Oil Level Check

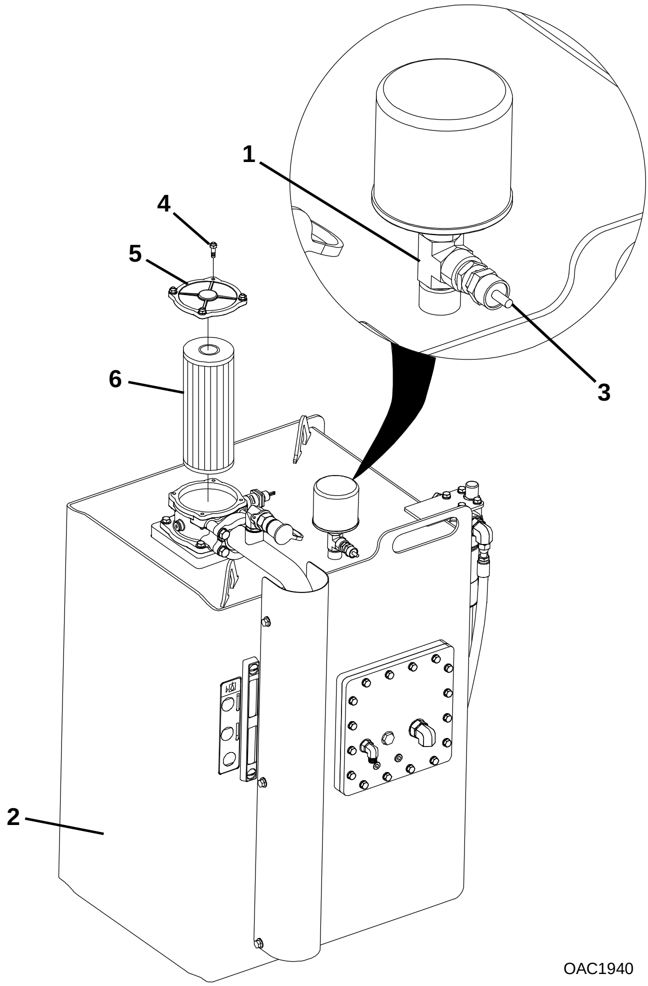




1. Be sure machine is level, boom is level and retracted and bucket is open.
2. Perform shutdown procedure on page 3-14 or page 3-33.
3. Check level of hydraulic oil at the sight gauge **(1)** on the hydraulic tank **(2)**. The oil level should be visible in the upper gauge window.
4. If hydraulic oil is low, locate reservoir breather **(3)** mounted on tank. Depress breather plunger **(4)** to relieve all hydraulic reservoir pressure.

5. Remove dust cap from pressure fill port **(5)**. Locate female coupling from tool kit and attach to pressure fill port. Add hydraulic fluid to level where oil is visible in upper gauge window.
6. Remove female coupling from fill port and replace dust cap.

Hydraulic Tank Element Change (as filter indicator light indicates)



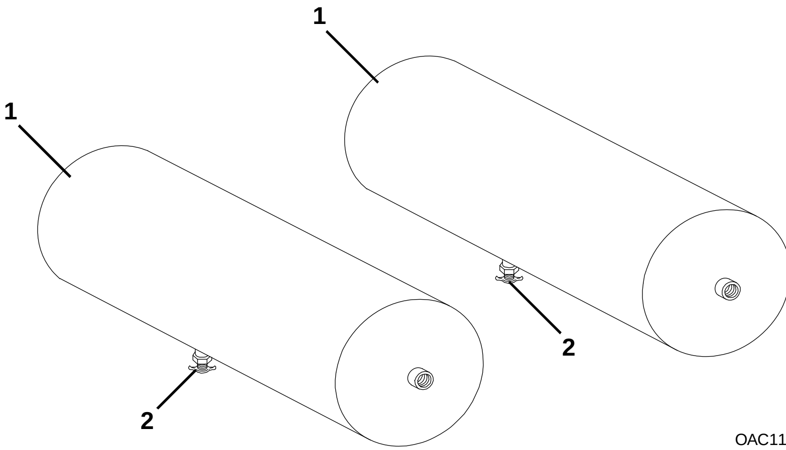
1. Perform shutdown procedure on page 3-14 or page 3-33.
2. Locate reservoir breather **(1)** mounted on hydraulic tank **(2)**.
3. Depress breather plunger **(3)** to relieve all hydraulic reservoir pressure.

4. Remove bolts **(4)** on return filter to allow removal of filter cover **(5)**.
5. Remove old filter element **(6)** and replace with new element.
6. Replace filter cover **(5)** and bolts **(4)**. (Torque bolts to 200-225 lb-in).

50 Hours

Check & Drain Air Tanks

OAC1070 OAC1150

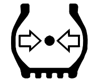


OAC1190

1. Perform shutdown procedure on page 3-14 or page 3-33.
2. Locate air tanks **(1)**.
3. Loosen drain cocks **(2)** to drain any moisture from air tanks. If significant moisture is found, check operation of air drier.
4. Tighten drain cocks.

Tire Air Pressure Check

OAC1070



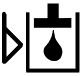
OW1040

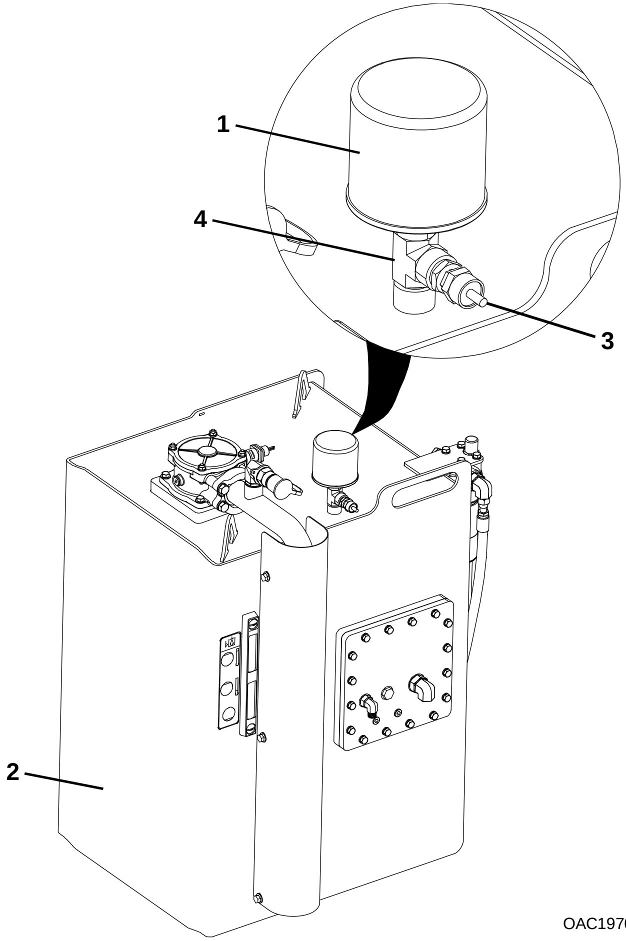
1. Perform shutdown procedure on page 3-14 or page 3-33.
2. Remove valve stem cap.
3. Check tire pressure using a good quality gauge.
4. Add air if required (inflate tires to air pressure located on sidewall of equipped tire).
5. Replace valve stem cap.

100 Hours

Replace Hydraulic Reservoir Breather

OAC2050

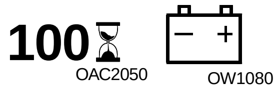

OW1030

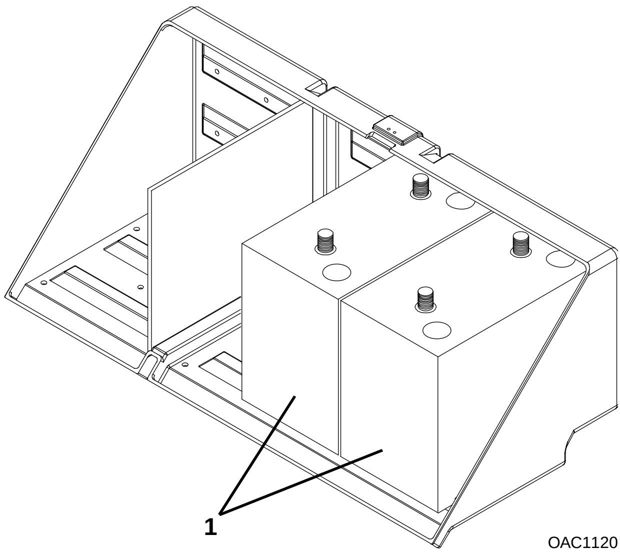


OAC1970

1. Perform shutdown procedure on page 3-14 or page 3-33.
2. Locate reservoir breather **(1)** mounted on hydraulic tank **(2)**.
3. Depress breather plunger **(3)** to relieve hydraulic reservoir pressure.
4. Spin reservoir breather counter-clockwise to remove from tee **(4)**.
5. Spin replacement reservoir breather clockwise to attach to tee.

Battery Check

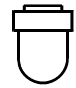


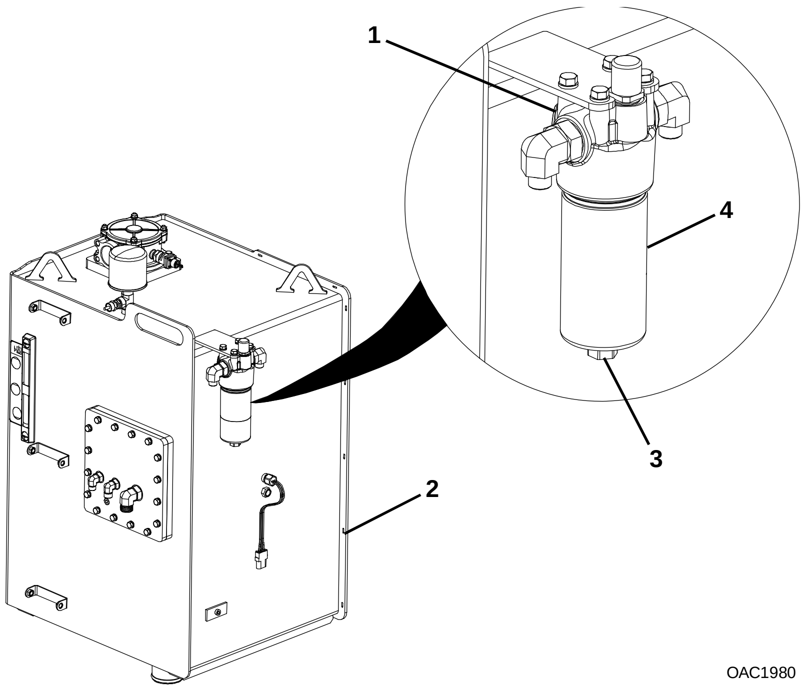


1. Perform shutdown procedure on page 3-14 or page 3-33.
2. Open the battery box cover.
3. Wearing eye protection, visually inspect the batteries **(1)**. Check terminals for corrosion. Replace battery if it has a cracked, melted or damaged case.
4. Close and secure the battery box cover.

750 Hours

Replace In-Line Pilot Filter



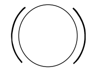


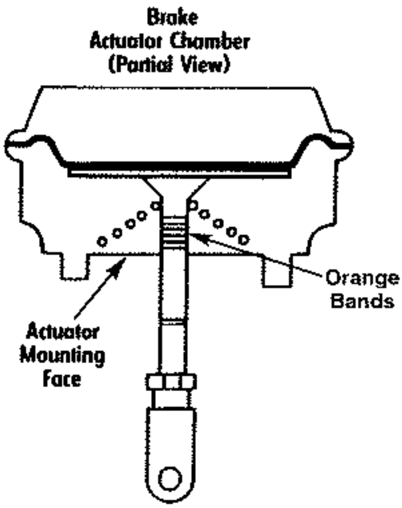
In-Line Pilot Filter Element

1. Perform shutdown procedure on page 3-14 or page 3-33.
2. Locate in-line pilot filter **(1)** located on hydraulic tank **(2)**.
3. Remove oil drain plug **(3)**. Drain oil into a suitable container.
4. Unscrew bowl **(4)** and remove filter element from element location spigot in the filter head.
5. Replace the filter element. Verify that the designation corresponds to that of the old element and place filter element carefully into the element location spigot in the filter head.
6. Screw in bowl fully, then unscrew by one quarter-turn. Replace oil drain plug.

Automatic Slack Adjuster Check

OAC1090


OAC1100



OAC0580

Note: *Brake actuator chamber is shown with digging brake applied and with brake worn to a point just before automatic adjustment. If orange band is visible, notify maintenance personnel for adjustment or repair.*

1. Position unit in a safe, level area.
2. With brake system fully charged (125 psi), apply digging brake, stop engine and remove key.
3. Install wheel chocks.
4. If one or more orange bands located on the push rods are visible at mounting face of any actuator, immediately notify your supervisor and/or maintenance personnel for inspection and/or repair.

SECTION 6 - EMERGENCY PROCEDURES

6.1 LOSS OF POWER

The engine will de-rate if a problem develops. If this occurs, place the boom in the boom rest as soon as possible. Make all necessary repairs before continued operation.

If the machine loses power before the boom is place in the boom rest, follow the procedures below:

Stowing the boom without engine power

Be sure there is enough clearance for the attachment when the boom is in the boom rest by measuring the length from the roller bracket on the main boom to the attachment pivot point. If the distance is less than 6 feet, it will be necessary to extend the boom with another machine by performing the following procedure:

To extend the boom without engine power

1. Attach a test hose to the test fitting for the retract side of the boom circuit.
2. Direct the rod side oil into a waste container as the boom is SLOWLY pulled out.
3. Once the boom is at the proper extension, secure the telescoping boom to the main boom using a chain or strap to keep the boom from further movement.

To raise the boom without engine power

1. If the boom needs to be raised to place in the boom rest, it will be necessary to release the swing brake.
2. Secure the end of the boom to keep the upperstructure from swinging once the swing brake has been released.
3. Release the swing brake using a port-a-power to pressurize the swing brake to a maximum of 500 psi.
4. Attach a chain to the end of the telescoping boom to a machine having sufficient lift capacity and lift height to raise the boom.
5. Be certain that the boom will not contact any obstructions while raising it.
6. Attach a test hose on the rod side of the hoist cylinders to bleed oil into a waste container.
7. Lift the boom SLOWLY, directing the hoist cylinder rod side oil into a container.

8. Once the boom is raised high enough to clear the cab and boom rest, swing into position over the boom rest.
9. While still supporting the boom with another machine, remove the test hose from the hoist up side of the circuit.
10. Attach test hose to the hoist down test fitting, directing oil into a waste container.
11. SLOWLY lower the boom into place squarely on the boom rest.
12. Once the boom is in the rest, use the boom tie-down to secure it.
13. Remove test hoses used for the procedure.
14. Secure the telescope boom to keep it from extending and retracting.
15. Follow the procedure on page 3-34 for shifting the machine into travel mode.
16. Make sure that the machine air pressure is such that it will allow the shift back to travel mode.

Towing

When transporting the vehicle with one or all axles on the road, it is possible to damage the axles if the wrong procedure is used before transporting begins.

Before towing the vehicle, apply the park brake, block the wheels, and put the transmission in neutral.

The front axle drive shaft (if equipped) and rear axle drive shafts must be removed prior to towing.

All repairs must be made and the machine verified for correct operation before allowing it back into service.

If You Get Stuck

If unit becomes stuck, you can use the boom to help free it.

- Position undercarriage and upperstructure controls for remote control operation.
- Position boom over rear of undercarriage (centered over rear to prevent tipping) and imbed bucket or attachment in ground.

While actuating travel pedal in appropriate direction, extend or retract boom as required to help push or pull unit to solid ground. Keep wheels in contact with ground.

SECTION 7 - SPECIFICATIONS

7.1 PRODUCT SPECIFICATIONS

Lubrication & Fluid Capacities

Note: *Lubricants described in this table are used in standard machines when they are shipped from Gradall Industries, Inc.*

Engine Crankcase Oil

Capacity with Filter Change (4-cylinder) ....17.2 quarts (16.3 liters)

Capactiy with Filter Change (6-cylinder) ....28.0 quarts (26.5 liters)

Type of Oil .... 15W-40 (Volvo VDS-4 rated oil)

Cooling System

System Capacity ....11 gallons (41.6 liters)

Type of Coolant .... OAT Coolant (p/n 80533046)

Hydraulic System

System Capacity
XL3100V...65 gallons (246 liters)

System Capacity
XL4100V, XL4130 & XL5100V..70 gallons (265 liters)

Type of Oil .... Mobilfluid® 424 Tractor Hydraulic Fluid (ISO 46)**

Upperstructure Cab Heater

Capacity ....1.3 gallons (4,9 liters)

Type of Fluid...................... Conoco Heat Transfer 32 Hydraulic Fluid (p/n 80533049)

Steering System

System Capacity ....2 gallons (7,6 liters)

Type of Fluid... Super ATF (8053-3026)

Transmission

Capacity .... 29 Quarts (27 liters)

Type of Fluid...................................... Synthetic ATF (Allison TES-295) (8053-3040)

Transfer Case

Capacity.. 21 pints (9,9 liters)

Type of Fluid .... Mobilfluid® 424 Tractor Hydraulic Fluid (ISO 46)**

DEF (Diesel Exhaust Fluid) Tank

Capacity... 10 gallons (37,8 liters)

Type of Fluid .... Clear DEF (8053-3041)

Rear Axle (XL3100V)

Capacity.. 31 pints (14,6 liters)

Type of Fluid 80w90 (8053-3027)

Rear Tandem Axle (forward) (XL4100V & XL5100V)

Capacity... 34 pints (16 liters)

Type of Fluid 80w90 (8053-3027)

Rear Tandem Axle (rear) (XL4100V & XL5100V)

Capacity.. 31 pints (14,7 liters)

Type of Fluid 80w90 (8053-3027)

Front Axle (XL3100V 4x4)

Capacity.. 27 pints (12,8 liters)

Type of Fluid 80w90 (8053-3027)

Front Axle Wheel Ends (XL3100V 4x2; XL4100V 6x4 & XL5100V 6x4; XL4130V)

Capacity.. 4 ounces (0,1 liters) (per wheel)

Type of Fluid 80w90 (8053-3027)

Front Axle (XL4100V 6x6 & XL5100V 6x6)

Capacity.. 27 pints (12,8 liters)

Type of Fluid 80w90 (8053-3027)

Fuel Tank

Capacity.. 100 gallons (378 liters)

Type of Fuel.. #2 Diesel (8053-3028)

Swing Transmission

Capacity .... 4.75 quarts (4,5 liters)

Type of Fluid 80w90 (8053-3027)

Swing Bull Gear

Capacity .... as required

Type of Fluid .... Extreme Pressure Lube #2

Tilt Transmission

Capacity .... 32-34 ounces (0,9-1,0 liters)

Type of Fluid 80w90 (8053-3040)

Tilt Bull Gear

Capacity .... as required

Type of Fluid .... Open Gear Lube (8053-3027)

Grease Fittings

Capacity .... as required

Type of Lube .... Extreme Pressure Lube #2

* Capacities are approximate - Check level to be sure
** Hydraulic Fluid Specifications; Pour Point -46°F., SSU @ 100° F. 275; Flash Point 442° F. Approved Supplier & Type: Mobil Mobilfluid 424

Tires

Air Pressure

Inflate tires to air pressure located on sidewall of equipped tire.

Battery

TROJAN C31
BCI Group 31
Maintenance Free CLAC/CALC w/handles
1000 Cold Cranking AMPS @ 0°F (-17°C)
200 Minutes Minimum Reserve Capacity @ 25 AMPS
Top Studs: 3/8-16
Trojan Type C31-1000S
Dimensions (LxWxH):
12.970” x 8.685” x 6.750” (329.4 mm x 220.59 mm x 171.45 mm)

Weight

XL3100V

Gross Vehicle Axle Weight Rating (4x2)..................................41,250 lb (18,711 kg)

Gross Vehicle Axle Weight Rating (4x4)..................................44,250 lb (20,071 kg)

XL4100V

Gross Vehicle Axle Weight Rating (6x4)..................................66,000 lb (29,937 kg)

Gross Vehicle Axle Weight Rating (6x6)..................................69,000 lb (31,928 kg)

XL4130V

Gross Vehicle Axle Weight Rating (6x4)..................................68,700 lb (31,162 kg)

XL5100V

Gross Vehicle Axle Weight Rating (6x4)..................................66,000 lb (29,937 kg)

Gross Vehicle Axle Weight Rating (6x6)..................................69,000 lb (31,928 kg)

Note: *Refer to detailed specification sheet for additional machine weight information. Specification sheets can be viewed/downloaded at www.gradall.com*

Dimensions

XL3100V

Wheelbase.. 13.4 ft (4,1 m)

Ground Clearance ....10 in (254 mm)

Transport Length (without bucket) .... 23.3 ft (7,1 m)

Transport Height (without bucket) (4x2).. 11.1 ft (3,4 m)

Transport Height (without bucket) (4x4).. 11.5 ft (3,5 m)

Transport Width .... 8.6 ft (2,6 m)

XL4100V & XL4130V

Wheelbase.. 14.2 ft (4,3 m)

Ground Clearance ....10 in (254 mm)

Transport Length (without bucket) .... 25.1 ft (7,6 m)

Transport Height (without bucket) (6x4).. 10.11 ft (3,3 m)

Transport Height (without bucket) (6x6).. 11.3 ft (3,4 m)

Transport Width .... 8.6 ft (2,6 m)

XL5100V

Wheelbase ....14.3 ft (4,4 m)

Ground Clearance..10 in (254 mm)

Transport Length (without bucket) ....25.6 ft (7,8 m)

Transport Height (without bucket) (6x4) ....11.2 ft (3,4 m)

Transport Height (without bucket) (6x6) ....11.5 ft (3,5 m)

Transport Width ....8.6 ft (2,6 m)

Note: *Refer to detailed specification sheet for additional machine dimension information. Specification sheets can be viewed/downloaded at www.gradall.com*

7.2 TORQUE CHART

To check **Gradall** torque values, set the torque wrench at 95% of the rated torque values and check fastener. If the torque wrench releases before the fastener moves, assume fastener torque is correct. When setting **Gradall** torque values, use the values given on the following chart. DO NOT EXCEED allowances.

Boom Cylinder Rod Retainer

Quantity 6

Thread Size (grade) 5/8-11 (8)

Torque (lubricated) .... 200-215 lb-ft (272-292 Nm)

Swing Bearing

Quantity 72

Thread Size (grade) 5/8-11 (8)

Torque (lubricated) .... 200-215 lb-ft (272-292 Nm)

Swing Motor

Quantity 4

Thread Size (grade) 1/2-13 (5)

Torque (lubricated) .... 68-78 lb-ft (92-105 Nm)

Swing Transmission

Quantity 10

Thread Size (grade) 3/4-10 (8)

Torque (lubricated) .... 340-365 lb-ft (461-496 Nm)

Tilt Bearing

Quantity 63

Thread Size (grade) 3/4-10 (8)

Torque (lubricated) .... 340-365 lb-ft (461-496 Nm)

Tilt Motor

Quantity 2

Thread Size (grade) 1/2-13 (8)

Torque (lubricated) .... 68-78 lb-ft (92-105 Nm)

Tilt Transmission

Quantity .... 31 pints (14,7 liters)

Thread Size (grade) 80w90 (1440-3126)

Torque (lubricated) .... 200-215 lb-ft (272-292 Nm)

Wheel Lug Nuts

Quantity .... ALL

Thread Size (grade) 3/4-10 (8)

Torque (lubricated) .... 450-500 lb-ft (610-678 Nm)

Front Axle U-Bolt Nuts

Quantity .... ALL

Thread Size (grade) 3/4-10 (8)

Torque .... 300-310 lb-ft (406-420 Nm)

Undercarriage Cab Steering Wheel Retaining Nut

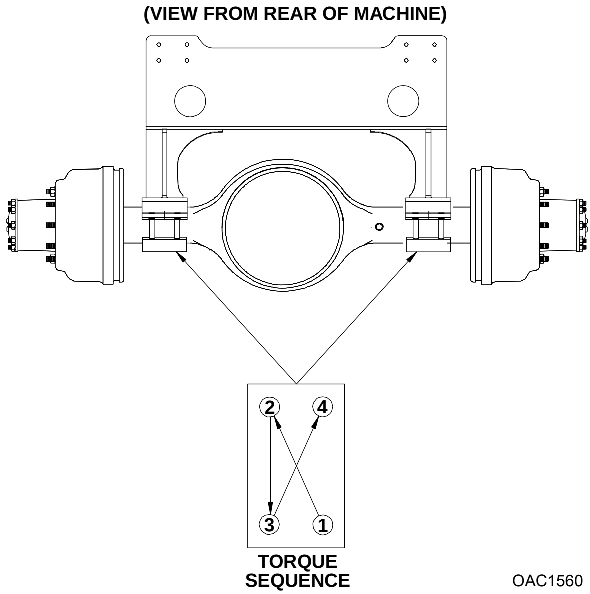
Quantity 1

Torque .... 40-45 lb-ft (54-61 Nm)

Rear Axle Mounting Bolts (XL3100V)

Quantity 8

Thread Size (grade).. 7/8-14 (8)



Torque bolts in a 4 stage, criss-cross pattern:

Torque (Stage 1).. 150-185 lb-ft (203-251 Nm)

Torque (Stage 2).. 280-315 lb-ft (380-427 Nm)

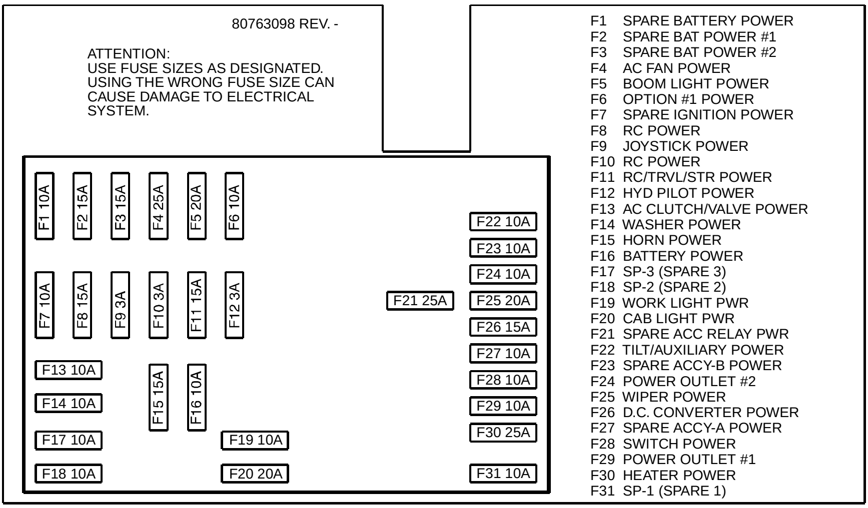
Torque (Stage 3).. 470-505 lb-ft (637-685 Nm)

Torque (Stage 4).. 560-595 lb-ft (759-807 Nm)

7.3 FUSES

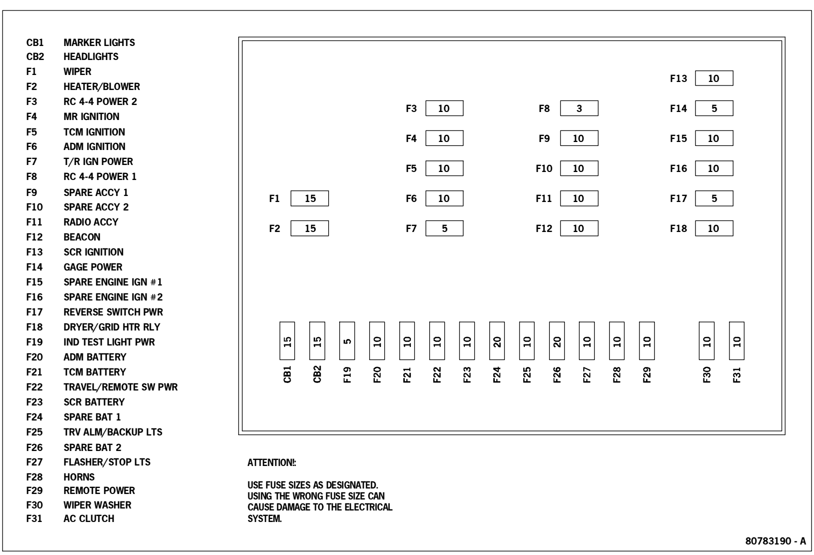
Fuse location and size designations are identified with the decals shown below.

Upperstructure



OAC1910

Undercarriage



OAC1920

This Page Intentionally Left Blank

Gradall Series V Highway Speed Excavator Pre-Operation Inspection Checklist

ID/Serial Number: ______________________ Shift: ________________________ Date: __________________

⚠WARNING **Before conducting the walk around inspection, make sure the engine is off and the transmission is in neutral with the park brake engaged. The boom and attachment must be resting on the ground, securely blocked, or retained in the transport position with all hydraulic pressure relieved.**

Item	•	Comments if not O.K.
Operator and Safety Manuals – located in each cab		
Warning Decals – in place and legible		
Chassis Cab Windows and Door – not broken and clean, door closes properly		
Chassis Cab Seat Belt – undamaged; working condition		
Front Axle – steering linkage - good condition; no cylinder or hose leaks		
Wheels – check lug nut torque; no damage or cracks		
Tires – proper inflation; no damage; adequate tread		
Air tanks – open petcocks to drain water; no damage; hoses in good condition		
Work lights – Clean and undamaged		
Upperstructure cab – windows not broken and clean, door latches in open and closed position		
Fuel/DEF Tank(s) – no leaks; filler cap securely fastened		
Mud Flaps – positioned for driving or digging operations		
Rear axle(s) – no axle leaks; axle bolts torqued		
Hydraulic Oil Reservoir – oil is clear and at proper level		
Boom Tilt Bearing – properly lubricated, undamaged		
Main control valve and cover – no damage or leaks; cover support gas strut and latch working properly		
Battery Box – cables tight; cover properly secured		

Item	•	Comments if not O.K.
Air Cleaner – check element condition indicator		
Engine – oil and coolant at proper level.		
Power Steering Fluid – at proper level		
Radiator – free of debris, no leaks		
Transmission – no leaks, undamaged		
Brakes – no damage; in good condition		
Grab Handles and Steps – secure and clean		
Horn – clean and undamaged		
Headlights, Marker Lights, and Turn Signals – clean and undamaged		
Boom – rollers adjusted, no damage; secure for driving		
Boom Attachment – securely installed		
Hydraulic Hoses – no leaks or damage		
Fuel/DEF Level(s) – adequate		
Windshield Washer Fluid – level adequate in each cab		
Mirrors – good condition, clean, and properly adjusted		
Maintenance – up to date with schedule in manual		
Lubrication – Reference lubrication chart in manual		
Overall Machine Condition – No cracks on boom, upperstructure frame, chassis frame, or fiberglass		

Comments:

DO NOT OPERATE UNSAFE EQUIPMENT

Repair any deficiencies before driving or operating the equipment

Operators Signature: ______________________________ **Date:** ____________

Gradall Series V Highway Speed Excavator Pre-Operation Inspection Checklist

ID/Serial Number: ______________________ Shift: ________________________ Date: __________________

WARNING **Before conducting the operational check of the excavator perform a walk around inspection. Do not operate the excavator until any discrepancies noted during the walk around inspection have been repaired. Make sure others are clear of the machine before starting the engine and during operation.**

Item (Chassis Operation)	•	**Comments if not O.K.**
Park Brake – functions properly		
Transmission – Neutral start switch functions properly		
Engine – operates properly		
Dash Lights, Indicators, and Gages – function properly		
Low Air Warning Buzzer – sounds with less than 60 PSI		
Air Pressure – reaches minimum of 100 PSI		
Service Brakes – functions properly		
Windshield Wiper – functions properly		
Steering – functions properly		
Backup Alarm – functions properly		
Horn – functions properly		
Head Lights, Marker Lights, Turn Signals – clean and function properly		

Item (Upperstructure Operation)	•	**Comments if not O.K.**
Control Cut Out Lever – engine only starts with the lever raised.		
Engine – operates properly		
Upperstructure Lights, Indicators, and Gages – function properly		
Control Cut Out Lever – controls do not operate while in the raised position.		
Control Pattern Decal – matches control pattern		
Boom Functions (Boom - Up, Down, In, Out, Tilt Left, Tilt Right, Bucket Open, Bucket Closed) – function properly		
Swing Function – swing left, right, and swing brake functions properly		
Swing Lights – function properly		
Dig Brakes – function properly		
Park Brake – functions properly		
Remote Steering – functions correctly		
Remote Travel – forward and reverse functions correctly		
Travel Alarm – functions properly		
Horn – functions properly		

Comments:

DO NOT OPERATE UNSAFE EQUIPMENT

Repair any deficiencies before driving or operating the equipment

Operators Signature: ________________________________ **Date:** ______________

Gradall Series V Highway Speed Excavator Pre-Operation Inspection Checklist

ID/Serial Number: ______________________ Shift: ________________________ Date: __________________

WARNING **Before conducting the walk around inspection, make sure the engine is off and the transmission is in neutral with the park brake engaged. The boom and attachment must be resting on the ground, securely blocked, or retained in the transport position with all hydraulic pressure relieved.**

Item	•	Comments if not O.K.
Operator and Safety Manuals – located in each cab		
Warning Decals – in place and legible		
Chassis Cab Windows and Door – not broken and clean, door closes properly		
Chassis Cab Seat Belt – undamaged; working condition		
Front Axle – steering linkage - good condition; no cylinder or hose leaks		
Wheels – check lug nut torque; no damage or cracks		
Tires – proper inflation; no damage; adequate tread		
Air tanks – open petcocks to drain water; no damage; hoses in good condition		
Work lights – Clean and undamaged		
Upperstructure cab – windows not broken and clean, door latches in open and closed position		
Fuel/DEF Tank(s) – no leaks; filler cap securely fastened		
Mud Flaps – positioned for driving or digging operations		
Rear axle(s) – no axle leaks; axle bolts torqued		
Hydraulic Oil Reservoir – oil is clear and at proper level		
Boom Tilt Bearing – properly lubricated, undamaged		
Main control valve and cover – no damage or leaks; cover support gas strut and latch working properly		
Battery Box – cables tight; cover properly secured		

Item	•	Comments if not O.K.
Air Cleaner – check element condition indicator		
Engine – oil and coolant at proper level.		
Power Steering Fluid – at proper level		
Radiator – free of debris, no leaks		
Transmission – no leaks, undamaged		
Brakes – no damage; in good condition		
Grab Handles and Steps – secure and clean		
Horn – clean and undamaged		
Headlights, Marker Lights, and Turn Signals – clean and undamaged		
Boom – rollers adjusted, no damage; secure for driving		
Boom Attachment – securely installed		
Hydraulic Hoses – no leaks or damage		
Fuel/DEF Level(s) – adequate		
Windshield Washer Fluid – level adequate in each cab		
Mirrors – good condition, clean, and properly adjusted		
Maintenance – up to date with schedule in manual		
Lubrication – Reference lubrication chart in manual		
Overall Machine Condition – No cracks on boom, upperstructure frame, chassis frame, or fiberglass		

Comments:

DO NOT OPERATE UNSAFE EQUIPMENT

Repair any deficiencies before driving or operating the equipment

Operators Signature: ______________________________ **Date:** ____________

Gradall Series V Highway Speed Excavator Pre-Operation Inspection Checklist

ID/Serial Number: ______________________ Shift: ______________________ Date: ____________________

WARNING **Before conducting the operational check of the excavator perform a walk around inspection. Do not operate the excavator until any discrepancies noted during the walk around inspection have been repaired. Make sure others are clear of the machine before starting the engine and during operation.**

Item (Chassis Operation)	•	**Comments if not O.K.**
Park Brake – functions properly		
Transmission – Neutral start switch functions properly		
Engine – operates properly		
Dash Lights, Indicators, and Gages – function properly		
Low Air Warning Buzzer – sounds with less than 60 PSI		
Air Pressure – reaches minimum of 100 PSI		
Service Brakes – functions properly		
Windshield Wiper – functions properly		
Steering – functions properly		
Backup Alarm – functions properly		
Horn – functions properly		
Head Lights, Marker Lights, Turn Signals – clean and function properly		

Item (Upperstructure Operation)	•	**Comments if not O.K.**
Control Cut Out Lever – engine only starts with the lever raised.		
Engine – operates properly		
Upperstructure Lights, Indicators, and Gages – function properly		
Control Cut Out Lever – controls do not operate while in the raised position.		
Control Pattern Decal – matches control pattern		
Boom Functions (Boom - Up, Down, In, Out, Tilt Left, Tilt Right, Bucket Open, Bucket Closed) – function properly		
Swing Function – swing left, right, and swing brake functions properly		
Swing Lights – function properly		
Dig Brakes – function properly		
Park Brake – functions properly		
Remote Steering – functions correctly		
Remote Travel – forward and reverse functions correctly		
Travel Alarm – functions properly		
Horn – functions properly		

Comments:

DO NOT OPERATE UNSAFE EQUIPMENT
Repair any deficiencies before driving or operating the equipment

Operators Signature: ______________________________ **Date:** ______________

A

B

C

D

E

F

G

H

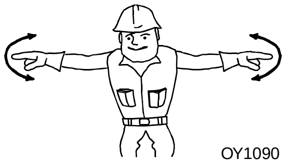
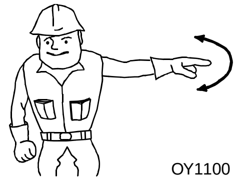
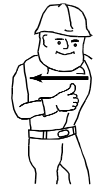
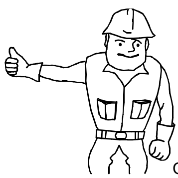
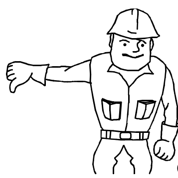
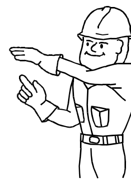
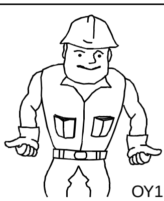
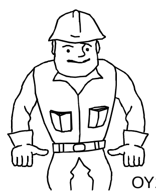
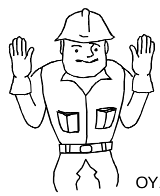
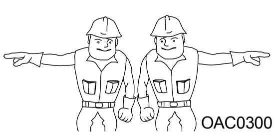
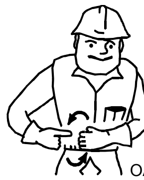
I

J

L

O

Hand Signals

 OY1090 EMERGENCY STOP - With both arms extended laterally, hands open downward, move arms back and forth.	 OY1100 STOP - With either arm extended laterally, hand open downward, move arm back and forth.	 OY1110 STOP ENGINE - Draw thumb or forefinger across throat.
 OY1120 RAISE BOOM - With either arm extended horizontally, fingers closed, point thumb upward.	 OY1130 LOWER BOOM - With either arm extended horizontally, fingers closed, point thumb downward.	 OY1140 MOVE SLOWLY - Place one hand motionless in front of hand giving motion signal. (Raise load slowly shown)
 OY1150 EXTEND BOOM - With both hands clenched, point thumbs outward.	 OY1160 RETRACT BOOM - With both hands clenched, point thumbs inward.	 OY1170 THIS FAR TO GO - With hands raised and open inward, move hands laterally, indicating distance to go.
 OAC0300 SWING- With either arm extended horizontally, point with forefinger to direction of swing rotation.	 OAC0310 OPEN BUCKET- Hold one hand open and stationary. Rotate other hand in small vertical circle with forefinger pointing horizontally at open hand.	 OAC0320 CLOSE BUCKET- Hold one hand closed and stationary. Rotate other hand in small vertical circle with forefinger pointing horizontally at closed hand.

Special Signals - When signals for auxiliary equipment functions or conditions not covered are required, they shall be agreed upon in advance by the operator and signalman.

Gradall Industries, Inc.
406 Mill Ave SW
New Philadelphia OH. 44663
USA
Phone: (330) 339-2211
Customer Support Toll Free: (800) 445-4752
Fax: (330) 339-3579
www.gradall.com

Gradall Europe
Division of Tieluiska
Harkkokatu 6
FI-05800 Hyvinkää, Finland
Tel. +358 (0)20 759 0400
Fax. +358 (0)19 485 278
VAT:FI05973039
www.gradalleurope.com

Electric Drives and Controls | Hydraulics | Linear Motion and Assembly Technologies | Pneumatics | Service

Rexroth
Bosch Group

Verstellpumpe A11VO/A11VLO
Variable Pump A11VO/A11VLO

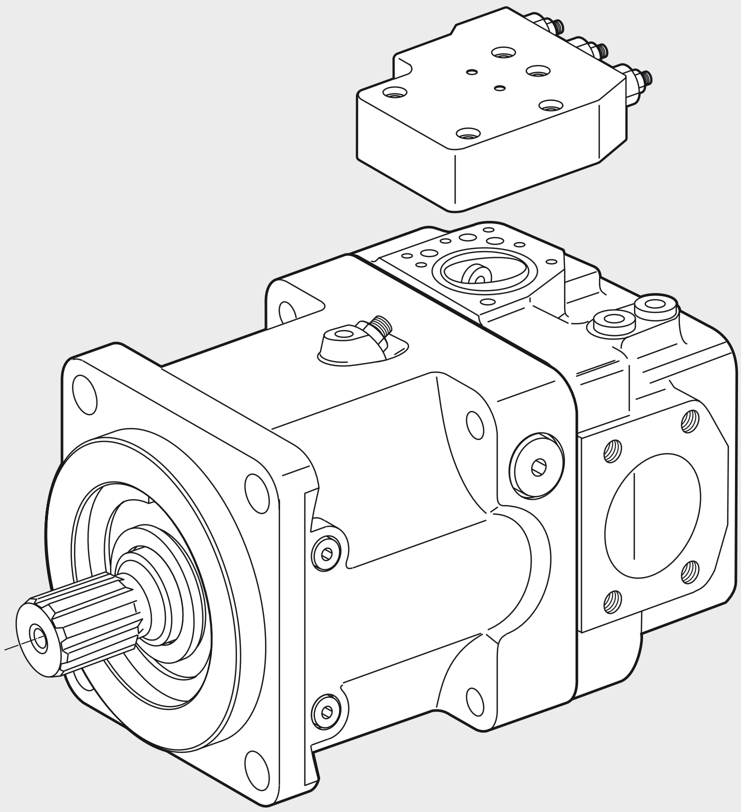
Baureihe / Series 11

NG / Size 190 – 260

RDE 92500-21-R/07.07

R1

Reparaturanleitung / Repair Manual
Baugruppen / Assembly Groups



Vermeidung von Gefahren

Für einen sicheren Betrieb und um Schäden bei der Reparatur zu vermeiden, lesen Sie diese Reparaturanleitung sorgfältig und aufmerksam durch!

Für Personen- oder Maschinenschäden, die durch Nichtbeachtung dieser Reparaturanleitung entstehen, verfällt jegliche Gewährleistung der Bosch Rexroth AG.

Avoiding Dangers

To ensure safe operations and avoid damages during repairs, read this repair manual carefully and attentively.

Bosch Rexroth AG accepts no responsibility for personal injuries or damages to the machine that arise from disregarding this repair manual.

1 Zu dieser Anleitung

Diese Anleitung unterstützt Sie bei der Reparatur und der Wiederinbetriebnahme von Rexroth A11VO/A11VLO Verstellpumpen Diese Anleitung umfasst die folgenden Kapitel:

- „Sicherheit“ auf Seite 7

  Hier erhalten Sie grundsätzliche Hinweise zum sicheren Umgang mit Verstellpumpen und zu deren Betrieb.

  Lesen Sie dieses Kapitel, bevor Sie anfangen zu arbeiten.
- „Produktbeschreibung“ auf Seite 11

  Hier erfahren Sie, wie Sie den Typ einer Verstellpumpe feststellen. Ferner finden Sie hier eine Übersicht über die Funktionsweise und Informationen zur bestimmungsgemäßen Verwendung der Pumpe

  Lesen Sie dieses Kapitel, um Ihr Grundwissen über Verstellpumpen aufzufrischen.
- „Austausch von Baugruppen“ auf Seite 15

  Rexroth stellt verschieden Reparatursätze zur Verfügung. Dieses Kapitel erklärt Ihnen, wie Sie Dichtungen und Baugruppen einer Verstellpumpe austauschen.
- „Funktionsprüfungen“ auf Seite 25

  Hier erfahren Sie, wie Sie die Funktion einer Rexroth A11V(L)O Verstellpumpe mit LRDS-Regler überprüfen können.

1 About this Manual

This manual supports you in the repair, adjustment and recommissioning of Rexroth A11VO/A11VLO variable pumps. The manual is structured as follows:

- “Safety” on page 7

  This chapter provides you with basic hints and tips regarding working with and operating variable pumps.

  Read this chapter before you start working.
- “Product Description” on page 11

  This chapter explains how you identify the fvariable pump. Additionally, it provides you an overview about how the variable pump works and information regarding the correct usage.

  Read this chapter to refresh your knowledge of the variable pumps.
- “Exchanging Subassemblies” on page 15

  Rexroth provides various replacement parts for repairs. This section explains, how you exchange seals and components of a variable pump.
- “Functional Checks” on page 25

  This chapter explains how you check the proper function of a Rexroth A11V(L)O variable pump with LRDS regulator.

1.1 Inhalt

1.1 Content

1.2 Gültigkeitsbereich dieser Anleitung

Diese Reparaturanleitung gilt für die Verstellpumpen A11VO/A11VLO der Bosch Rexroth AG. Informationen zu zugelassenen Druckflüssigkeiten entnehmen Sie den Angaben des Anlagenherstellers.

Diese Reparaturanleitung richtet sich an folgende Zielgruppen:

- Anlagenbetreiber
- autorisierte Fachbetriebe bzw. Händler
- Anlagenhersteller

  Für den Anlagenhersteller sind zusätzlich auch die jeweilige Einbauzeichnung, das technische Datenblatt, die Betriebsanleitung und die Auftragsbestätigung der Bosch Rexroth AG verbindlich.

1.2 Validity of this Manual

This manual is valid for the Bosch Rexroth variable pumps A11VO/A11VLO. Refer to the system manufacturer for information about the allowed hydraulic fluids.

This repair manual is directed at:

- the system operator
- authorized dealers
- the system manufacturer

  For the system manufacturer, the installation drawing, the catalog sheet, the manual, and the confirmation of order from the Bosch Rexroth AG are also obligatory.

1.3 Wichtige Unterlagen

Bevor Sie mit den in dieser Anleitung beschriebenen Arbeiten anfangen, stellen Sie sicher, dass Sie folgende Unterlagen griffbereit haben:

- **Auftragsbestätigung**

  Die Auftragsbestätigung enthält die voreingestellten technischen Daten. Die Verstellpumpe darf nur unter den in der Auftragsbestätigung angegebenen Werten und Bedingungen betrieben werden.
- **Einbauzeichnung**

  Die Einbauzeichnung der Verstellpumpe enthält die Außenabmessungen, sämtliche Anschlüsse und den Schaltplan.
- **Technisches Datenblatt**

  Die technischen Datenblätter RD 92500 enthalten u. a. die zulässigen technischen Daten für die Verstellpumpen.
- **Gesamtschaltplan der Maschine bzw. Anlage**

  Der Hydraulikschaltplan und der elektrische Schaltplan der Maschine bzw. Anlage enthalten die Informationen zu den hydraulischen bzw. elektrischen Anschlüssen. Diese Daten brauchen Sie, um mit der Verstellpumpe als Teil der Maschine bzw. Anlage zu arbeiten. Die Unterlagen erhalten Sie vom Maschinen- bzw. Anlagenhersteller.
- **RD 90300-B: Allgemeine Betriebsanleitung für Verstellpumpen**

  Die allgemeine Betriebsanleitung unterstützt Sie bei Installation, Inbetriebnahme und Betrieb von Rexroth-Verstellpumpen.
- **Produktspezifische Betriebsanleitung**

  Die produktspezifische Betriebsanleitung enthält spezielle, für die Verstellpumpe gültige Informationen. Informieren Sie sich bei Rexroth, ob es zu Ihrer Verstellpumpe eine produktspezifische Betriebsanleitung gibt.

Folgende Rexroth-Druckschriften geben Ihnen weitere Informationen zu Installation und Betrieb der Verstellpumpe:

- **RD 90220: Druckflüssigkeiten auf Mineralölbasis**

  Diese Druckschrift beschreibt die Anforderungen an eine Druckflüssigkeit auf Mineralölbasis für den Betrieb in Rexroth-Verstellpumpen und unterstützt Sie bei der Wahl einer Druckflüssigkeit für Ihre Anlage.
- **RD 90221: Umweltfreundliche Druckflüssigkeiten HEES, HEPG, HETG für Verstellpumpen**

  Diese Druckschrift beschreibt die Anforderungen an eine umweltfreundliche Druckflüssigkeit für den Betrieb mit Rexroth-Verstellpumpen und unterstützt Sie bei der Wahl einer Druckflüssigkeit für Ihre Anlage.
- **RD 90223: Verstellpumpen für den Betrieb mit HF-Druckflüssigkeiten**

  Diese Druckschrift enthält zusätzliche Informationen zum Einsatz von Rexroth-Verstellpumpen mit HF-Druckflüssigkeiten.
- **RD 90300-03-B: Hinweise zum Einsatz von hydraulischen Antrieben bei tiefen Temperaturen**

  Diese Druckschrift enthält zusätzliche Informationen zum Einsatz von Rexroth-Verstellpumpen bei tiefen Temperaturen.

1.3 Important Documents

Before you start any of the procedures described in this manual, make sure you have the following documents ready to hand:

- **Confirmation of Order**

  The confirmation of order contains the values set during the commissioning by Rexroth. The variable pump may only be operated with the values and conditions specified in the confirmation of order.
- **Installation Drawing**

  The installation drawing of the variable pump contains the sizes, all connections and the wiring diagram.
- **Technical Data Sheet**

  The technical data sheets RE 92500 contain the maximum allowed technical data for the variable pumps and further information.
- **Hydraulic Diagram / Wiring Diagram**

  The hydraulic diagram and the wiring diagram of the unit or system contain the information related to the hydraulic or electric connections. You need this data to work with the axial piston as part of the unit or system. You can get this information from the unit or system manufacturer.
- **RE 90300-B: General Manual for Variable Pumps**

  The general manual supports you during the installation, initiation, and operation of Rexroth variable pumps.
- **Product Specific Manual**

  The product-specific manual contains specific information designed for the variable pump. Get in touch with Rexroth to find out if there is any product-specific information on your variable pump.

The following Rexroth publications provide additional information to the installation and operation of variable pumps:

- **RE 90220: Mineral-oil Based Pressure Fluids**

  This publication describes the requirements on a hydraulic fluid based on mineral oil for operation in an variable pump and supports you in the selection of a hydraulic fluid for your system.
- **RE 90221: Environmentally Acceptable Hydraulic Fluids HEES, HEPG, HETG for Variable Pumps**

  This publication describes the demands on environmentally compatible, readily biodegradeable hydraulic fluids HETG, HEPG, HEES that can be used in Rexroth variable pumps and supports you by the selection of a hydraulic fluid for your system.
- **RE 90223: Variable Pumps for Use with HF Fluids**

  This publication provides additional information for the use of Rexroth variable pumps with HF hydraulic fluids.
- **RE 90300-03-B: Instructions on the Use of Hydrostatic Drives at Low Temperatures**

  This publication provides additional information for the use of Rexroth variable pumps at low temperatures.

1.4 Gefahrenkennzeichnungen und Piktogramme

Diese Anleitung unterscheidet zwischen Kategorien von Gefahren gemäß ISO Guide 37:

⚠ GEFAHR

Weist auf hohes Risiko und die Gefahr von Tod oder schweren Verletzungen hin.

⚠ WARNUNG

Weist auf mittleres Risiko und die Gefahr von Verletzungen und schweren Sachschäden hin.

⚠ VORSICHT

Weist auf geringes Risiko und Sachschäden hin.

Hinweis

Kennzeichnet Informationen, die zum besseren Verständnis der Maschinenabläufe beitragen oder weist auf einen besonderen bzw. wichtigen Sachverhalt hin.

Tipp

Kennzeichnet Informationen, die zum effizienteren Arbeiten beitragen.

1.4 Danger Labels and Pictograms

This manual differentiates between the following categories of hazards, according to ISO Guide 37:

⚠ DANGER

Indicates high risk, mortal danger and serious injuries.

⚠ WARNING

Indicates middle risk, injuries or serious material damage.

⚠ CAUTION

Indicates low risk or material damage.

Note

Indicates information that contributes to a better understanding of the machine processes or indicates important information.

Tip

Indicates information that contributes to more efficient work.

2 Sicherheit

Lesen Sie dieses Kapitel sorgfältig durch, bevor Sie mit Arbeiten an der Verstellpumpe beginnen.

Die Rexroth-Verstellpumpen sind im Sinne der Maschinenrichtlinie 98/37/EG Komponenten, die zum Einbau in eine Anlage bestimmt sind. Die Sicherheitsrichtlinien in dieser Anleitung beziehen sich nur auf die Verstellpumpe. Beachten Sie zusätzlich die Sicherheitsrichtlinien des Anlagenherstellers.

Informieren Sie sich an Hand der allgemeinen Betriebsanleitung für Verstellpumpen über die bestimmungsgemäße Verwendung und die Sorgfaltspflicht des Betreibers und Bedieners.

2.1 Grundlegende Sicherheitshinweise

Befolgen Sie die folgenden Sicherheitshinweise und die des Anlagenherstellers genau, um Verletzungen und Gesundheitsschäden sowie Sach- und Umweltschäden auszuschließen.

⚠ GEFAHR

Lebensgefahr

Das Arbeiten an nicht stillgelegten Maschinen bzw. Anlagen stellt eine Gefahr für Leib und Leben dar.

Die in diesem Dokument beschriebenen Arbeiten dürfen nur an **stillgelegten Maschinen bzw. Anlagen** vorgenommen werden. Bevor Sie mit den Arbeiten beginnen:

- Stellen Sie sicher, dass der Antriebsmotor nicht eingeschaltet werden kann.
- Stellen Sie sicher, dass sämtliche kraftübertragenden Komponenten und Anschlüsse (elektrisch, pneumatisch, hydraulisch) gemäß den Herstellerangaben ausgeschaltet sind und nicht eingeschaltet werden können. Falls möglich, entfernen Sie die Hauptsicherung der Maschine bzw. Anlage.
- Stellen Sie sicher, dass die Maschine bzw. Anlage komplett hydraulisch entlastet ist (drucklos). Folgen Sie hierzu den Angaben des Maschinen- bzw. Anlagenherstellers.

⚠ WARNUNG

Verletzungsgefahr

Um Verletzungen zu vermeiden, beachten Sie bitte folgende Empfehlungen betreffend **Sicherheitskleidung**:

- Tragen Sie bei Arbeiten an Maschine bzw. Anlage Sicherheitsschuhe mit Stahlkappen.
- Tragen Sie bei Arbeiten mit gefährlichen Stoffen (beispielsweise Druckflüssigkeiten) Schutzhandschuhe und Schutzbrille.

2 Safety

Read through this chapter carefully before you start any work on the variable pump.

The Rexroth variable pumps are in the sense of the machine guideline 98/37/EG components of a system. The safety guidelines in this manual only cover the variable pump. You must additionally follow the system manufacturer's safety guidelines.

Read the general manual for variable pump units to get more information on the designated use and the operator's obligation to exercise diligence.

2.1 Basic Safety Information

Pay attention to the following safety information and that of the system manufacturer to eliminate injuries and health damages as well as damages to material or the environment.

⚠ DANGER

Danger to life

Working on systems that have not been shut down completely is life-threatening.

The work described in this document must only be carried out on a **shut down system**. Before you start any of the tasks:

- Make sure that the motor cannot be switched on.
- Make sure that all components and connections that carry energy (electrical, pneumatic, hydraulic) have been shut down according to the manufacturer's instructions and cannot be switched on. If possible, remove the main fuse.
- Make sure that the system is completely unpressurized. Follow the instructions of the system manufacturer.

⚠ WARNING

Danger of injury

To avoid injuries, pay attention to the following recommendations regarding **safety clothing**:

- When working on the system, wear steel-toed safety shoes.
- When working with dangerous substances (for example, certain hydraulic fluids), wear protective gloves and protective glasses.

⚠ GEFAHR

Vergiftungs- und Verletzungsgefahr

Der Kontakt mit Druckflüssigkeiten ruft Gesundheitsschäden hervor (z.B. Augenverletzungen, Haut- und Gewebeschädigungen, Vergiftungen beim Einatmen).

- Überprüfen Sie vor jeder Inbetriebnahme die Leitungen auf Verschleiß bzw. Beschädigungen.
- Tragen Sie dabei Schutzhandschuhe und Schutzbrille.
- Wenn dennoch Druckflüssigkeit in die Augen gelangt oder in die Haut eindringt, konsultieren Sie unmittelbar einen Arzt.
- Beachten Sie beim Umgang mit Druckflüssigkeiten unbedingt die Sicherheitsangaben des Druckflüssigkeitsherstellers.

⚠ DANGER

Danger of poisoning or injury

Contact with hydraulic fluids can cause health damage (e. g. eye injuries, skin and tissue damage, poisoning due to inhalation).

- Always check the hydraulic lines for wear and damage prior to putting the unit into operation.
- When checking the lines, wear protective gloves and safety glasses.
- Should pressure fluid come into contact with your eyes or skin: Get medical help immediately!
- When handling hydraulic fluids, pay attention to the hydraulic fluid manufacturer's safety instructions.

⚠ WARNUNG

Verbrennungsgefahr

Die Verstellpumpe erwärmt sich während des Betriebs. Auch die Magnete an der Verstellpumpe werden im laufenden Betrieb heiß. Finger und Hände können bei Berührung der Verstellpumpe oder der Magnete schwere Brandverletzungen erleiden.

- Lassen Sie die Verstellpumpe vor jedem Kontakt abkühlen.
- Schützen Sie sich mit hitzebeständigen Handschuhen und Schutzkleidung.

⚠ WARNING

Danger of burns

The variable pump heats up during operation. The unit's solenoids get hot during operation. Fingers and hands can be badly burned when touching the variable pump or solenoids.

- Let the variable pump cool down prior to any contact.
- Protect yourself from burns by wearing safety gloves and protective clothing.

⚠ GEFAHR

Vergiftungs- und Verletzungsgefahr

Beim Suchen nach Leckstellen kann entweichende Druckflüssigkeit in die Haut eindringen und schwerste Vergiftungen und Verletzungen hervorrufen.

- Suchen Sie nur bei abgestellter und druckloser Maschine nach Leckstellen.

⚠ DANGER

Danger of poisoning and injuries

When looking for leaks, escaping hydraulic fluid can break into the skin and cause serious poisoning and injuries.

- Look only for leaks, if the variable pump unit is shut down and unpressurized.

⚠ WARNUNG

Verletzungs- und Beschädigungsgefahr

Durch falsch angeschlossene Komponenten können erhebliche Fehlfunktionen entstehen.

- Achten Sie auf korrekte Verrohrung gemäß Schaltplan.
- Führen Sie komponentenorientierte Funktionstests durch.

⚠ WARNING

Danger of injuries or damage

Incorrectly connected components can considerably impair the functionality of a hydraulic system.

- Make sure that the hydraulic lines are connected properly according to the wiring diagram.
- Check the correct functioning of all components.

⚠ GEFAHR

Feuergefahr

Hydraulische Druckflüssigkeit ist brennbar.

- Halten Sie offenes Feuer und Zündquellen von der Verstellpumpe fern.

⚠ DANGER

Danger of fire

Hydraulic fluid is inflammable.

- Keep open fires and ignition sources away from the variable pump.

⚠ WARNUNG

Gehörschäden

Die Geräuschemission von Verstellpumpen ist u.a. von Drehzahl, Betriebsdruck und Einbauverhältnissen abhängig. Es ist damit zu rechnen, dass der Schalldruckpegel bei normalen Einsatzbedingungen über 70 dBA steigt. Dies kann zu Gehörschäden führen.

- Schützen Sie sich stets mit Gehörschutz bei Arbeiten in der Nähe der Verstellpumpe während des laufenden Betriebs.

⚠ WARNING

Danger of hearing damage

The noise emission produced by variable pump units depends on speed, operating pressure, and installation. During normal application conditions, over 70 dBA can be anticipated. This can lead to hearing damage.

- Always wear hearing protection when working in the vicinity of the variable pump during operation.

⚠ WARNUNG

Umweltschäden

Druckflüssigkeiten sind wassergefährdende Flüssigkeiten.
Das Austreten von Druckflüssigkeiten kann zu Grundwasservergiftung und Bodenverseuchung führen.

- Bringen Sie unter der Verstellpumpe eine Auffangwanne an.
- Beseitigen Sie Leckstellen unverzüglich.
- Es sind stets die nationalen Gesetze und Vorschriften zu beachten. In Deutschland sind hydraulische Maschinen bzw. Anlagen „Anlagen zum Umgang mit wassergefährdenden Stoffen im Sinne des Wasserhaushaltsgesetzes (WHG)“. Beachten Sie in diesem Zusammenhang besonders §1 und §19 WHG (§19g, 19i, 19l).
- Weitere Informationen finden Sie in den Rexroth-Druckschriften „Druckflüssigkeiten auf Mineralölbasis“, RD 90 220, „Umweltschonende, biologisch schnell abbaubare Druckflüssigkeiten HEPG, HEES für Axialkolbenmaschinen“, RD 90 221-1 und „Axialkolbenmaschinen für den Betrieb mit HF-Druckflüssigkeiten, RD 90 223.

⚠ WARNING

Risk of damage to the environment

Hydraulic fluid is hazardous to waters.
Hydraulic fluid leakage leads to contamination of the ground and ground water.

- A basin for catching any hydraulic fluid must be placed under the variable pump.
- Leaks must be cleaned up immediately.
- Pay always attention to any national regulations and norms. In Europe, hydraulic systems are considered “Systems using water-threatening substances” in the sense of the Water Management Law (WHG).Therefore, pay special attention to §1 and §19 WHG (§19g, 19i, 19l).
- Further information is available in the Rexroth publications „Mineral-oil based hydraulic fluids“, RE 90 220. „Environmentally acceptable, rapid biologically degradable hydraulic fluids HEPG, HEES for axial piston units“, RE 90 221-1 and „Axial piston units for operation with HF hydraulic fluids, RE 90 223.

2.2 Anforderungen an das Personal

Diese Reparaturanleitung richtet sich an **Fachkräfte mit Hydraulik-Fachwissen**, die an einer Service-Schulung bei Rexroth teilgenommen haben.

Als **Fachkraft** gilt, wer aufgrund seiner fachlichen Ausbildung und Erfahrung ausreichende Kenntnisse hat, sowie mit den einschlägigen Bestimmungen so weit vertraut ist, dass er

- die ihm übertragenenen Arbeiten beurteilen kann,
- mögliche Gefahren erkennen kann,
- die notwendigen Maßnahmen zur Beseitigung von Gefahren ergreifen kann,
- Kenntnisse über die möglichen Gesundheitsgefahren von Druckflüssigkeiten hat
- und die erforderlichen Reparatur- und Montagekenntnisse hat.

Hydraulik-Fachwissen bedeutet, das Personal muss

- in der Lage sein, die Hydraulikpläne zu lesen und vollständig zu verstehen,
- insbesondere die Zusammenhänge bezüglich der eingebauten Sicherheitseinrichtungen vollständig verstehen
- und Kenntnisse über Funktion und Aufbau von hydraulischen Bauteilen haben.

2.2 Requirements on the Personnel

This repair manual is directed at **qualified personnel with specialized hydraulics know-how** who have taken part at a service training at Rexroth.

Qualified personnel is defined as persons who have sufficient knowledge on the basis of specialized training and experience, and are familiar with the relevant regulations, so that they are able to

- judge the delegated tasks,
- recognize possible dangers,
- take the necessary measures for the elimination of dangers,
- know the possible health risks from hydraulic fluids,
- and have the required repair and installation know-how.

Specialized hydraulics know-how means that the personnel must:

- be able to read and completely understand hydraulic plans
- especially understand completely the coherences regarding the installed safety equipment
- be familiar with the function and structure of hydraulic components.

3 Produktbeschreibung

Dieses Kapitel gibt Ihnen einen allgemeinen Überblick über die Funktionalität der Rexroth A11VO/A11VLO Verstellpumpen.

Machen Sie sich mit den Inhalten dieses Kapitels vertraut, bevor Sie mit Arbeiten an einer Verstellpumpe beginnen.

3.1 Typschild

Die Verstellpumpe ist am Typschild zu identifizieren (Beispiel):

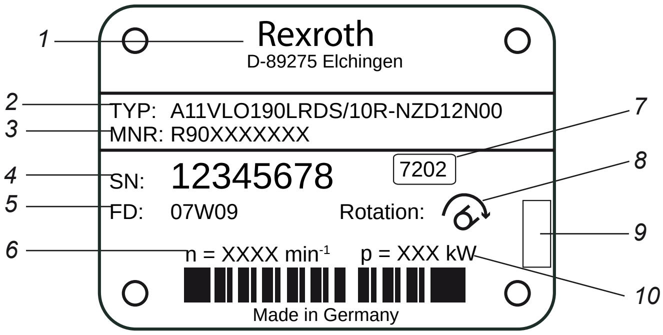
3 Product Description

This chapter provides a general overview of the functionality of the A11VO/A11VLO variable displacement pumps.

You should be familiar with the contents of this chapter before starting any work on the variable displacement pump.

3.1 Name Plate

The variable displacement pump can be identified on its type plate (example):



Folgende Informationen finden Sie auf dem Typschild:

1 Hersteller
2 Typschlüssel
3 Materialnummer der Axialkolbenmaschine
4 Seriennummer
5 Fertigungsdatum
6 Drehzahl
7 interne Werksbezeichnung
8 Drehrichtung (bei Blick auf die Welle; hier: im Uhrzeigersinn)
9 Vorgesehener Platz für Prüfstempel
10 Leistung

Stellen Sie sicher, dass Typ und Nenngröße der zu reparierenden Verstellpumpe mit dieser Anleitung übereinstimmen.

The following information can be found on the type plate:

1 Manufacturer
2 Ordering code
3 Material number of the axial piston unit
4 Serial number
5 Date of manufacturing
6 Speed
7 Internal manufacturing code
8 Direction of rotation (when facing the shaft; here: clockwise)
9 Designated space for certification stamp
10 Power

Ensure that the variable displacement pump to be repaired is of the type and size covered by this manual.

3.2 Funktionsbeschreibung

Damit Sie in der Lage sind, Probleme an der Verstellpumpe zu identifizieren und gezielt Reparaturen durchzuführen, sind Kenntnisse der Funktionsweise und des Aufbaus erforderlich. Dieser Abschnitt gibt Ihnen eine grobe Übersicht.

Die A11VO/A11VLO Verstellpumpen sind Axialkolben-Verstellpumpe in Schrägscheibenbauart für hydrostatische Antriebe im offenen Kreislauf. Der Volumenstrom ist proportional zu der Antriebsdrehzahl und dem Verdrängungsvolumen. Durch die Verstellung der Schrägscheibe ist eine stufenlose Volumenstromänderung möglich.

A11VLO Pumpen haben einen eingebauten Impeller (Ladepumpe). Das ist eine Kreiselpumpe, die es erlaubt, die Pumpen mit höheren Drehzahlen zu betreiben.

3.2 Functional Description

To make sure that you are able to identify problems with a variable displacement pump and to carry out specific repairs, familiarity with how the unit functions and its assembly are required. This section provides you with a rough overview.

The variable displacement axial piston pumps type A11VO/A11VLO in swashplate design are designed for open circuit hydrostatic drives. The flow is proportional to the input drive speed and displacement. By adjusting the swashplate, it is possible to infinitely vary the flow.

A11VLO pumps have a built-in impeller. This is a turbo pump that makes it possible to increase the rotational speed for driving the pumps.

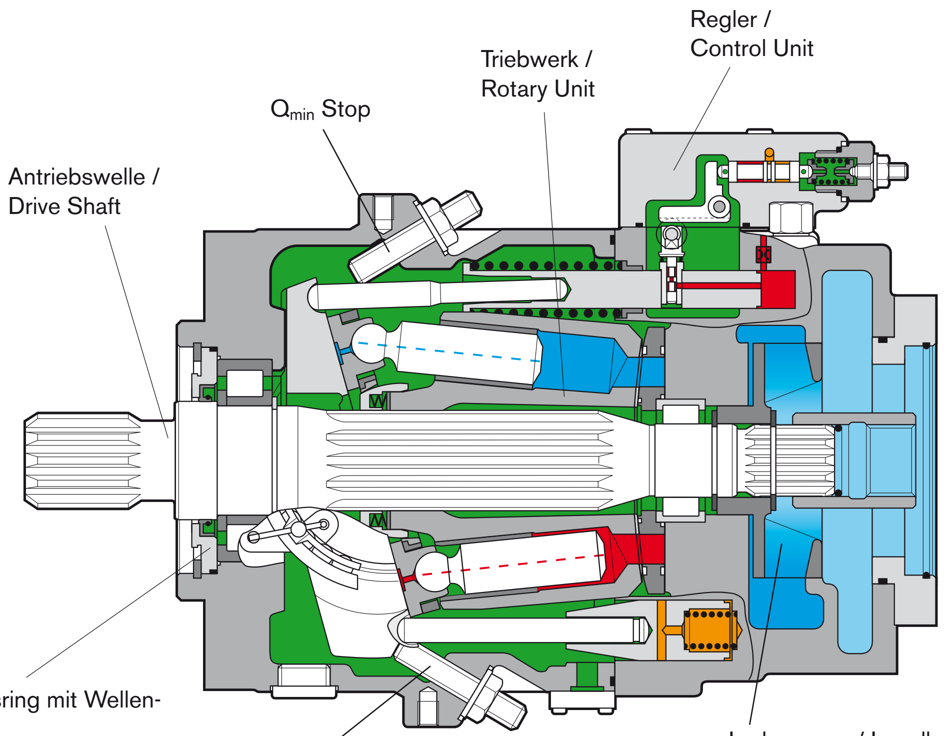
Schnittzeichnungen

Die folgenden Schnittzeichnungen zeigen den Aufbau der A11VO/A11VLO Verstellpumpe.

Sectional Drawings

The following drawings show the design of the A11VO/A11VLO variable displacement pump.

A11VLO 190, 260 LRDS

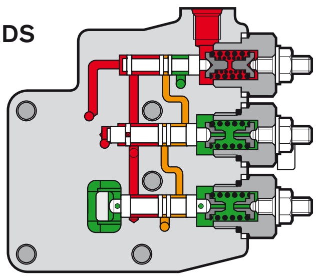


Q_{min} Stop / Q_{max} Stop: Anschlag für minimalen/maximalen Schwenkwinkel.

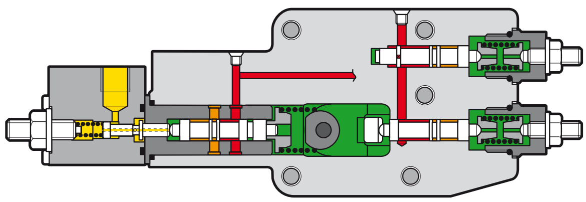
Q_{min} Stop / Q_{max} Stop: Stop for minimum/maximum swivel angle.

Reglerbeispiele / Control Unit Examples

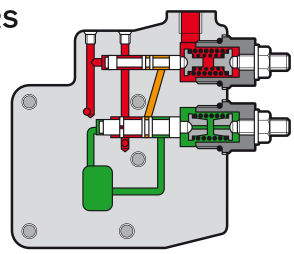
LRDS



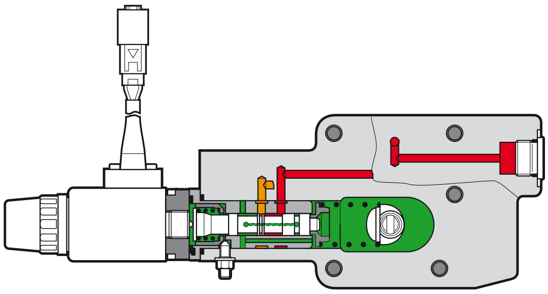
LRDH



DRS



EP



LR:	Leistungsregler	Power Control
D, DR:	Druckregler	Pressure Control
S:	Load-Sensing	Load-Sensing Control
EP:	Elektrische Verstellung	Electrical Control
HD:	Hydraulische Verstellung	Hydraulic Control

3.3 Technische Daten

Die technischen Daten der Verstellpumpe finden Sie in der Auftragbestätigung. Ergänzend dazu ist das jeweilige technische Datenblatt. Für die A11VO/A11VLO Verstellpumpe gilt das technische Datenblatt RD 92500.

3.3 Technical Data

You can find the technical data for the variable displacement pump in the Confirmation of Order. This is supplemented by the unit's data sheet. For the A11VO/A11VLO variable displacement pump, the valid data sheet is RE 92500.

4 Austausch externer Baugruppen

Dieses Kapitel beschreibt den Austausch von Baugruppen und Dichtungen der Verstellpumpen A11VO/A11VLO.

Der Austausch von Dichtungen folgender Baugruppen wird beschrieben:

- Triebwelle
- Regler
- Dichtmuttern

⚠ WARNUNG

Gefahr von Verschleiß und Funktionsstörungen

Die Sauberkeit der Druckflüssigkeit und die Lebensdauer der Hydraulikanlage stehen in unmittelbarem Zusammenhang. Verschmutzung der Druckflüssigkeit führt zu Verschleiß und Funktionsstörungen. Insbesondere harte Fremdkörper in den Hydraulikleitungen, wie z.B. Schweißperlen und Metallspäne, beschädigen die Axialkolbenmaschine.

Beachten Sie daher unbedingt folgende Hinweise:

- Achten Sie auf äußerste Sauberkeit. Die Axialkolbenmaschine muss schmutzfrei eingebaut werden. Verunreinigungen in der Druckflüssigkeit können die Funktion und Lebensdauer der Axialkolbenmaschine erheblich beeinträchtigen.
- Achten Sie besonders bei der Installation darauf, dass Anschlüsse, Hydraulikleitungen und Anbauteile (z.B. Messgeräte) sauber sind. Reinigen Sie diese gründlich, bevor Sie Anschlüsse öffnen. Stellen Sie sicher, dass auch beim nachfolgenden Verschließen der Anschlüsse keine Verunreinigungen eindringen.
- Verwenden Sie für die Beseitigung von Schmiermitteln und anderen starken Verschmutzungen geeignete flüssige Reinigungsmittel. Es darf kein Reinigungsmittel in das Hydrauliksystem eindringen.
- Verwenden Sie zur Reinigung keine Putzwolle oder fasernde Putzlappen.
- Verwenden Sie als Dichtungsmittel keinesfalls Hanf oder Kitt.

4 Exchanging External Assembly Groups

This chapter describes the replacement of the externally accessible assembly groups and sealings of the variable pumps A11VO/A11VLO.

The exchange of sealings of the following assembly groups is described:

- Drive shaft
- Control unit
- Seal Locks

⚠ WARNING

Danger of wear and malfunction

The durability of the hydraulic unit depends to a great extent on how clean the unit is kept. Dirt in the hydraulic fluid can lead to malfunctions. Especially hard foreign matter in the hydraulic lines, for example, welding beads and metal cuttings, will definitely damage the axial piston unit.

Therefore you should observe the following instructions:

- Make sure everything is kept extremely clean. The axial piston unit must be installed in a dirt-free environment. Contamination of the hydraulic fluid can lead to considerable wear and malfunctions of the axial piston unit.
- Especially during the installation, you should make sure that ports, hydraulic conduits, and mounting components (for example, gauges) are clean. Clean these thoroughly before you open connections. After that, when sealing the ports, make sure that contaminating elements cannot enter the system.
- When removing grease and other dirt you should use appropriate liquid cleaning agents. Cleaning agents must not enter the hydraulic system.
- Do not use cotton waste or rags which lose threads.
- Never use hemp or putty as a sealant.

4.1 Triebwelle abdichten

Dieser Abschnitt erklärt, wie Sie die Triebwelle abdichten.

Benötigtes Sonderwerkzeug:

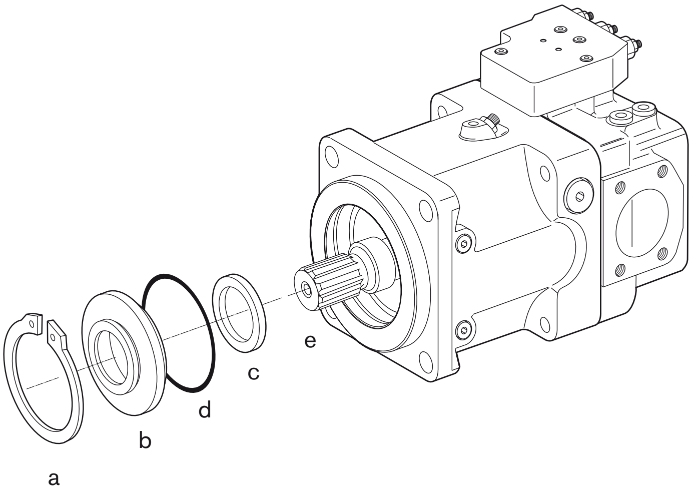
- Montagebüchse
  Die Materialnummern sind je nach Pumpenmodell verschieden:
  A11VO/A11VLO
  – NG 190: Mat. Nr. R90450647
  – NG 260: Mat. Nr. R90450941

4.1 Sealing the Drive Shaft

This section explains how you seal the drive shaft.

Required Special Tools:

- Mounting sleeve
  The material number depends on the pump model:
  A11VO/A11VLO
  – Size 190: Mat. no. R90450647
  – Size 260: Mat. no. R90450941



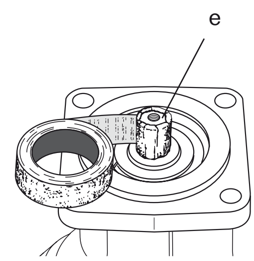
a:	Sicherungsring	Circlip
b:	Verschlussring	Cover Ring
c:	Wellendichtring	Shaft Seal
d:	O-Ring	O-ring
e:	Triebwelle	Drive Shaft

Um die Triebwelle abzudichten:

1 Kleben Sie die Triebwelle (e) ab, um Beschädigungen bei der Montage des neuen Wellendichtrings zu vermeiden.

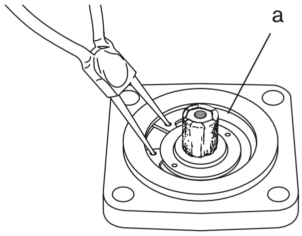
To seal the drive shaft:

1 Mask the drive shaft (e) for damage protection while replacing the shaft seal.



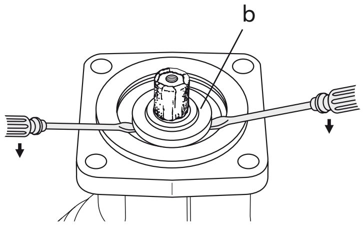
2 Entfernen Sie den Sicherungsring (a).

2 Remove the circlip (a).



3 Drücken Sie den Verschlussring (b) ab.
Damit entfernen Sie auch den Wellendichtring, der in den Verschlussring eingepresst ist

3 Press off the cover ring (b).
This action removes also the shaft seal that is pressed into the cover ring.

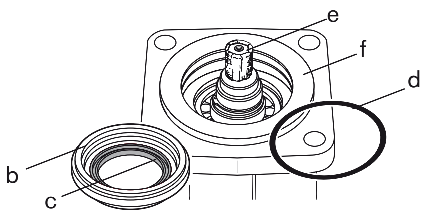


4 Entfernen Sie den Wellendichtring (c) aus dem Verschlussring (b) sowie den O-Ring (d) aus dem Gehäuse.

Kontrollieren Sie den Verschlussring (b), die Triebwelle (e) und das Gehäuse (f) auf Verschleiß und Verunreinigungen.

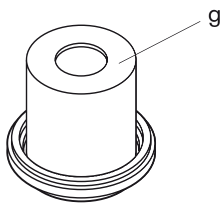
4 Remove the shaft seal (c) from the cover ring (b) and the o-ring (d) from the housing.

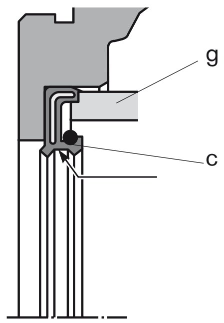
Check the cover ring (b), the drive shaft (e), and the housing (f) for wear and dirt.



5 Pressen Sie den Wellendichtring (c) mit Hilfe der passenden Montagebüchse (g) (Sonderwerkzeug) lagerichtig in den Verschlussring ein.

5 Using the suitable mounting bush (g) (special tool), press in the shaft seal (c) until it is correctly orientated in the cover ring.





Bei tiefer Laufrille legen Sie eine Scheibe auf den Wellendichtring.

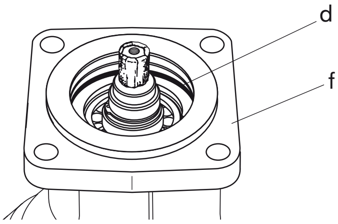
If the shaft is deeply grooved, insert a shim behind the shaft seal.

6 Fetten Sie den neuen Wellendichtring zwischen Dicht- und Staublippe leicht ein, um Trockenlauf zu vermeiden.

6 Grease the new shaft seal between the seal and dust lips to avoid a dry run.

7 Fetten Sie den neuen O-Ring (d) leicht ein und legen Sie ihn in das Gehäuse (f) ein. Prüfen Sie, ob der O-Ring bündig anliegt.

7 Grease the the new o-ring (d) slightly and insert it into the housing (f). Ensure, that it is correctly placed.



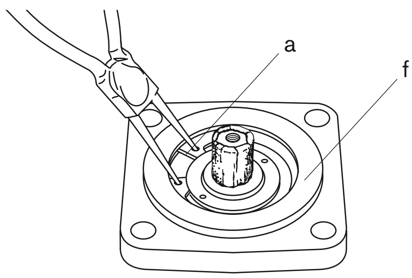
8 Setzen Sie den Verschlussring mit dem Wellendichtring in das Gehäuse ein.

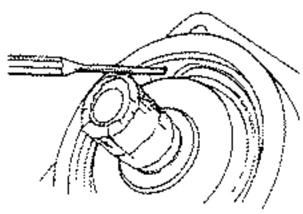
8 Insert the cover ring with the shaft seal into the housing.

9 Führen Sie den Sicherungsring (a) so in das Gehäuse (f) ein, dass er in die dafür vorgesehene Nut des Verschlussrings einrastet.
Kontrollieren Sie den Sitz des Sicherungsrings in der Nut.

9 Place the safety ring (a) into the housing (f) so that it locks into place in the respective slot of the cover ring.

Check to ensure that the circlip is correctly located within the groove.





10 Entfernen Sie die Abklebung der Triebwelle.

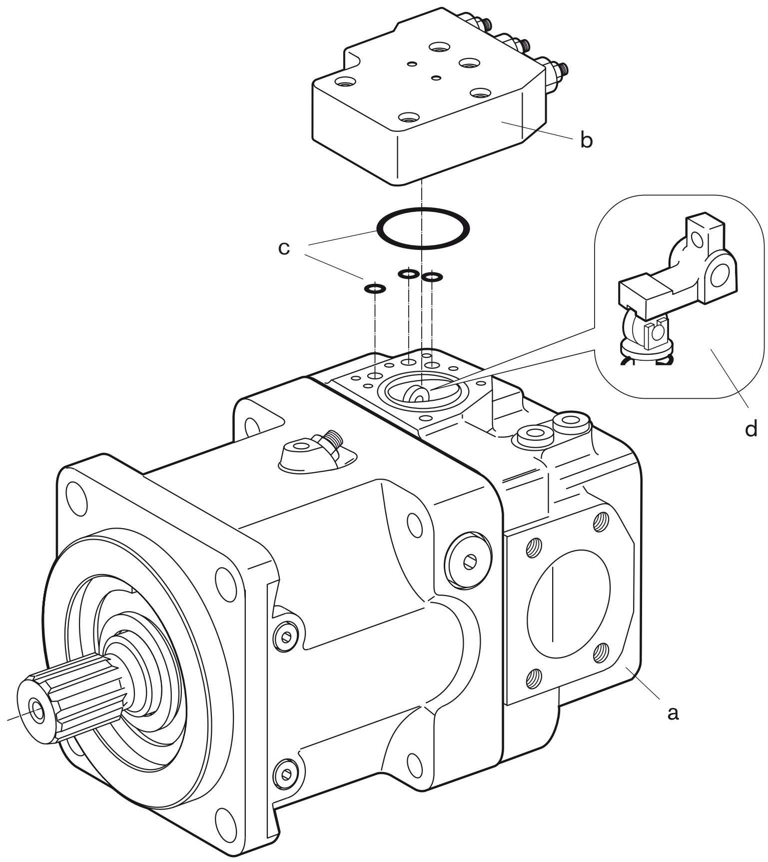
10 Remove the mask from the drive shaft.

4.2 Reglergehäuse abdichten

Das Reglergehäuse wird mit vier O-Ringen gegen die Anschlussplatte abgedichtet.

4.2 Sealing the Control Unit Housing

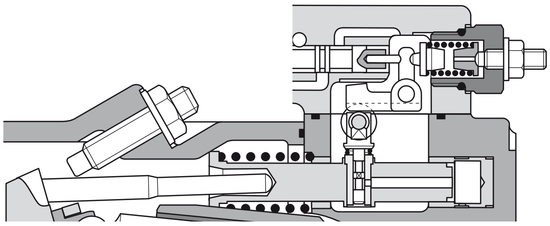
Four o-rings are used to seal the regulator housing from the port plate.

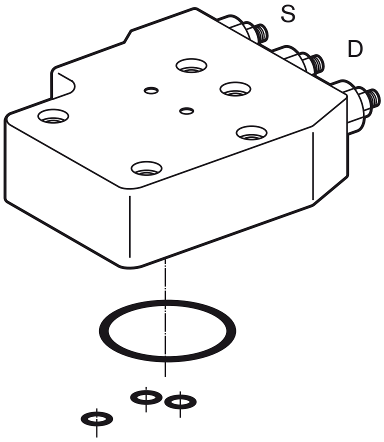


a:	Anschlussplatte	Port Plate
b:	Regler	Control Unit
c:	O-Ringe	O-rings
d:	Messkolben mit Winkelhebel	Measuring Piston with angled Lever

Regler, z. B. LRDS

Control Unit Example, LRDS





LR:	Leistungsregler	Power control
D:	Druckregler	Constant pressure control
S:	Load-sensing Regler	Load-sensing valve

Hinweis

Einstellschrauben nicht verändern. Falls erforderlich, Gewindehülse komplett mit Einstellschrauben ausbauen.

Note

Do not change the position of adjustment screws. If necessary, remove the complete set of threaded bush with adjustment screws.

⚠ VORSICHT

Vor dem Abschrauben eines Reglers mit Messfeder (z. B. LRDH, EP):
Zuerst Steuerbuchse mit Messfeder ausbauen, dann Reglergehäuse abbauen!.

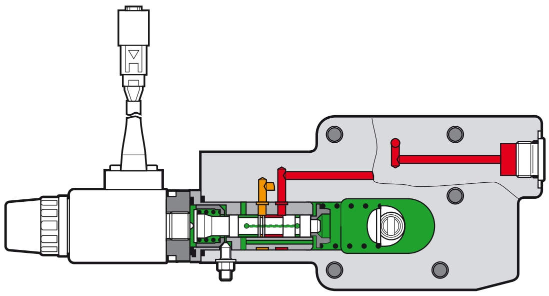
⚠ CAUTION

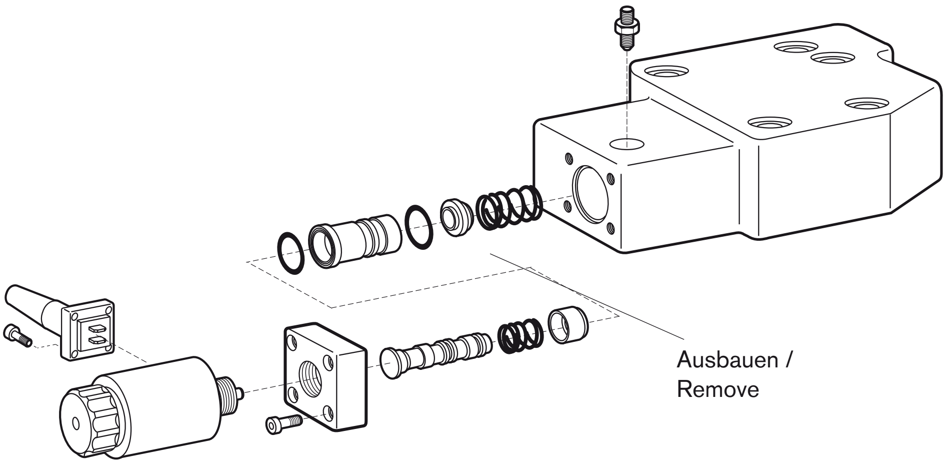
Before removing a control unit with measuring spring (for example LRDH, EP):
First remove the control bush with the measuring spring, then remove the regulator housing!

Beispiel für einen Regler mit Messfeder

Example of a Control Unit with Measuring Spring

EP





Um den Regler abzudichten:

1 Entfernen Sie die fünf Befestigungsschrauben.

2 Drücken Sie den Regler ab.

To seal the control unit:

1 Remove the five fixing screws.

2 Press off the control unit.

⚠ VORSICHT

Dichtfläche nicht beschädigen!

⚠ CAUTION

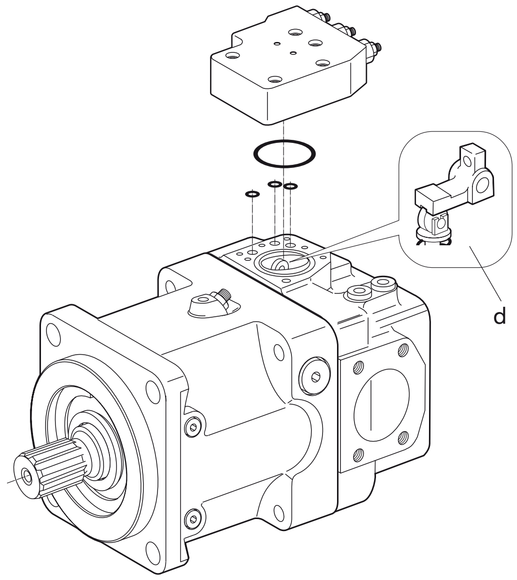
Make sure that the sealing surface is not damaged!

3 Legen Sie vier neue O-Ringe in die Anschlussplatte ein.

3 Insert four new o-rings into the grooves of the port plate.

4 Achten Sie vor dem Aufsetzen des Reglers auf die korrekte Positionierung von Messkolben und Winkelhebel (d).

4 Before mounting the regulator ensure that the measuring piston and angled lever (d) are correctly positioned.



5 Ziehen Sie die fünf Befestigungsschrauben an.

5 Insert and tighten the five fixing screws

4.3 Dichtungen austauschen

Dieser Abschnitt erklärt, wie Sie die Dichtmuttern ersetzen.

Benötigtes Sonderwerkzeug: Keines

Um eine Dichtmutter auszutauschen:

1 Messen und notieren Sie das Maß X für die spätere Montage der Dichtmutter (a).
Entfernen Sie die Dichtmutter.

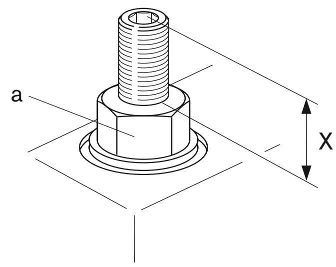
4.3 Replacing Seals

This section explains how you replace the seal nuts.

Required special tools: None

To replace a seal nut:

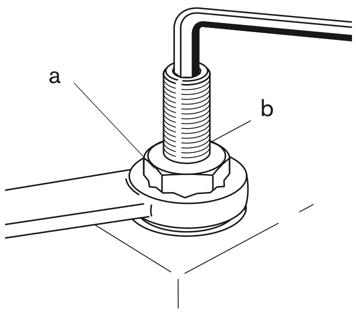
1 Measure and write down the dimension X of the seal nut (a). You need this for the subsequent assembly.
Remove the seal nut.



2 Schrauben Sie die neue Dichtmutter (a) ein. Blockieren Sie die Stellschraube (b) während Sie die Dichtmutter festziehen.
Kontrollieren Sie das Maß X nach der Montage.

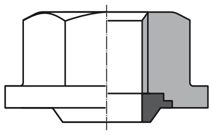
2 Screw in the new seal lock (a) manually. Block the adjusting screw (b) while you tighten the seal nut.

Check the dimension X after assembly.



Anziehdrehmomente für Seal-Lock Dichtmuttern
(nach N 02.100)

Tightening Torques for Seal-Lock Sealing Nuts
(according to N 02.100)



Gewinde / Thread	Anziehdrehmoment M_A in Nm Tightening torque M_A in Nm
M6	10
M6 x 0,5	11
M8	22
M8 x 1	24
M10	40
M10 x 1	44
M12	69
M12 x 1,5	72
M14	110
M14 x 1,5	120
M16	170
M16 x 1,5	180

5 Funktionsprüfungen

Dieses Kapitel gibt Ihnen Beispiele, wie Sie die Funktion einer Rexroth A11VO/A11VLO Verstellpumpe mit LRDS-Regler überprüfen können.

5.1 Vorbereitungen

1 Fordern Sie das Leistungsdiagramm bei Bosch Rexroth an.
2 Überprüfen Sie die Drehrichtung.
3 Bauen Sie die Pumpe ein, befestigen Sie sie, und befüllen Sie das Gehäuse.

5 Functional Checks

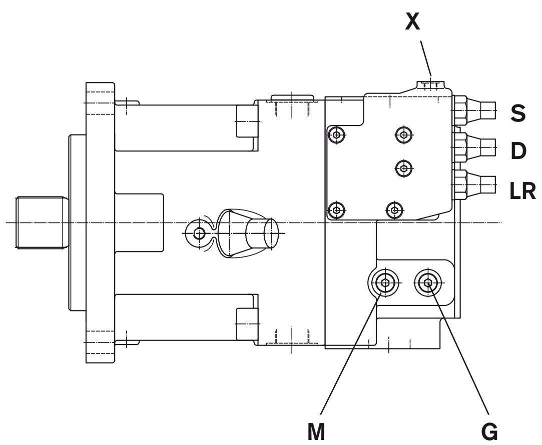
This chapter provides examples on how to check the proper function of a Rexroth A11VO/A11VLO variable pump with LRDS regulator.

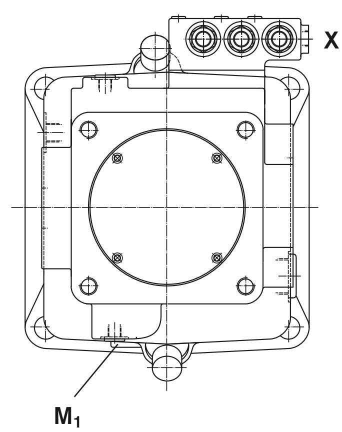
5.1 Preparations

1 Order the power curve diagram at Bosch Rexroth.
2 Check the direction of rotation.
3 Install and fix the pump. Fill the housing.

Anschlüsse / Ports

A11VO/A11VLO 190 ... 260 LRDS





M:	Messstelle Arbeitsanschluss	Test port for pressure
M_1:	Messstelle Stellkammer	Test port for stroking cylinder
LR:	Leistungsregler	Power Control
D:	Druckabschneidung	Pressure Cut-off
S:	Load-Sensing-Regler	Load-Sensing Control
X:	Anschluss für LS-Regler	Port for LS Control
G:	Anschluss für Fremdstelldruck	Port for externally applied control pressure

5.2 Prüfung des Load-Sensing Reglers (S)

Einstellvorgang

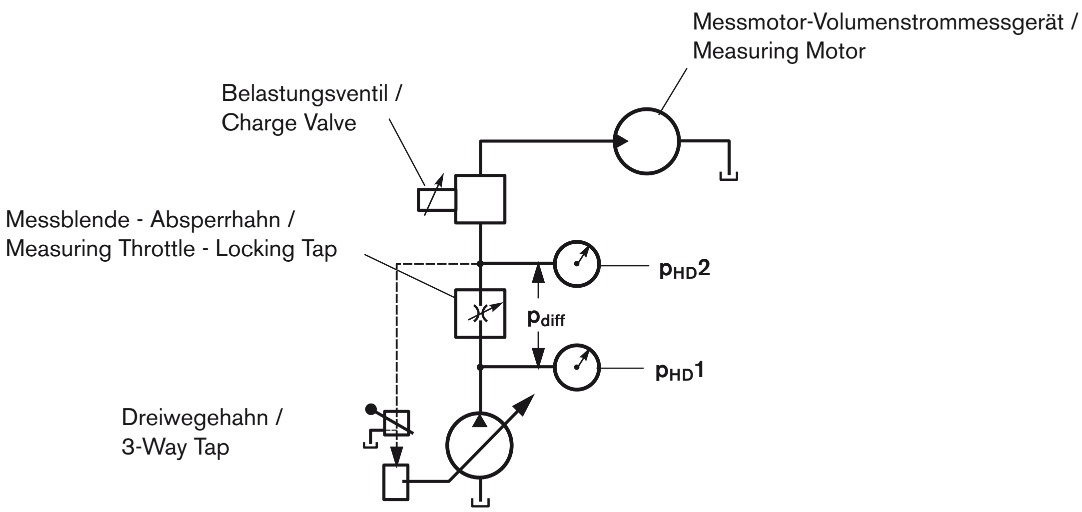
1 Auf Prüftemperatur fahren
2 Antriebsdrehzahl einstellen
3 Q_{min} Anschlag ausschrauben
4 Verwenden Sie folgenden Testaufbau

5.2 Checking the Load-Sensing Control (S)

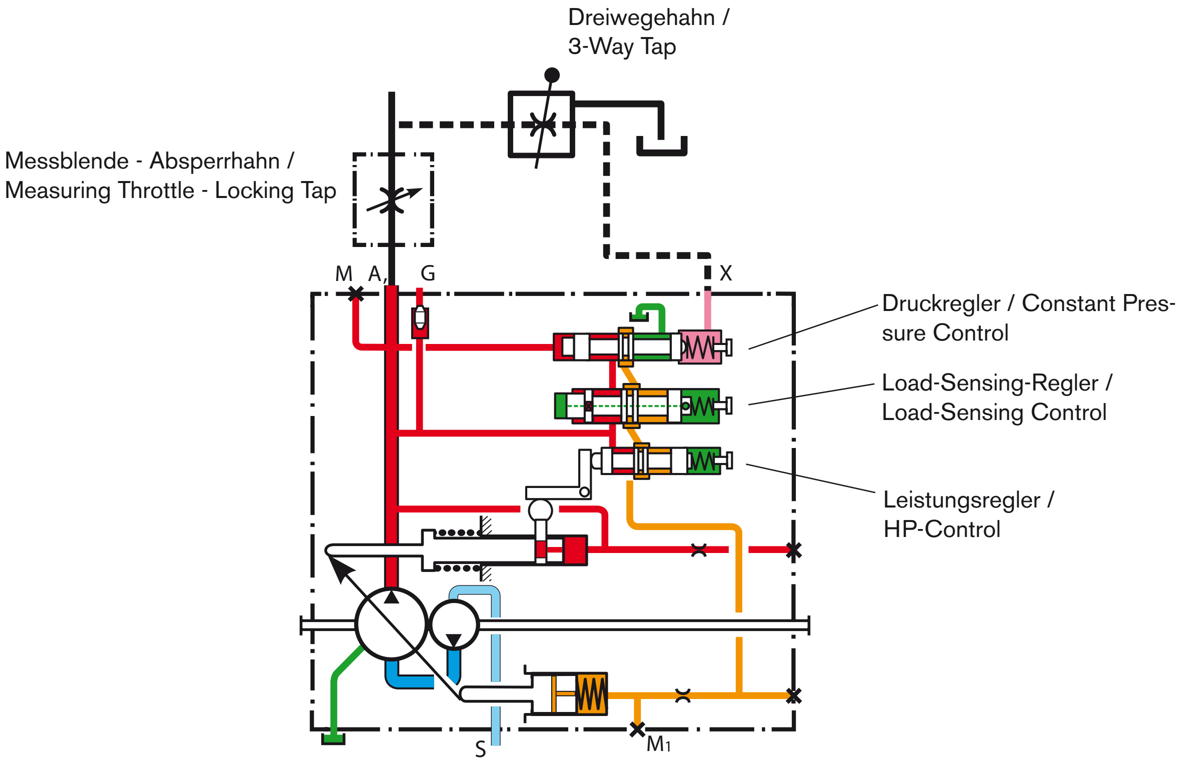
Setting process

1 Heat up the system to test temperature
2 Set drive speed
3 Screw out Q_{min} stop
4 Use the following test setup

Testaufbau / **Test Setup**



Anschlüsse / **Connections**



5 Messblende/Absperrhahn vorsichtig schließen bis $Q_{max}/2$ (halber Volumenstrom).
Hochdruck 100 bar ($p_{HD}2$) nach der Messblende (Belastungsventil) einstellen.

6 p_{diff} am LS-Regler einstellen und kontern.
Zum Beispiel: p_{diff} = 18 bar:
$p_{HD}2$ = 100 bar
$p_{HD}1$ = 118 bar

7 Dreiwegehahn in der X-Leitung vorsichtig schließen.

8 Q_{min} Schraube anlegen, 1/2 Umdrehung wieder herausdrehen und kontern.

5 Carefully close the measuring throttle's locking tap up to $Q_{max}/2$ (half flow).
Set high pressure 100 bar ($p_{HD}2$) behind the measuring throttle (charge valve).

6 Set p_{diff} at the HP-control and jam the screw.
For example: p_{diff} = 18 bar:
$p_{HD}2$ = 100 bar
$p_{HD}1$ = 118 bar

7 Close the measuring throttle's locking tap entirely.

8 Place Q_{min} screw, screw-out again 1/2 rotation and jam the screw.

5.3 Prüfung des Leistungsreglers (LR)

Einstellvorgang

1 Druckregler blockieren (eindrehen).
2 Leistungsregler nach Leistungsdiagramm (LD) einstellen.
3 Messblende, Absperrhahn öffnen.
4 Förderstrom Q_{max} einstellen (Q_{max}-Schraube).

Beispiel 1

Einstellung des Regelbeginns über einen Punkt auf der Leistungskennlinie nach Druck und Volumen.

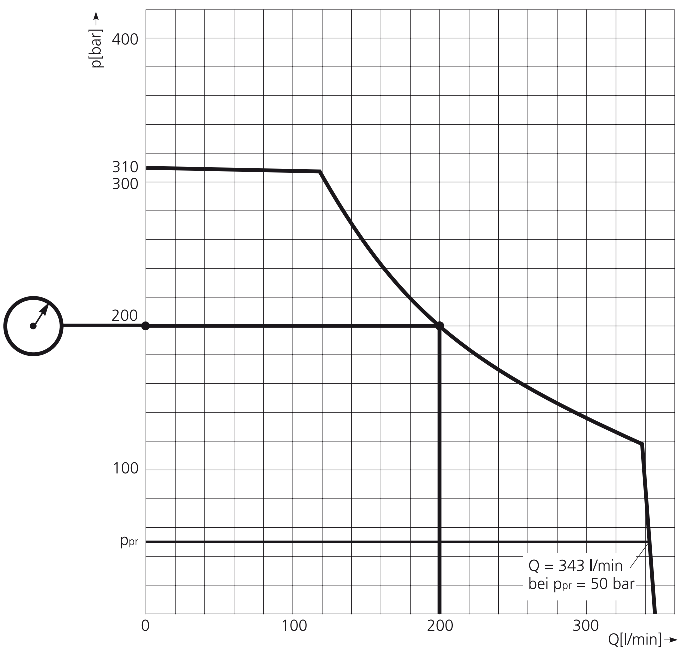
5.3 Checking the Power Control (LR)

Setting process

1 Block constant pressure control (screw-in).
2 Set the power control as to HP diagram (power diagram).
3 At the measuring throttle, open the locking tap.
4 Set flow to Q_{max} (Q_{max} screw).

Example 1

Setting the start of regulation at a point of the horse power diagram (pressure/flow).



Beispiel 2

Einstellung des Regelbeginns. Druck (Stelldruck) an M_1.

Hinweis

Diese Einstellung ist „ungenau“ (Toleranz).

Beispiel:

Regelbeginn = 120 bar.

Betriebsdruck langsam erhöhen bis Manometer an M = 120 bar anzeigt. Ddabei darf der Stelldruck an M_1 ca. 1/3 vom Betriebsdruck, also etwa 40 bar betragen.

Das ist der Regelbeginn.

Example 2

Setting the start of regulation, pressure (stroking pressure) at M_1.

Note

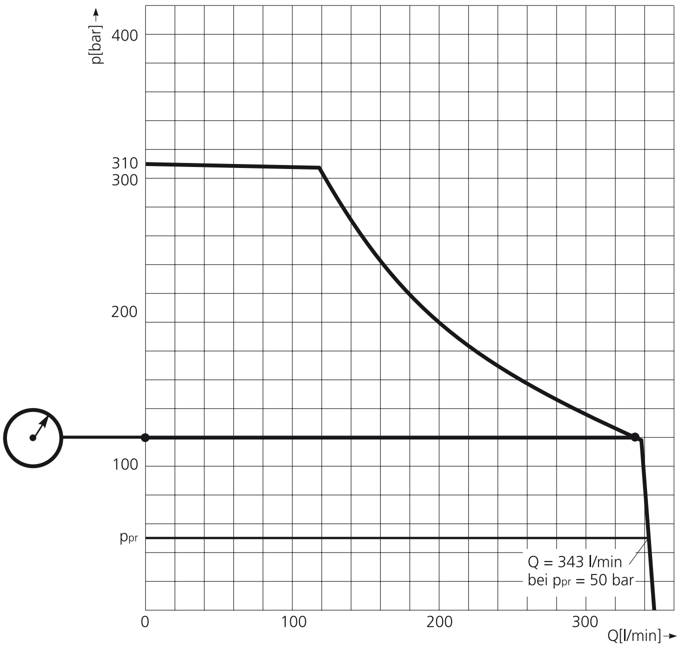
This setting is „unprecise“ (Tolerance).

Example:

Begin of regulation = 120 bar.

Slowly increase operation pressure up to pressure gauge at M = 120 bar. The positioning pressure at M_1 may be up to approx. 1/3 of the operation pressure, i.e. approx. 40 bar.

This is the start of the regulation.



Zum Beispiel:

Druck an M = 120 bar

Druck an M_1 = 20 bar

Regelbeginn zu spät, also Leistungsüberschreitung

Einstellschraube herausdrehen bis ca. 40 bar erreicht werden.

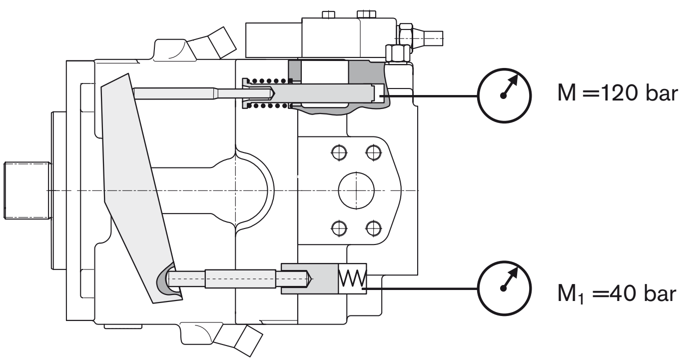
For example:

Pressure at M = 120 bar

Pressure at M_1 = 20 bar

Start of regulation too late, i.e. Power excess.

Unscrew setting screw until approx. 40 bar are reached.



5.4 Prüfung des Druckreglers (D)

Einstellung des Druckreglers mittels Belastungsventil nach Leistungsdiagramm.

Beispiel: Druckreglereinstellung = 310 bar

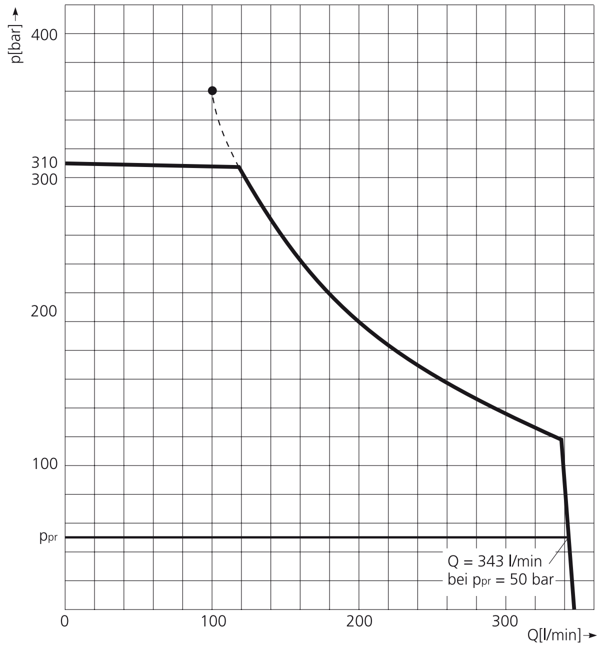
1 Betriebsdruck mit Belastungsventil auf ca. 350 bar erhöhen.

5.4 Checking the Pressure Control (D)

Setting with help of the charge valve the constant pressure control as to HP diagram.

Example: Setting of constant pressure control = 310 bar

1 Increase operation pressure with help of charge valve to approx. 350 bar.



2 Blockierten Druckregler vorsichtig herausdrehen bis 310 bar erreicht werden.

3 Einstellschraube kontern.

2 Unscrew blocked constant pressure control carefully until 310 bar are reached.

3 Jam setting screw.

Bosch Rexroth AG
Hydraulics
Produktsegment Axialkolbenmaschinen
Werk Elchingen
Glockeraustraße 2
89275 Elchingen, Germany
Telefon +49 (0) 73 08 82-0
Telefax +49 (0) 73 08 72-74
info.brm-ak@boschrexroth.de
www.boschrexroth.com/brm

MANNESMANN
REXROTH

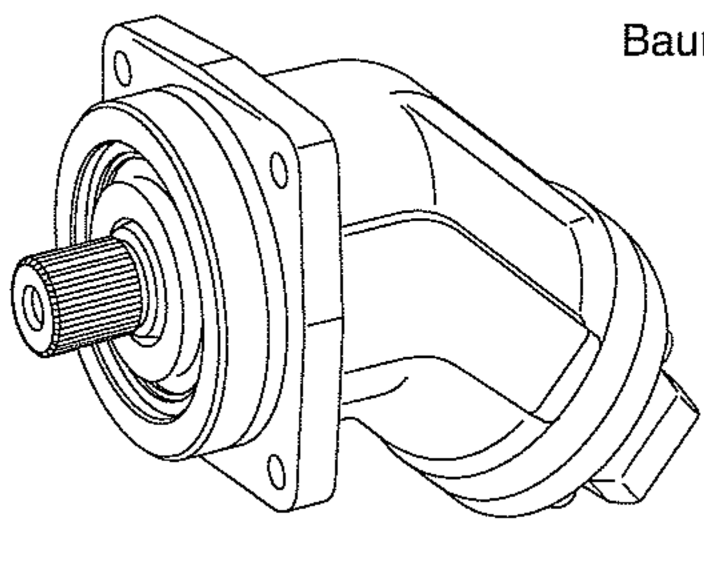
Brueninghaus Hydromatik

R

Reparaturanleitung
Repair Instructions

A2F

Baureihe/Series 6.1



RDE 91001-01 -R
07.96

Zurück zum Verzeichnis /
Return to the index

HINWEIS

Bezeichnungen, Beschreibungen und Darstellungen entsprechen dem Informationsstand zum Zeitpunkt der Drucklegung dieser Unterlage.

Änderungen können den Service am Produkt beeinflussen, Verpflichtungen entstehen uns daraus nicht.

Methoden und Vorrichtungen sind Empfehlungen, für deren Resultat wir keine Haftung übernehmen können.

BRUENINGHAUS HYDROMATIK- Baugruppen, mit Angabe der Fabrik-Nr. bestellt, sind die Basis guter Reparaturen.

Einstell- und Prüfarbeiten sind bei Betriebstemperatur auf dem Teststand vorzunehmen.

Schutz von Personen und Eigentum ist durch Vorkehrungen sicherzustellen.

Sachkenntnis, die Voraussetzung für jede Servicearbeit, vermitteln wir in unseren Schulungskursen.

NOTICE

Specifications, descriptions and illustrative material shown herein were as accurate as known at the time this publication was approved for printing.

BRUENINGHAUS HYDROMATIK reserves the right to discontinue models or options at any time or to change speci-fications, materials, or design without notice and with-out incurring obligation.

Optional equipment and accessories may add cost to the basic unit, and some options are available only in combination with certain models or other options.

For the available combinations refer to the relevant data sheet for the basic unit and the desired option.

Adjustment and tests have to be carried out on the test bench under operating temperatures.

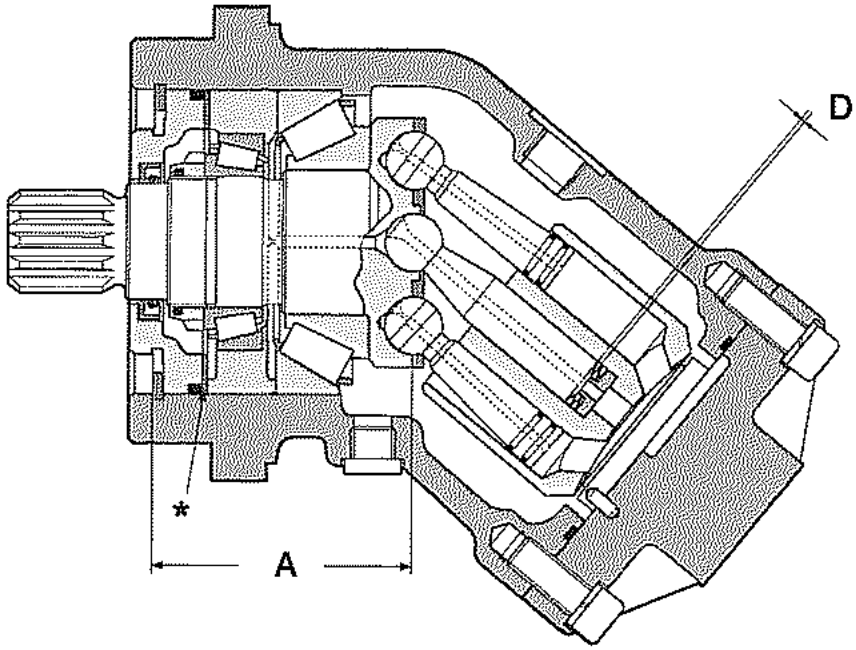
Protection of personnel and property has to be guaranteed by appropriate measures.

Expert knowledge, the precondition of any service work, can be obtained in our training courses.

INHALT / CONTENTS

A2F

INHALT	Seite/ Page	CONTENTS

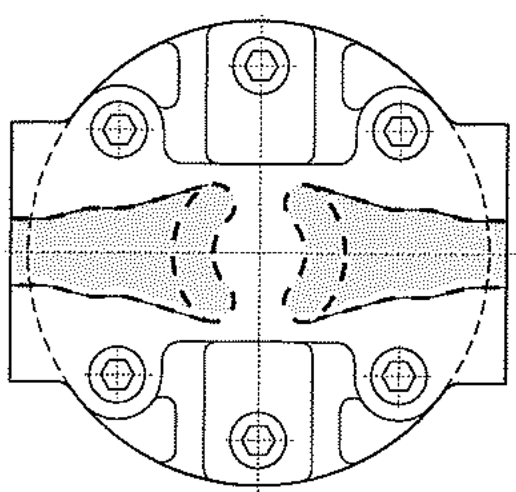


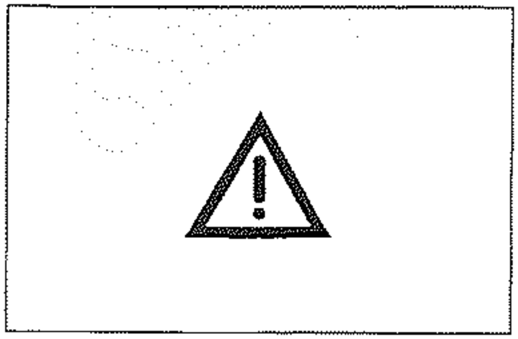
Meßpunkte:

Siehe Serviceinfo

Measuring points:

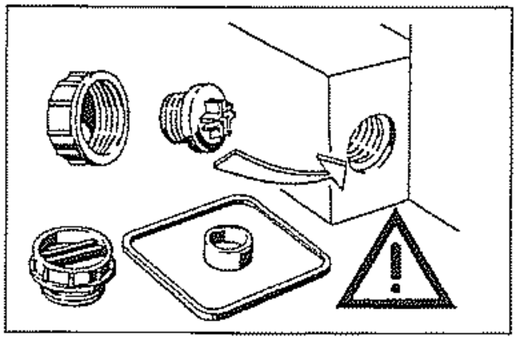
See service information





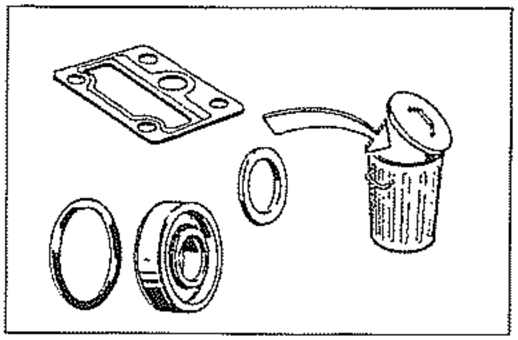
Achtung!
Nachfolgende Hinweise bei allen Reparaturarbeiten an Hydraulikaggregaten beachten!

Attention!
Observe the following notices when carrying out repair work at hydraulic aggregates!



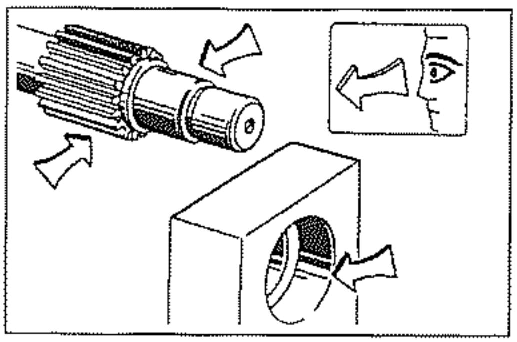
Alle Öffnungen der Hydraulikaggregate verschließen.

Close all ports of the hydraulic aggregates.



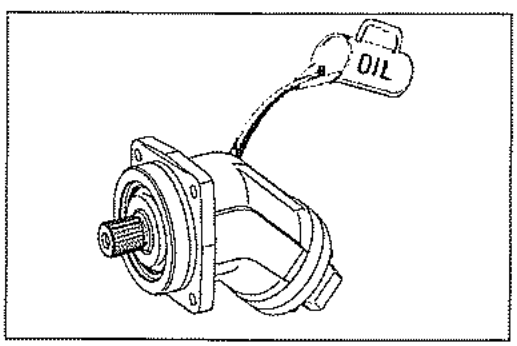
Alle Dichtungen erneuern.
Nur original HYDROMATIK - Ersatzteile verwenden!

Replace all seals.
Use only original HYDROMATIK spare parts!



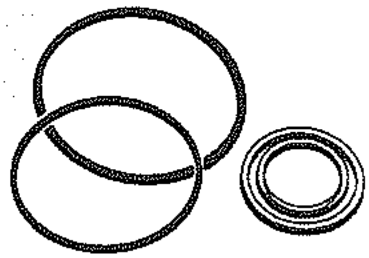
Alle Dicht- und Gleitflächen auf Verschleiß prüfen.
Achtung: Nacharbeiten an Dichtflächen z.B. durch Schleifpapier kann die Oberfläche beschädigen.

Check all seal and sliding surfaces for wear.
Attention: Rework of sealing area f. ex. with abrasive paper can damage surface.



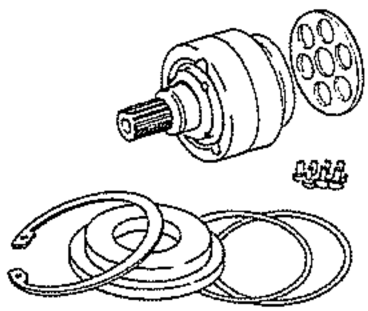
Hydraulikaggregate vor Inbetriebnahme mit Hydrauliköl befüllen.

Fill up hydraulic aggregates with hydraulic oil before start- up.



1 Äußerer Dichtsatz.

External seal kit.

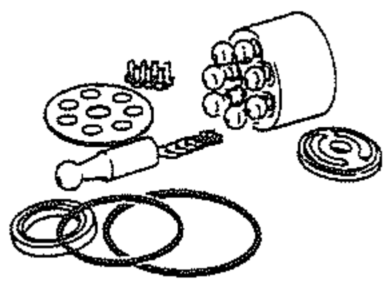


2 Triebwerk, mechanischer Teil; mit Dichtsatz,

⚠ muß abgestimmt werden auf Maß "A".

Rotary group, mechanical part; with seal kit,

⚠ has to be adjusted to dimension "A".

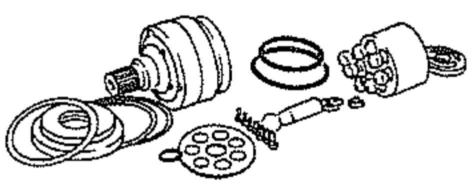


3 Triebwerk, hydraulischer Teil; mit Dichtsatz,

⚠ Abstimmung hydraulischer Teil Pos. "D".

Rotary group, hydraulic part; with seal kit,

⚠ Adjustment of the hydraulic part Pos. "D".

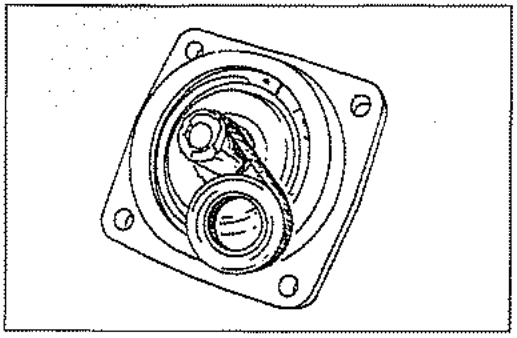


4 Triebwerk komplett; mit Dichtsatz, fertig vorabgestimmt.

⚠ Abstimmung hydraulischer Teil Pos. "D".

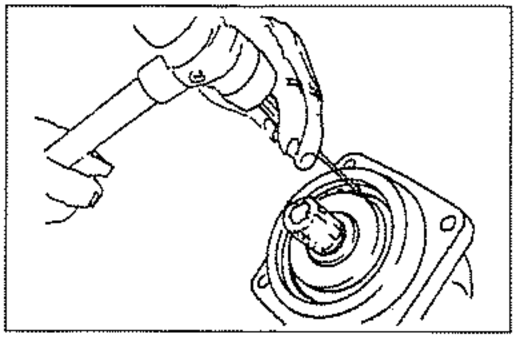
Complete rotary group, with seal kit, pre-adjusted.

⚠ Adjustment of the hydraulic part Pos. "D".



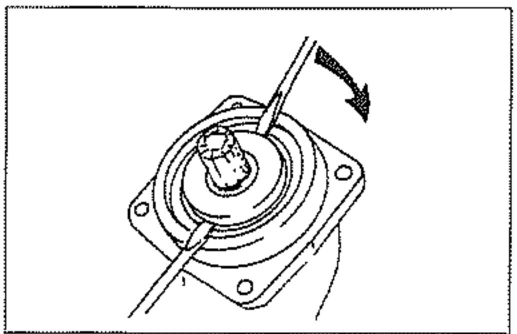
5 Bei nicht verzahnten Triebwellen: Paßfeder abnehmen. Triebwelle abkleben,

Remove protective cover. If keyed shaft,remove key.



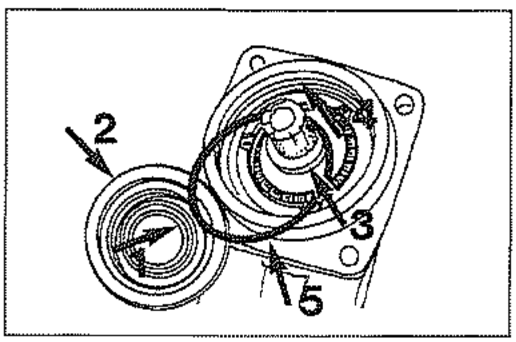
6 Sicherungsring lösen, danach ausbauen.

Free circlip and remove.



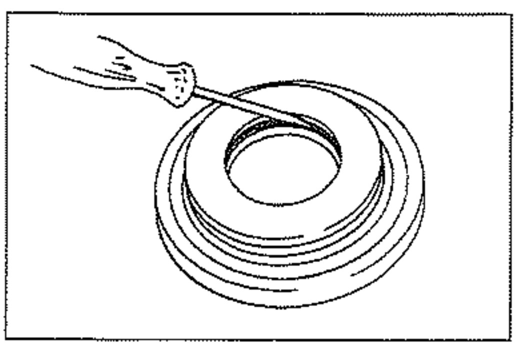
7 Verschlußring abdrücken.

Prise off front cover



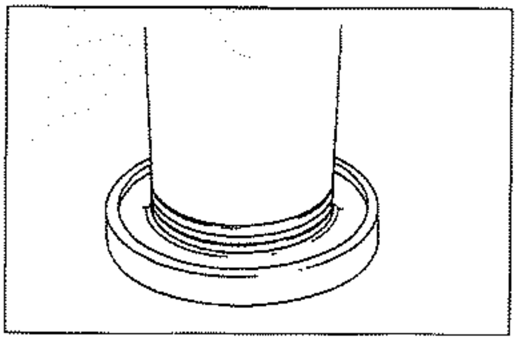
8 Sichtkontrolle
Wellendichtring (1), Verschlußring (2), Triebwelle (3), Gehäuse (4), O-Ring (5).

Visual check
Shaft seal (1), cover (2), drive shaft (3), housing (4), O-ring (5).



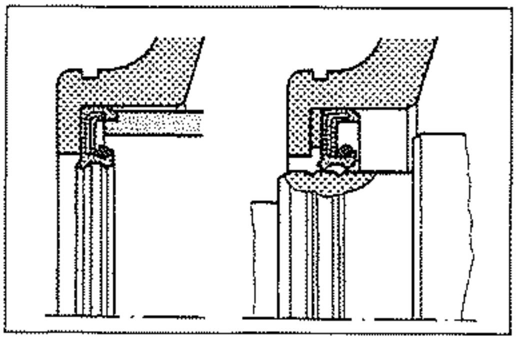
9 Wellendichtring demontieren.

Remove old shaft seal.



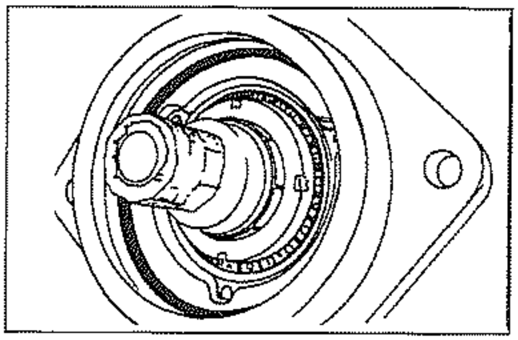
10 Neuen Wellendichtring lagerichtig mit passender Büchse einpressen.

Press in the shaft seal ring to the correCt position with a suitable sleeve.



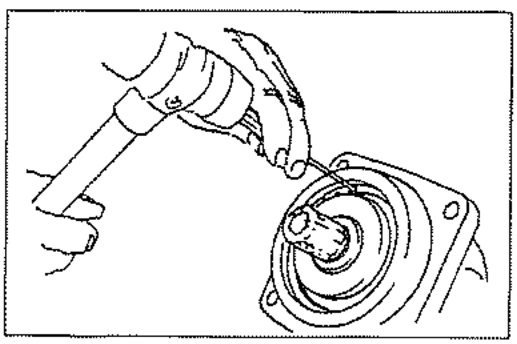
11 Bei tiefer Laufrille beiliegende Scheibe vor den Wellendichtring einlegen.

If the shaft is deeply grooved, insert shim behind seal.



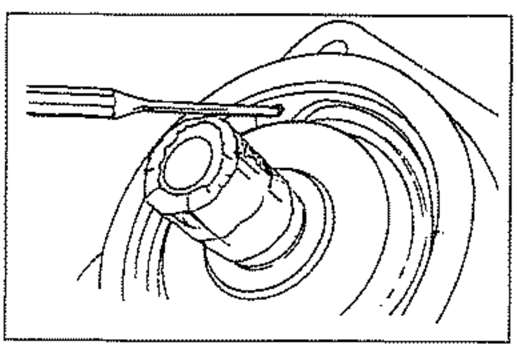
12 Neuen O-Ring einlegen, auf bündiges Anliegen achten. O-Ring sowie Dicht- und Staublippe des wellendichtringes einfetten.

Fit new O-ring, ensure it is a snug rit. Grease O-ring and lips or shaft seal.



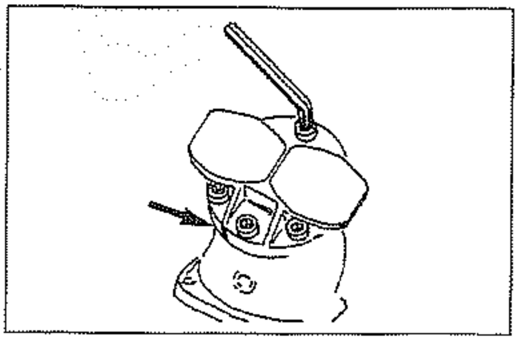
13 Sicherungsring mit Durchschlag einsprengen.

Fit circlip using a punch.



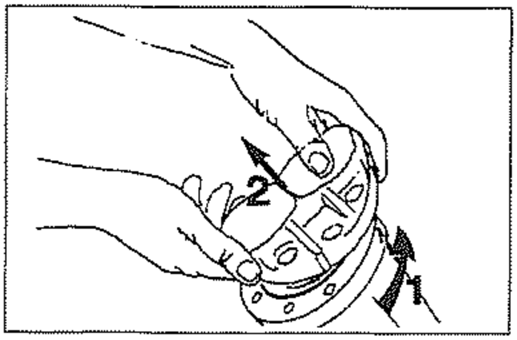
14 Sitzkontrolle des Sicherungsringes in der Nut.

Check that circlip is well seated.



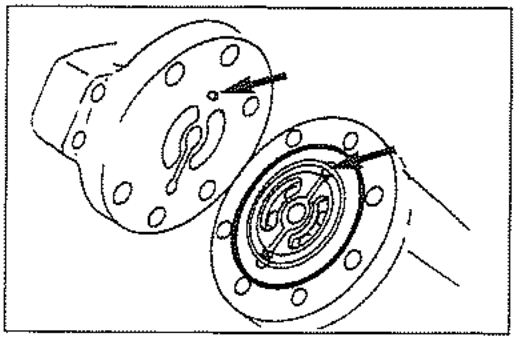
15 Lage der Anschlußplatte zum Gehäuse kennzeichnen (Pfeil), Befestigungsschrauben lösen.

Mark position of cover plate (arrowed). Remove screws.



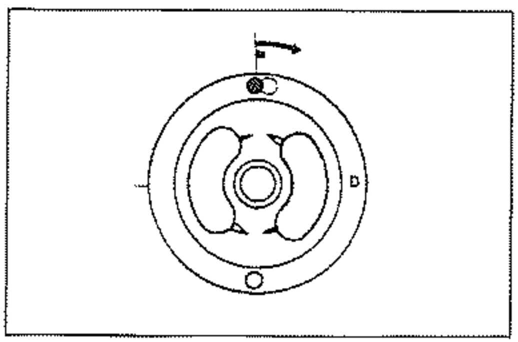
16 Anschlußplatte um Verdrillstift schwenken (1) und abheben (2).

Swivel port plate on locating pin and lift off.



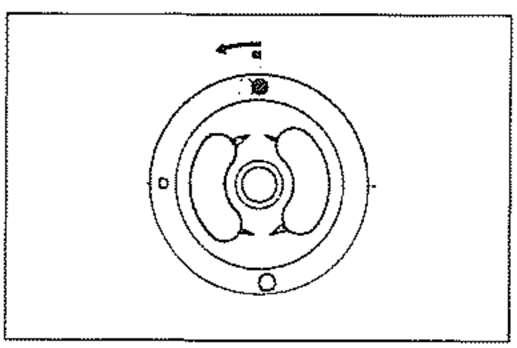
17 Auf Montagestellung des Verdrillstiftes achten (Pfeile).

Note position of locating pin. (arrow).



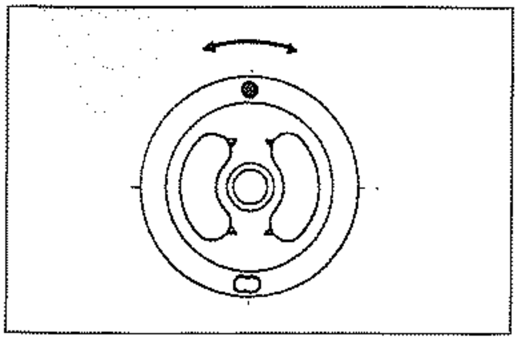
18 Pumpe, Drehrichtung rechts. (Blick **auf sphärische Fläche.**)

Pump, clockwise rotation. (viewed **on spherical surface.**)



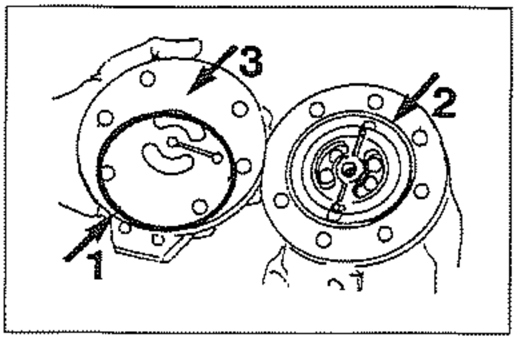
19 Pumpe, Drehrichtung links. (Blick **auf sphärische Fläche.**)

Pump, anti-clockwise rotation. (viewed **on spherical surface.**)



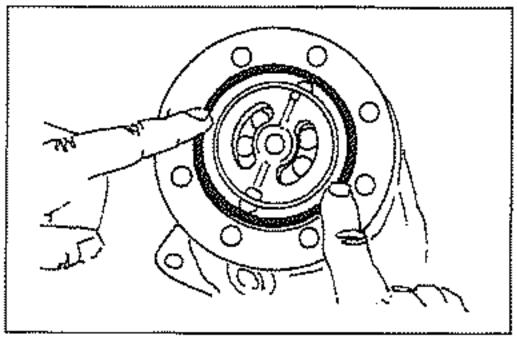
20 Motor, beide Drehrichtungen. (Blick **auf sphärische Fläche.**)

Motor, bi-directional. (Viewed **on spherical surface.**)



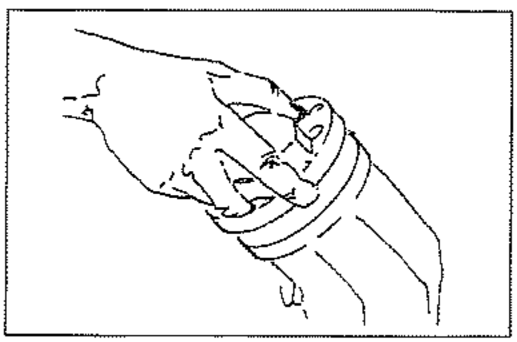
21 Sichtkontrolle
O-Ring (1), Einstich (2), Platte (3).

Visual check
O-ring (1), Groove (2), Plate (3).



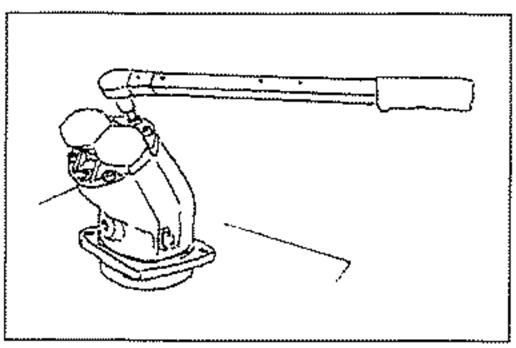
22 Neuen O-Ring einlegen, zuvor leicht einfetten.

Lightly grease and fit O-ring.



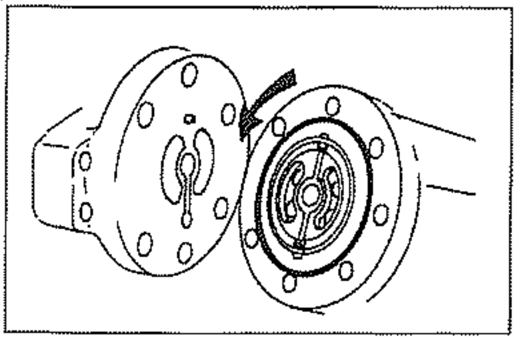
23 Anschlußplatte aufsetzen, auf Kennzeichnung (Bild 15) und Lage des Verdrillstiftes achten (18-20).

Assemble port plate to original mark (15), noting position of port plate (18-20).
See notes fitting control plate.



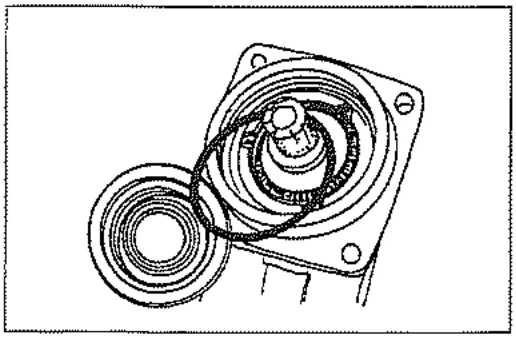
24 Befestigungsschrauben mit Drehmomentenschlüssel anziehen. Momente Seite 16.

Tighten screws using torque wrench. See page 16 for setting.



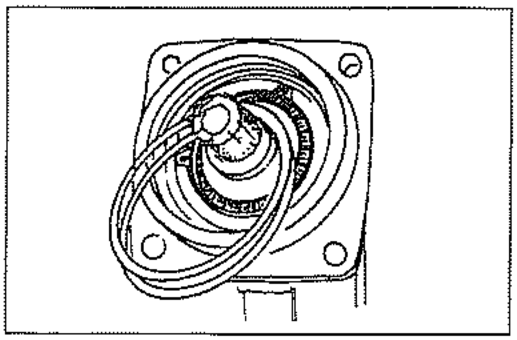
25 Demontage der Anschlußplatte (Seite 8). Steuerplatte drehend abheben.

Remove cover plate (page 8). Rotate control plate to remove.



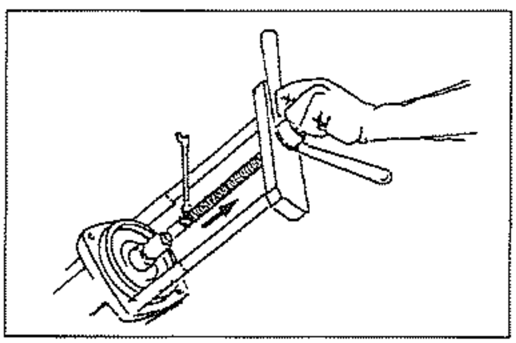
26 Demontage des Verschlußringes (Seite 6, 7).

Remove front cover (page 6, 7).



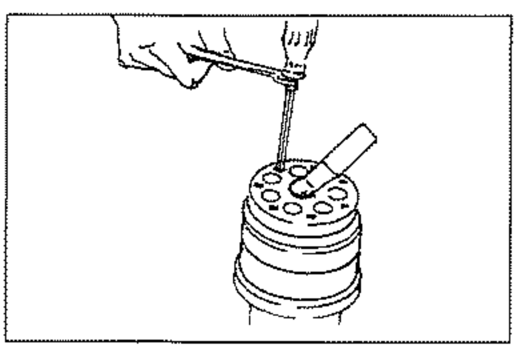
27 Paßscheibe(n) entnehmen.

Remove shim(s).



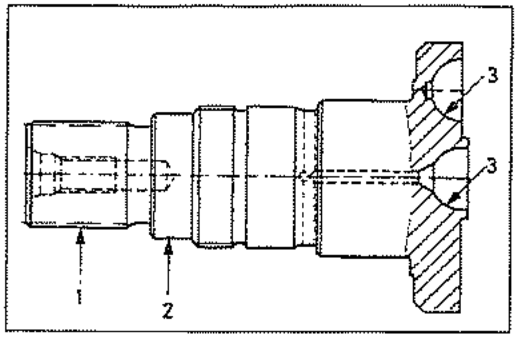
28 Triebwerk mit Vorrichtung ausbauen. Vorrichtung Bild 54.

Remove rotary group with extractor. (See fig.54).



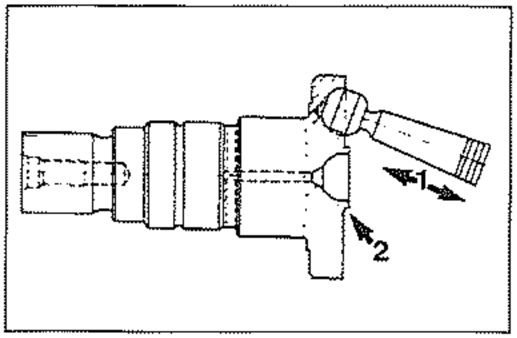
29 Rückzugplatte demontieren, Schrauben sind eingeklebt. Hinweis: Schrauben erwärmen.

Remove retaining plate. The screws are held by Loctite. Note: Warm up screws.



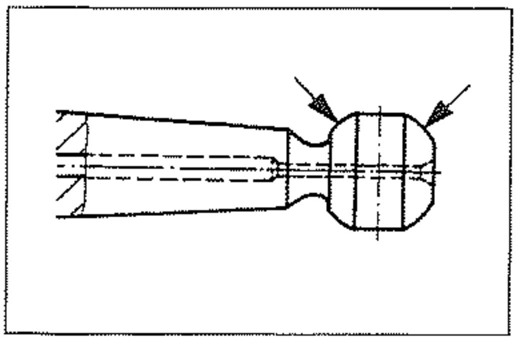
30 Triebwelle
1. kein Passungsrost, nicht ausgeschlagen.
2. keine Einlaufspuren, riefenfrei (Bild 11).
3. Kalotten riefenfrei und keine Pittings.

Drive shaft
1. Free of corrosion or erosion, no damage to splines or keyway.
2. No trace of wear, free of scratches (p. 11).
3. Cups free of scratches and no pittings.



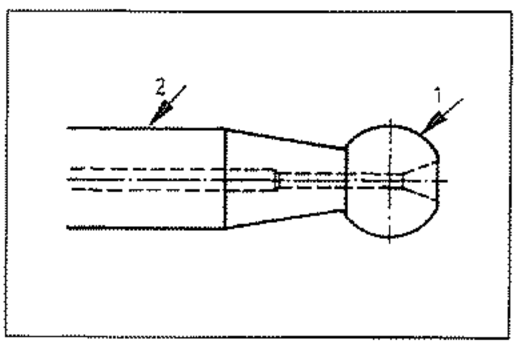
31
1. Axiales Kolbenspiel
2. Bundhöhe.

1. Axial play of piston.
2. Spigot.



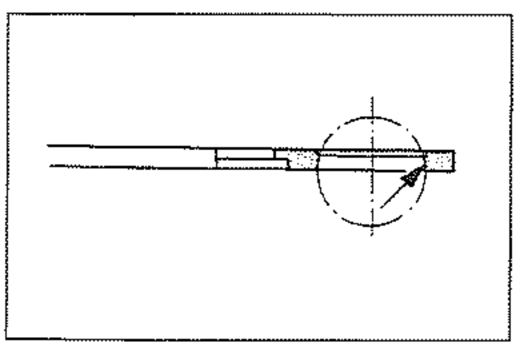
32 Kolben
Riefenfrei, keine Pittings (nicht demontieren, schräg stellen).

Piston
Free of scratches, no pitting (do not dismantle - tilt).



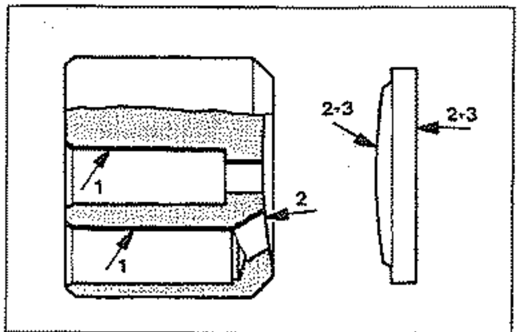
33 Mittelzapfen
1. Riefenfrei, ohne Pittings (nicht demontieren, schräg stellen).
2. Riefenfrei.

Center pin
1. Free of scratches, no pittings (do not dismantle - tilt).
2. Free of scratches.



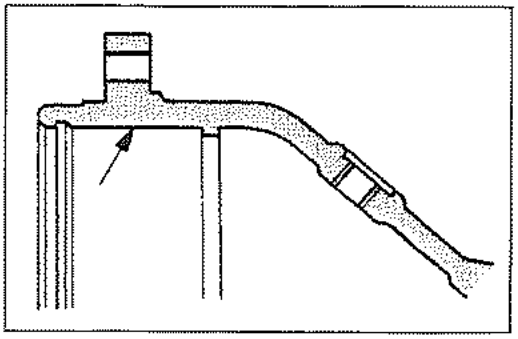
34 Rückzugplatte
Riefenfrei, keine Ausbrüche.

Retaining plate
Free of scratches, no wear.



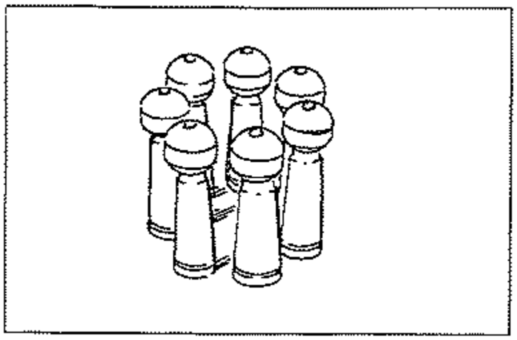
35 Zylinder/Steuerplatte
1. Bohrungen riefenfrei, nicht ausgelaufen.
2. Gleichmäßiges Tragbild, riß- und riefenfrei.
3. Mindesthärte 700 HV 10.

Cylinder block / Control plate
1. Bores unscratched, and not worn.
2. Faces, smooth and even, no cracks or scratches.
3. Min. hardness 700 HV 10.



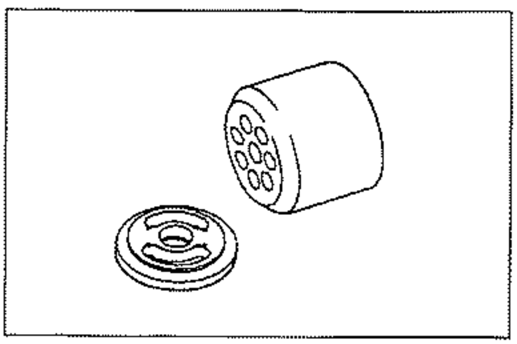
36 Gehäuse
Im Lagerbereich riefenfrei und keine Einlaufspuren.

Housing
No damage or wear where bearings fit.



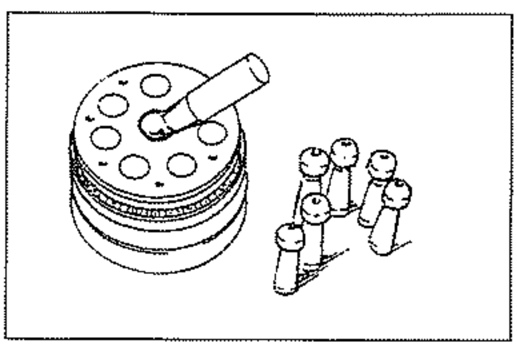
37 Nur kompletten Kolbensatz austauschen.

Only exchange piston as a complete set.



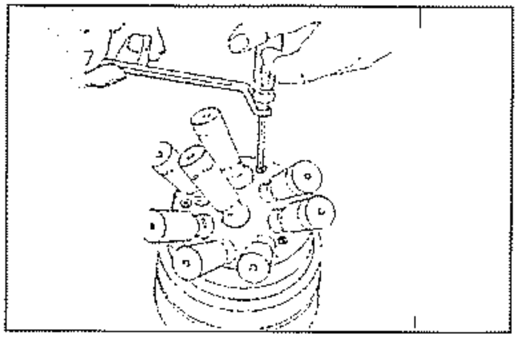
38 Zylinder und Steuerplatte nur gemeinsam austauschen.

Exchange cylinder block and control plate as a pair.



39 Mittelzapfen einsetzen, Beilagscheibe auflegen.
Rückzugplatte seitenrichtig auflegen.

Insert center pin with retaining ring.
Correctly fit retaining plate.

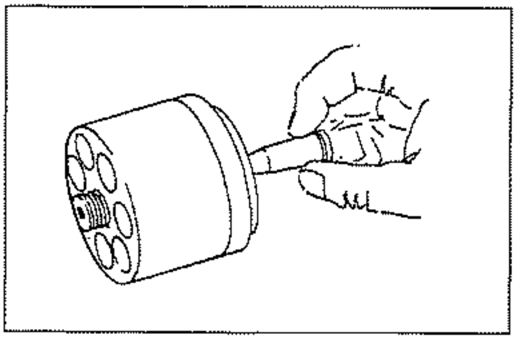


40 Schrauben mit Precote-Beschichtung verwenden.

⚠ Mit Kolben Rückzugplatte ausrichten.

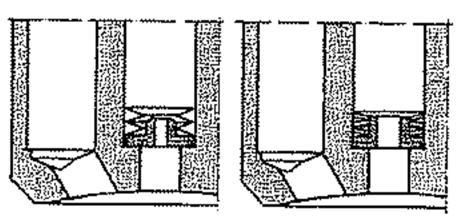
Use screws with Precote-coating.

⚠ Fit retaining plate correctly with pistons.

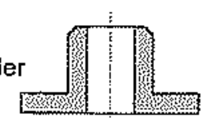


41 Federteller und Tellerfedern einlegen, Teile reichlich einfetten. Montagehilfe: Schraubendreher.

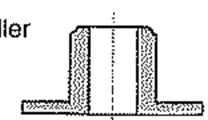
Heavily grease and fit spring pad and Belleville washers (using screwdriver).

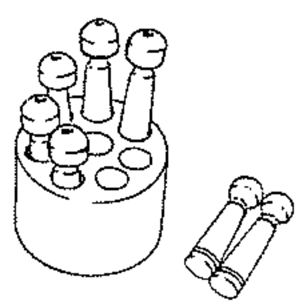


42 Auf richtige Schichtung aller Teile achten!
Make sure all parts are fitted in correctly !
Hinweis / Note:
A2F0 - Pumpe - 4 Tellerfedern / Federteller
A2FO - Pump - 4 Belleville washers / Spring pad



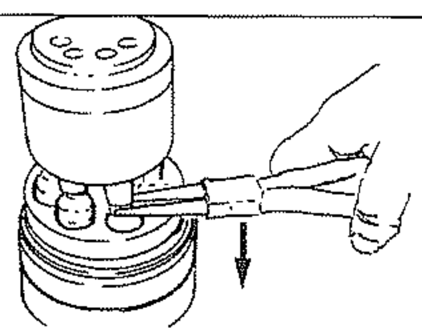
A2FM - Motor - 6 Tellerfedern / Federteller
A2FM - Motor - 6 Belleville washers / Spring pad





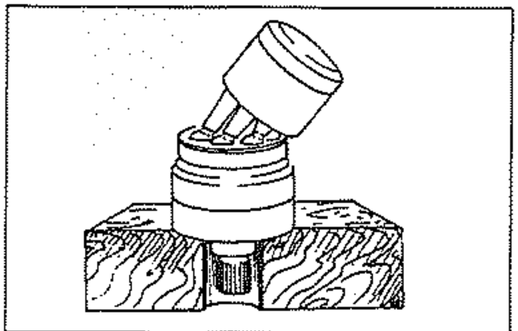
43 Kolben in Bohrung stecken.

Fit pistons in bores.



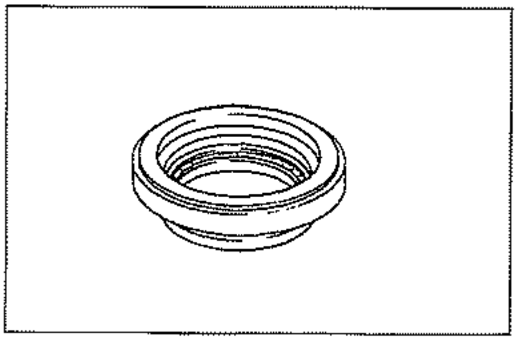
44 Bei 0-Grad-Schwenkwinkel Kolbenkugel kräftig in Kalotte drücken.

Press pistons firmly into cups with cylinder block held in central position.



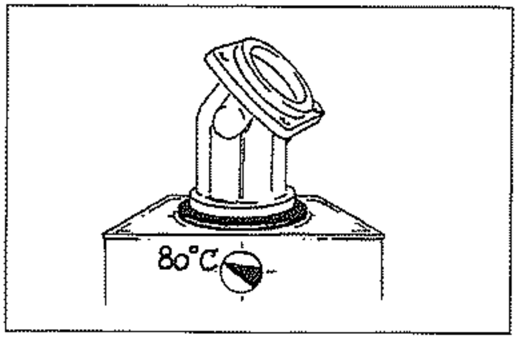
45 Triebwerk max. ausschwenken. Bei Hemmung: Bild 44.

Swivel cylinder block to max. It fouling occurs fig. 44.



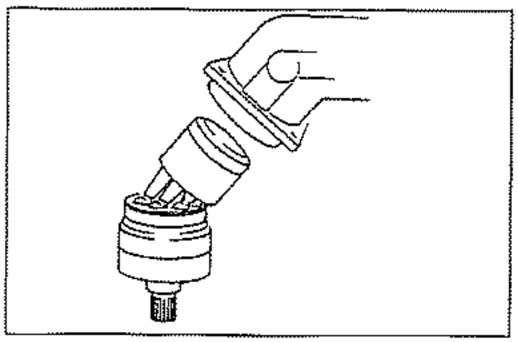
46 Neuer Radialwellendichtring montiert? (Vergleiche Bild 11).

Is new shaft seal fitted? (comparisons fig 11).



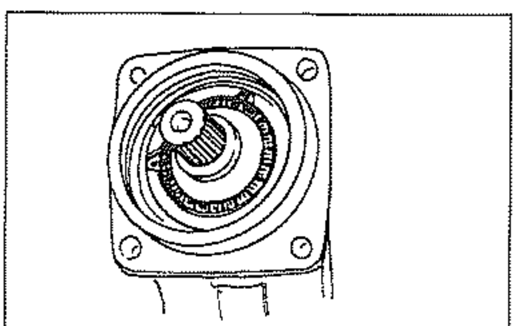
47 Gehäuse auf ca. 80° C erwärmen.

Heat the housing to 80° C.



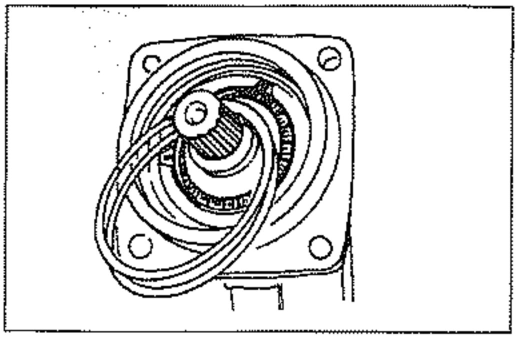
48 Heißes Gehäuse bis zum Anschlag aufsetzen.

Fit pre-heated housing up to stop.



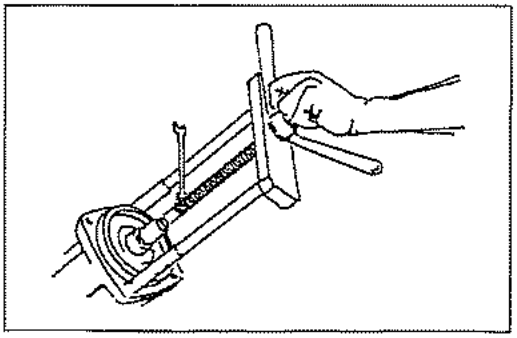
49 Neue Montagestellung

Re-position.



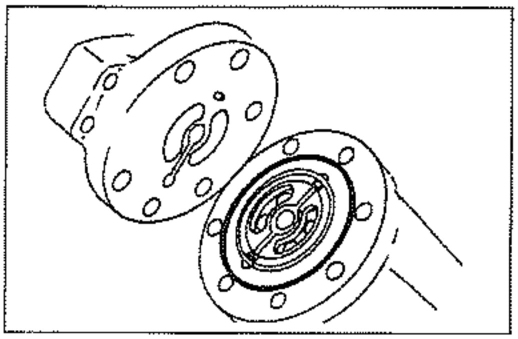
50 Paßscheiben beilegen und weitere Montage entsprechend Bild 11 - 14.

Insert shims and assemble to figs. 11 - 14.



51 Triebwerk gegen Verschlußring ziehen. Kontrolle: Verschlußring spielfrei.

Pull the rotary group against the cover plate. Check that the cover plate cannot move!

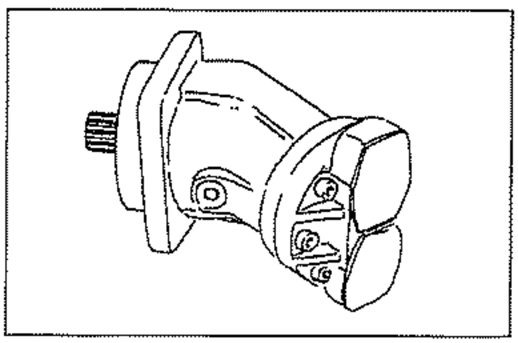


52 Fertigmontage entsprechend Bild 22 - 24.

⚠ Abstimmung Pos. D - siehe Serviceinfo

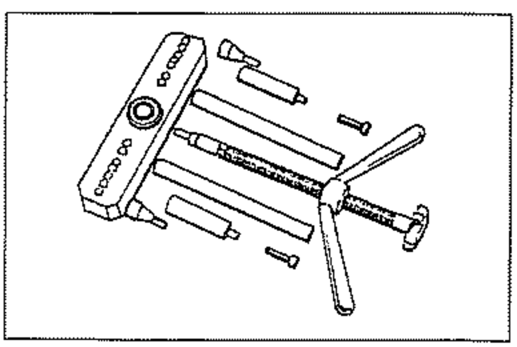
Completely assemble to figs. 22 - 24.

⚠ Adjustment of Pos. D - see service info



53 Anschlüsse mit Staubschutz abdichten. Korrosionsschutz (innen/außen). Fertig!

Seal connections to protect against dust. Corrosion proctection (internal/external). Assembly complete.



54 Ausziehvorrichtung für Triebwerk (Bild 24).

Extractor for rotary group (Fig. 24).

Anziehdrehmomente für Schaftschrauben (Metrisches ISO-Regelgewinde)

Die nebenstehenden Werte für Anziehdrehmomente gelten nur für Schaftschrauben mit metrischem ISO-Regelgewinde und Kopfauflagemaßen nach DIN 912, DIN 931 und DIN 933. Außerdem gelten diese Werte nur für leicht oder nicht geölte, unbehandelte Oberflächen, sowie nur bei Verwendung von Drehmoment- und Kraftbegrenzungsschlüsseln.

Gewindegröße	Festigkeitsklassen 8.8	10.9	12.9
	Anziehdrehmoment (Nm)		
M 3	1,1	1,6	1,9
M 4	2,9	4,1	4,9
M 5	6	8,5	10
M 6	10	14	17
M 8	25	36	41
M10	49	69	83
M12	86	120	145
M14	135	190	230
M16	210	295	355
M18	290	405	485
M 20	410	580	690
M 22	550	780	930
M 24	710	1000	1200
M 27	1050	1500	1800
M 30	1450	2000	2400

Tightening torques for shaft bolts (Metric ISO Standard Thread)

The values for tightening torques shown in the table are valid only for shaft bolts with metric ISO- standard threads and head support surface dimensions in accordance with DIN 912, DIN 931 and DIN 933. These values are also valid only for light or unoiled, untreated surface as well as for use only with torque-indicating wrenches and force limiting tools.

Thread size	Strength Classes 8.8	10.9	12.9
	Tightening Torque (lb.ft)		
M 3	0,8	1,2	1,4
M 4	2,1	3,0	3,6
M 5	4,4	6,3	7,4
M 6	7,4	10,3	12,5
M 8	18,4	25,8	30,2
M10	36,1	50,9	61,2
M12	63,4	88,4	106,9
M14	99,5	140,0	169,5
M16	154,8	217,4	261,6
M18	213,7	298,5	357,4
M 20	302,2	427,5	508,5
M 22	405,4	574,9	685,4
M 24	523,5	737,0	884,4
M 27	773,9	1105,5	1326,6
M 30	1068,7	1474,0	1768,8

Anziehdrehmomente für Verschlußschrauben VSTI (Metrisches Feingewinde)

Gewindegröße	Bezeichnung		Anziehdrehmoment (Nm)
M 8 x 1	VSTI 8 x 1	-ED/SA	≈ 5
M 10 x 1	VSTI 10x1	-ED	≈ 10
M 12 x 1,5	VSTI 12 x 1,5	-ED	≈ 20
M 14 x 1,5	VSTI 14 x 1,5	-ED	≈ 30
M 16 x 1,5	VSTI 16 x 1,5	-ED/SA	≈ 30
M 18 x 1,5	VSTI 18 x 1,5	-ED/SA	≈ 40
M 20 x 1,5	VSTI 20 x 1,5	-ED/SA	≈ 50
M 22 x 1,5	VSTI 22 x 1,5	-ED	≈ 60
M 26 x 1,5	VSTI 16 x 1,5	-ED/SA	≈ 70
M 27 x 2	VSTI 27 x 2	-ED	≈ 90
M 30 x 1 ,5	VSTI 30 x 1,5	-ED/SA	≈ 100
M 33 x 2	VSTI 33 x 2	-ED/SA	≈ 120
M 42 x 2	VSTI 42 x 2	-ED/SA	≈ 200
M 48 x 2	VSTI 48 x 2	-ED	≈ 300

Tightening torques for locking screws VSTI (Metric ISO fine thread)

Thread size	Designation		Tightening torques (lb.ft)
M 8 x 1	VSTI 8 x 1	-ED/SA	≈ 4
M 10 x 1	VSTI 10x1	-ED	≈ 7
M 12 x 1,5	VSTI 12 x 1,5	-ED	≈ 15
M 14 x 1,5	VSTI 14 x 1,5	-ED	≈ 22
M 16 x 1,5	VSTI 16 x 1,5	-ED/SA	≈ 22
M 18 x 1,5	VSTI 18 x 1,5	-ED/SA	≈ 29
M 20 x 1,5	VSTI 20 x 1,5	-ED/SA	≈ 37
M 22 x 1,5	VSTI 22 x 1,5	-ED	≈ 44
M 26 x 1,5	VSTI 16 x 1,5	-ED/SA	≈ 51
M 27 x 2	VSTI 27 x 2	-ED	≈ 66
M 30 x 1 ,5	VSTI 30 x 1,5	-ED/SA	≈ 74
M 33 x 2	VSTI 33 x 2	-ED/SA	≈ 88
M 42 x 2	VSTI 42 x 2	-ED/SA	≈ 147
M 48 x 2	VSTI 48 x 2	-ED	≈ 220

Anziehdrehmomente für Seal-Lock Bundmuttern (Metrisches ISO-Regelgewinde)

Die nebenstehenden Werte für Anziehdrehmomente gelten nur für Seal-Lock Bundmuttern der Festigkeitsklasse 8.8 mit metrischem ISO-Regelgewinde.

Gewindegröße	Festigkeitsklassen 8.8	10.9	12.9
	Anziehdrehmoment (Nm)		
M 6	10		
M 8	22		
M 10	40		
M 12	69		
M 14	110		
M 16	170		

Tightening torques for seal-lock nuts (Metric ISO-Standard Thread)

The values for tightening torques shown in the table are valid only for seal-lock nuts of the strength class 8.8 and with metric ISO-standard thread.

Thread size	Strength classes 8.8	10.9	12.9
	Tightening torque (lb.ft)		
M 6	7,4		
M 8	16,2		
M 10	29,5		
M 12	50,9		
M 14	81,1		
M 16	125,3		

Anziehdrehmomente für Linsenschrauben mit Kreuzschlitz DIN 7985 (Metrisches ISO-Regelgewinde)

Die nebenstehenden Werte für Anziehdrehmomente gelten nur für Linsenschrauben mit Kreuzschlitz DIN 7985 der Festigkeitsklasse 8.8 mit metrischem ISO-Regelgewinde

Gewindegröße	Festigkeitsklassen 8.8	10.9	12.9
	Anziehdrehmoment (Nm)		
M 3	1,1		
M 4	2,9		
M 5	6		
M 6	10		
M 8	25		
M10	49		

Tightening torques for cross-slotted lens head screws DIN 7985 (Metric ISO- Standard Thread)

The values for tightening torques shown in the table are valid only for cross-slotted lens head screws DIN 7985 of the strength class 8.8 and with metric ISO-standard thread.

Thread size	Strength classes 8.8	10.9	12.9
	Tightening torques (lb.ft)		
M 3	0,8		
M 4	2,1		
M 5	4,4		
M 6	7,4		
M 8	18,4		
M10	36,1		

Allgemein

- Machen Sie sich mit der Ausstattung der Maschine vertraut.
- Fahren Sie die Maschine nur, wenn Sie sich völlig mit den Bedien- und Steuerelementen sowie der Arbeitsweise der Maschine vertraut gemacht haben.
- Benutzen Sie Ihre Schutzausrüstung wie Schutzhelm, Sicherheitsschuhe und Gehörschutz.
- Machen Sie sich mit Ihrem Arbeitsgebiet vertraut.
- Benutzen Sie die Maschine nur für den ihr zugedachten Zweck.

Beachten Sie bitte die Richtlinien der Berufsgenossenschaft und des Maschinenherstellers

General advice

- Make yourself familiar with the equipment of the machine.
- Only operate the machine if your are completely familiar with the operating and control elements as well as the functioning of the machine.
- Use your safety equipment like helmet, safety shoes and hearing protection.
- Make yourself familiar with your working field.
- Only operate the machine for its intended purpose.

Please observe the guidelines of the Professional Association and the machine manufacturer.

Vor dem Start

- Beachten Sie die Bedienungshinweise vor dem Starten.
- Prüfen Sie die Maschine aut auffällige Fehler.
- Fahren Sie die Maschine nicht mit defekten Instrumenten, Kontrolleuchten oder Steuerorganen.
- Alle Schutzvorrichtungen müssen fest auf ihrem Platz sein.
- Nehmen Sie keine losen Gegenstände mit bzw. befestigen Sie diese an der Maschine.
- Halten Sie die Maschine von öligem und zündfähigem Material frei.
- Prüfen Sie vor dem Besteigen der Maschine, ob sich Personen oder Hindernisse neben oder unter der Maschine befinden.
- Vorsicht beim Besteigen der Maschine, benützen Sie Treppen und Griffe.
- Stellen Sie vor dem Start Ihren Sitz ein.

Before starting

- Observe the operating instructions before starting.
- Check the machine for remarkable faults.
- Do not operate the machine with defective instruments, warning lights or control elements.
- All safety devices must be in a secure position.
- Do not carry with you movable objects or secure them to the machine.
- Keep oily and inflammable material away from the machine.
- Before entering thc driver's cabin, check if persons or obstacles are beside or beneath the machine.
- Be careful when entering the driver's cabin, use stairs and handles.
- Adjust your seat before starting.

Starten

- Beim Starten müssen alle Bedienhebel in "Neutralstellung" stehen.
- Die Maschine nur vom Fahrersitz aus Starten.
- Prüfen Sie die Anzeigeinstrumente nach dem Start, um sicher zu gehen, daß alles ordnungsgemäß funktioniert.
- Lassen Sie die Maschine nicht unbewacht, während der Motor läuft.
- Beim Start mit Batterieverbindungskabeln verbinden Sie Plus mit Plus und Minus mit Minus. Massekabel (Minus) immer zuletzt anschliesen und zuerst abtrennen.

Vorsicht

- Auspuffgase sind lebensgefährlich. Bei Start in geschlossenen Räumen für ausreichende Luftzufuhr sorgen!

Hydraulikanlage

1. Hydraulikanlage steht unter hohem Druck!

⚠ Unter hohem Druck austretende Hochdruck-Flüssigkeiten (Kraftstoff, Hydrauliköl) können die Haut durchdringen und schwere Verletzungen verursachen. Daher sofort einen Arzt aufsuchen, da anderenfalls schwere Infektionen entstehen können!

2. Bei der Suche nach Leckstellen wegen Ver letzungsgefahr geeignete Hilfsmittel verwenden!
3. Vor Arbeiten an der Hydraulikanlage diese unbedingt drucklos machen und angebaute Geräte absenken!
4. Bei Arbeiten an der Hydraulikanlage unbedingt Motor abstellen und Traktor gegen Wegrollen sichern (Feststellbremse, Unterlegkeil)!
5. Beim Anschließen von Hydraulikzylindern und -motoren ist auf vorgeschriebenen Anschluß der Hydraulikschläuche zu achten!
6. Bei Vertauschen der Anschlüsse umgekehrte Funktionen (z.B. Heben/Senken) - Unfallgefahr!
7. Hydraulikschlauchleitungen regelmäßig kontrollieren und bei Beschädigung und Alterung austauschen! Die Austauschschlauchleitungen müssen den technischen Anforderungen des Geräteherstellers entsprechen!

⚠ Öle, Kraftstoffe und Filter ordnungsgemäß entsorgen!

Start

- When starting all operating levers must be in "neutral position".
- Only start the machine from the driver's seat
- Check the indicating instruments after start to assure that all functions are in order.
- Do not leave the machine unobserved when the motor is running.
- When starting with battery connection cables connect plus with plus and minus with minus. Always connect mass cable (minus) at last and cut off at first.

Attention

- Exhaust gas is dangerous. Assure sufficient fresh air when starting in closed rooms!

Hydraulic equipment

1. Hydraulic equipment is standing under high pressure.

⚠ High pressure fluids (fuel, hydraulic oil) which escape under high pressure can penetrate the skin and cause heavy injuries.
Therefore immediately consult a doctor as otherwise heavy infections can be caused.

2. When searching leakages use appropriate auxiliary devices because of the danger of accidents.
3. Before working at the hydraulic equipment, lower pressure to zero and lower working arms of the machine.
4. When working at the hydraulic equipment, absolutely stop motor and secure tractor against rolling away (parking brake, shim)!
5. When connecting hydraulic cylinders and motor pay attention to correct connection of hydraulic flexible hoses.
6. In case of exchanging the ports, the functions are vice versa (f. ex. lift-up/lower) - danger of accidents!
7. Check hydraulic flexible hoses regularly and replace them in case of dammage or wear! The new hose pipes must comply with the technical requirements of the machine manufacturer!

⚠ Orderly disposal or recycling of oil, fuel and filters!

Brueninghaus Hydromatik GmbH, Werk Elchingen, Glockeraustraße 2, D-89275 Elchingen, Tel. (07308) 820, Telex 712538, Fax (07308) 7274

Rexroth
Bosch Group

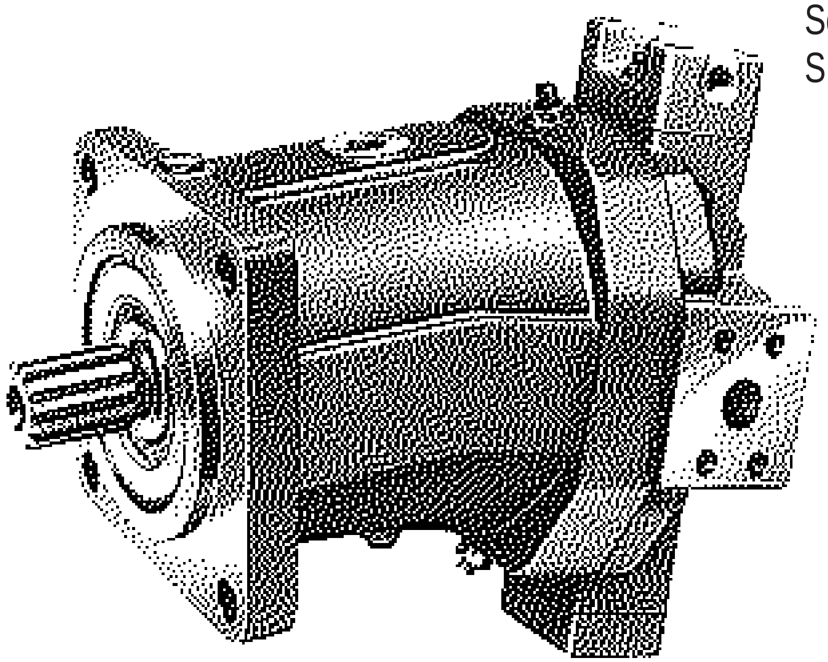
Bosch Rexroth AG
Mobile Hydraulics
Glockeraustraße 2
89275 Elchingen, Germany
Telefon +49 (0) 73 08 8170-1
Telefax +49 (0) 73 08 82 2683
info.brm@boschrexroth.de
training.elchingen@boschrexroth.de
www.boschrexroth.com/brm

Printed in Germany
RDE 92 500-02-R/03.04

Application &
Service Manual

AA6VM

Series 6.3
Size 55…200



RA 91604-S
12.97

Index

Introduction

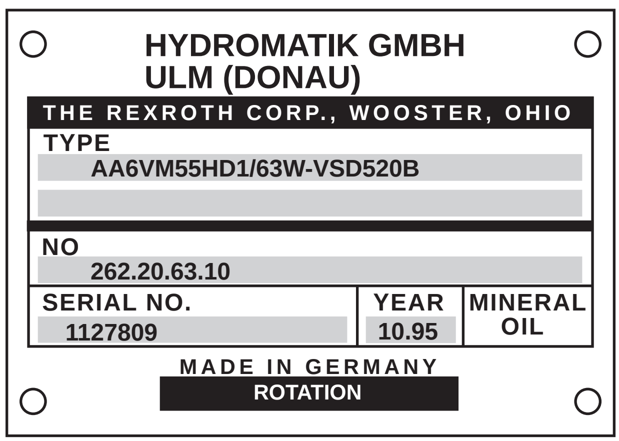
This manual is intended to provide the information required to successfully start up, adjust, trouble shoot and service the Rexroth Variable Displacement Motor, Model AA6VM.
The adjustment and disassembly procedures described herein may be performed in clean conditions without affecting the warranty. Dismantling the units beyond the stages described in this manual without the express permission of Rexroth may void the warranty.
When performing any type of service or conversion to these motors, the utmost cleanliness of work area, tools, cleaning rags, and the components is required. Dirt and contamination introduced during assembly and service is a major cause of failure in high pressure piston equipment. Therefore, the importance of cleanliness cannot be over emphasized.
For dimensions and detailed descriptions of the function of the various controls, please refer to brochure RA 91604.

Ordering of Parts

For Rexroth to supply the correct parts for your unit, please include all of the following information along with your parts order.

Model Code
Serial Number
Unit Number
Part Name
Part Number

Due to modifications and improvements to our products, minor changes can occur to the parts, even though the type code may not necessarily reflect these changes. The type number and serial number will guarantee that the correct parts for your unit are supplied.



Ordering Example

To order a replacement viton shaft seal for an AA6VM variable displacement motor having the above nameplate, the following information would be required.

+	**Model Code**	**AA6VM55HD1/63W-VSC520B**
+	**Serial Number**	**1127809**
+	**Unit Number**	**5621-004-014**
*	**Part Name**	**Shaft Seal**
*	**Part Number**	**5000-076-026**

+ This information is taken from the nameplate on the motor.
* This information is taken from page 25.

Variable Displacement Motor AA6VM

Ordering Code

Fluid

Petroleum Oil *(No Code)*	

Axial Piston Unit

Variable bent axis design, SAE *p_N = 5800 psi (400); p_{max} = 6500 psi (450)*	**AA6V**

Mode of Operation

Motor	**M**

Size

≈ Displacement $V_{g\,max}$ (cm^3)	**28**①	**55**	**80**	**107**	**140**①	**160**	**200**
≈ Displacement $V_{g\,max}$ (in^3)	**1.71**	**3.34**	**4.88**	**6.53**	**8.54**	**9.76**	**12.20**

Control Options

					28①	55	80	107	140①	160	200	
Hydraulic control pilot pressure related	HD	1				●	●	●		●	●	**HD1**
	HD		2			●	●	●		●	●	**HD2**
	HD	1		D		●	●	●		●	●	**HD1D**
	HD		2	D		●	●	●		●	●	**HD2D**

Pilot pressure increase Δp=145 psi (10 bar) (1)
Pilot pressure increase Δp=365 psi (25 bar) (2)
With constant pressure control (D)

					28①	55	80	107	140①	160	200	
Hydraulic two-position control	HZ1					●	●	●		●	●	**HZ1**
	HZ3					❍	❍	❍		–	–	**HZ3**
Electrical control with proportional solenoid	EP	1				●	●	●		●	●	**EP1**
	EP		2			●	●	●		●	●	**EP2**
	EP	1		D		●	●	●		●	●	**EP1D**
	EP		2	D		●	●	●		●	●	**EP2D**

Control Voltage 12V (1)
Control Voltage 24V (2)
With constant pressure control (D)

					28①	55	80	107	140①	160	200	
Electrical two-position control with switching solenoid	EZ	1				●	●	●		●	●	**EZ1**
	EZ		2			●	●	●		●	●	**EZ2**
	EZ	3				❍	❍	❍		–	–	**EZ3**
	EZ		4			❍	❍	❍		–	–	**EZ4**

Control Voltage 12V
Control Voltage 24V

					28①	55	80	107	140①	160	200	
Automatic control high pressure related	HA	1				●	●	●		●	●	**HA1.**
	HA		2			●	●	●		●	●	**HA2.**

Model without pressure increase (1)
with pressure increase Δp=1450 psi (100 bar) (2)

Override Controls	**HA1**	**HA2**	
Without override (omit)	●	●	
With hydraulic override	●	●	**T**
With electrical override 12V	●	●	**U1**
With electrical override 24V	●	●	**U2**
With el. override, drive dir. valve 12V	●	●	**R1**
With el. override, drive dir. valve 24V	●	●	**R2**

Hydraulic control, speed dependent — DA	28①	55	80	107	140①	160	200	
P_{St} / P_{HD} = 5/100, hydraulic drive dir. valve		●	●	●		●	●	**DA1**
Electrical drive direction valve (12V) + electrical Q_{max} switching (12V)		●	●	●		●	●	**DA2**
Electrical drive direction valve (24V) + electrical Q_{max} switching (24V)		●	●	●		●	●	**DA3**
P_{St} / P_{HD} = 8/100, hydraulic drive dir. valve		●	●	●		●	●	**DA4**
Electrical drive direction valve (12V) + electrical Q_{max} switching (12V)		●	●	●		●	●	**DA5**
Electrical drive direction valve (24V) + electrical Q_{max} switching (24V)		●	●	●		●	●	**DA6**

① Size 28 and 140 Available in ISO Version Only, see Data Sheet RE 91604
● Available
– Not Available
❍ On Request; Consult Factory

AA6V	**M**			**/**	**6**	**3**	**W**	**–**	**V**	**S**					

Axial Piston Unit

Mode of Operation

Displacement

Control Options

Series

	6

Index

	3

Direction of Rotation

Bi-directional **(**As viewed from drive shaft)	**W**

Seals

FPM **Phosphate ester fluids*	**V**

Shaft Type	28①	55	80	107	140①	160	200	
Spline–SAE		●	●	●		●	●	**S**

Mounting Flange	28①	55	80	107	140①	160	200	
SAE 2–bolt		–	●	–		–	–	**C**
SAE 4–bolt		●	–	●		●	●	**D**

Port Connections	28①	55	80	107	140①	160	200	
Ports A & B; *(SAE, rear end)*		❍	❍	❍		❍	❍	**51**
Ports A & B; *(SAE 4–bolt flange), on opposite sides*		●	●	●		●	●	**52**
Port plate with secondary valves, for mounting a motion control valve (ports A, B: rear end) ③		–	–	●		–	–	**37**
Port plate with secondary valves, for mounting a motion control valve (ports A, B: rear end) ③		●	●	●		●	–	**38**

Valves	28①	55	80	107	140①	160	200	
Without valve		●	●	●		●	●	**0**
With built-on flushing valve ④		●	●	●		●	●	**7**

Speed Sensor	28①	55	80	107	140①	160	200	
Without speed sensor *(no code)*		●	●	●		●	●	**Omit**
With provisions for speed sensor		❍	❍	❍		❍	❍	**D**

Beginning of Control	28①	55	80	107	140①	160	200	
At min. displace. $V_{g\,min}$ *(standard for HA)*		●	●	●		●	●	**A**
At max. displace. $V_{g\,max}$ *(standard for HD, HZ, EP, EZ, DA)*		●	●	●		●	●	**B**

① Size 28 and 140 Available in ISO Version Only, see Data Sheet RE 91604

③ Only possible in connection with controls HD, HA1, HA2.

④ For design with motion control valve (port plate 37 or 38) the use of a built-on flushing valve is not possible.

● Available

❍ On Request; Consult Factory

– Not Available

Technical Data

Fluid Recommendations

The AA6VM motor in the standard design, should be used with good quality, petroleum oil based, anti-wear hydraulic fluids. More detailed information regarding the selection of hydraulic fluids and their application limits can be found in our Data Sheets RA 90220 *(Petroleum Oil)*, RA 90221 *(Biodegradable Fluids)* and RA 90223 *(Type HF-Fire Resistant/Synthetic Fluids).*

When operating with environmentally compatible fluids *(Biodegradable)* or fire resistant fluids *(Type HF Synthetic)* possible reduction of the operating specifications may be required. Please consult us and your fluid supplier.

Operating Viscosity Range *(See Selection Diagram)*

In order to obtain optimum efficiency and service life, we recommend that the operating viscosity *(at normal operating temperature)* be selected from within the range.

Optimum Viscosity (ν_{opt}) . . . . 80–170 SUS (16–36 mm²/s)

Viscosity Limits

The limiting values for viscosity are as follows:
Maximum Viscosity (ν_{max}) . . . . 7400 SUS (1600 mm²/s)
Only for short periods during cold start-up (t_{min} = -40°F/C)
Absolute Minimum Viscosity (ν_{min}) . . . . 42 SUS (5 mm²/s)

Operating Temperature Range

Min. operating temp. . . . . -13°F (-25°C)
Absolute min temp. . . . . -40°F (-40°C)
Max. operating temp. for short duration . . . . 240°F (115°C)

Please note that applications with low start-up temperatures -40...-15°F (-40...-25°C) may require special installation positions, please consult us.

Notes on Hydraulic Fluid Selection

In order to select the correct fluid, it is necessary to know the normal operating temperature in the circuit in relation to the ambient temperature - In an open circuit, the reservoir temperature and in a closed circuit, the loop temperature.

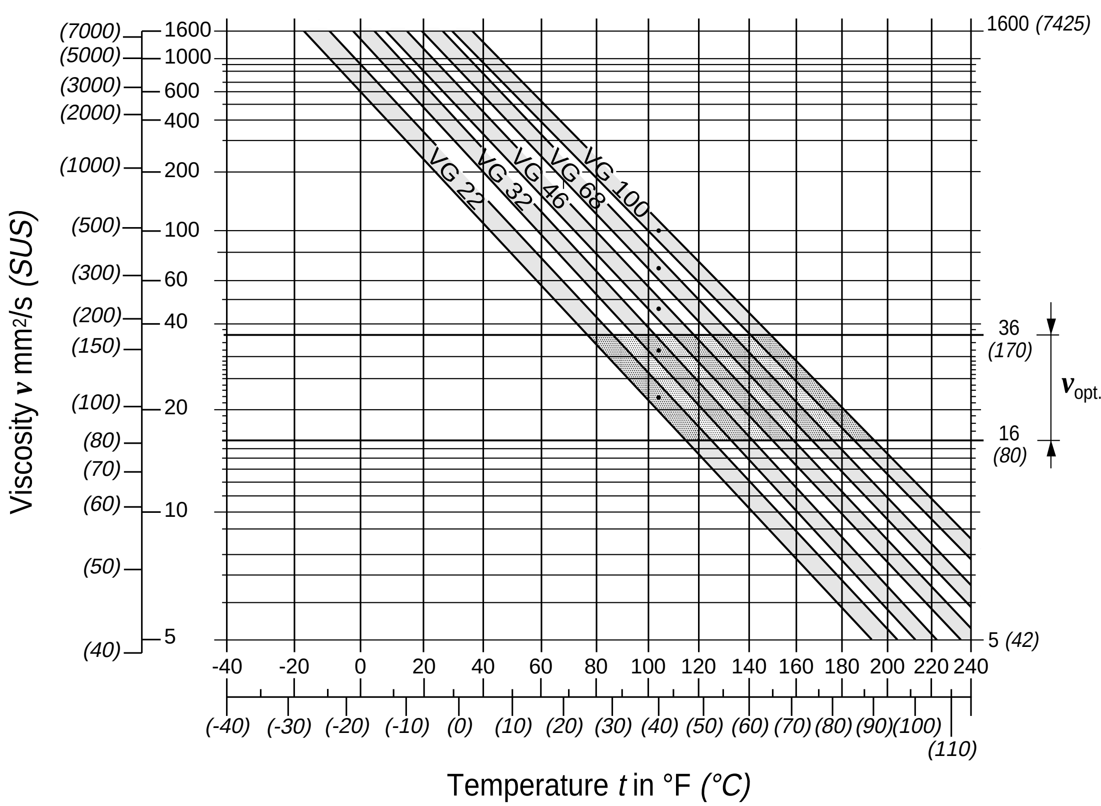
The hydraulic fluid should be selected so that, within the operating temperature range, the fluid viscosity is within the optimum range ν_{opt} *(see shaded area of the fluid selection diagram).* We recommend that the higher viscosity grade is selected in each case.

Example: At an ambient temperature of X°, the operating temperature in the reservoir is 140°F (60°C). In the optimum operating viscosity range ν_{opt}, (shaded area), this corresponds to viscosity grades VG46 or VG68, VG68 should be selected.

Important: The leakage fluid *(case drain fluid)* temperature is influenced by pressure and speed and is typically higher than the circuit temperature. However, maximum temperature at any point in the system must be less than 240°F (115°C).

If it is not possible to comply with the above conditions because of extreme operating parameters or high ambient temperature, please consult us.

Selection Diagram



Technical Data

Built-On Flushing Valve

The built-on flushing valve is set at a fixed pressure of 230 psi* (16 bar) and serves to maintain the minimum boost pressure. A quantity of hydraulic fluid, determined by the orifice fitted (see table), is drawn off from the low pressure side and passed into the motor housing, from where it is led off to tank together with the leakage fluid. The fluid thus taken from the circuit must be replaced with cooled oil by means of the boost pump .
Different flushing volumes can be selected by means of orifices.
* set primary charge relief valve accordingly.
The following flushing volumes are possible:

Volume	Orifice No.
0.9 gpm (3.5 L/min)	HU09651766/503.12.01.01
1.3 gpm (5 L/min)	HU09419695/503.12.01.01
2.1 gpm (8 L/min)	HU09419696/503.12.01.01
2.6 gpm (10 L/min)	HU09419697/503.12.01.01
3.7 gpm (14 L/min)	HU09444361/503.12.01.01

Values given for charge pressure Δp = 360 psi (25 bar)
When ordering please state required orifice in clear text.

For Flushing valve schematic and dimensions see page 24.

Installation Position

Optional. The unit may be mounted in any horizontal position *(drive shaft axis)*. Other mounting orientations *(Ex. drive shaft vertical)* are possible, see data sheet RA 90270 for further installation information.

The housing must be filled prior to start-up, and must always remain full of fluid. Therefore, the case drain line should be connected to the highest case drain port.

The case drain line, or hose should be sized to accept the full flow of the charge pump at the maximum anticipated drive speed, with minimal pressure drop.

Fluid Cleanliness Levels

In order to ensure proper and reliable operation, the hydraulic fluid must be maintained at a minimum cleanliness level of 18/15 *(according to ISO/DIS 4406; SAE J1165)*. Axial piston component life is directly dependent on the cleanliness of the fluid in the system.

Temperature Range	-40...195°F (-40...90°C)	195...240°F (90...115°C)
Cleanliness Recommendations:	Class	Class
ISO/DIS 4406 (SAE J1165)	18/15	17/14
NAS 1638	9	8
SAE	6	5

Filtration

Many factors influence the selection of a filter to achieve the desired cleanliness level, including: dirt ingression rate, required cleanliness level, and system complexity. We have found the following filter Beta (ß) ratios (ISO 4572) to be satisfactory:
$ß_{20...}ß_{30} \geq 100$

Direction of Flow

Clockwise Rotation	Counter-clockwise Rotation
A to B	B to A

Operating Pressure Range

Maximum pressure at port A or B
Nominal pressure p_n . . . . 5800 psi (400 bar)
Peak pressure p_{max} . . . . 6525 psi (450 bar)

The sum of the pressures at ports A and B must not exceed 10,000 psi (700 bar). Individual pressure per side of 6525 psi (450 bar) is not to be exceeded. This summation pressure is for intermittent duty only. Consult us for applications where continuous summation pressure greater than 7250 psi (500 bar) exists.

Speed Range

There is no limitation on minimum speed n_{min}. If smooth shaft rotation is required *(no cogging)*, then the minimum speed n_{min} should not be allowed to fall below 50 rpm.

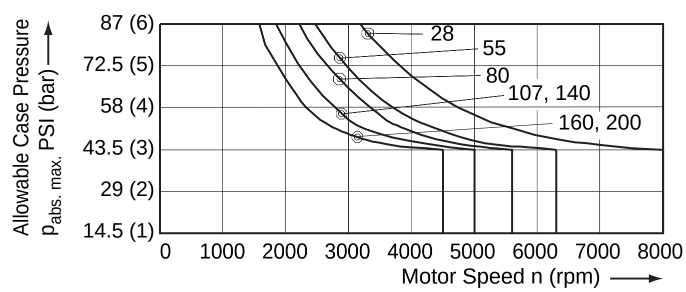
The maximum flow from the pump and the minimum displacement of the variable motor together determine the maximum output speed. The minimum displacement is mechanically limited by means of an adjustment screw, so that the maximum permissible speed (of the variable motor or driven unit) are not exceeded.

Adjustment range from $V_{g\,0}$ to $V_{g\,max}$

Minimum displacement ($V_{g\,min}$) is factory set and secured by a tamper proof cap. For special applications, the AA6VM series 6.3 is capable of zero displacement operation.
See table page 6 for maximum permissible speeds.

Case drain pressure

Maximum shaft seal life is achieved with low case pressures and low motor speeds. The values shown in the diagram are the maximum permissible case pressure and speed conditions, and should not be exceeded. Exceeding these values will result in decreased shaft seal life. For short periods (t < 5 min.) case pressures up to 75 psi (5 bar) regardless of drive speed are permissible, and up to 90 psi (6 bar) at low speeds.



Special operating conditions may require limitations of these values.
Note:
Maximum permissible motor speeds are given on page 8.
Max. permissible case pressure $p_{abs.\,max}$. . . . . 90 psi (6 bar)
The pressure in the housing must be the same or greater than the external pressure on the shaft seal.

Variable Displacement Motor AA6VM

Technical Data

Table of Values (Theoretical values rounded)

Size				28	55	80	107	140	160	200
Displacement	Variable motor	$V_{g\,max}$	cm³/rev	28.1	54.8	80	107	140	160	200
			in³/rev	1.71	3.34	4.88	6.53	8.54	9.76	12.20
		$V_{g\,0}$ 1)	cm³/rev	0	0	0	0	0	0	0
			in³/rev	0	0	0	0	0	0	0
Speed	max. rpm at $V_{g\,max}$	$n_{max\,cont}$	rpm	5300	4200	3750	3300	3150	3000	2750
	max. rpm at $V_{g\,max}$	$n_{max\,intermittent}$ 2)	rpm	5850	4600	4100	3650	3450	3300	3000
	max. rpm at $V_g < V_{g\,.1}$		rpm	8000	6300	5600	5000	4700	4500	4100
	$V_{g\,.1}$		cm³/rev	19	37	54	71	93	107	134
			in³/rev	1.16	2.26	3.30	4.33	5.68	6.53	8.18
	max. rpm at $V_{g\,0}$		rpm	8800	7100	6300	5600	5200	5000	4500
Flow	at $n_{max\,cont}$ and $V_{g\,max}$	Q_{max}	L/min	149	230	300	353	441	480	550
			gpm	39.4	60.8	79.3	93.3	116.5	126.8	145.3
Torque Constant	at $V_{g\,max}$	T_k	Nm/bar	0.446	0.87	1.27	1.70	2.23	2.54	3.18
			lb-ft/psi	0.02	0.04	0.06	0.09	0.11	0.13	0.16
Torque	at $V_{g\,max}$ (Δp = 400 bar)	T_{max}	Nm	178	348	510	679	891	1016	1273
	(Δp = 5800 psi)		lb-ft	131.3	256.7	376.2	500.8	657.2	749.4	938.9
Power	at $n_{max\,cont}$ (Δp = 400 bar)	P_{max}	kW	99	153	200	235	294	320	367
	(Δp = 5800 psi)		hp	132.8	205.2	268.2	315.1	394.3	429.1	492.1
Moment of inertia (about drive axis)		J	Kgm²	0.0014	0.0042	0.0080	0.0127	0.0207	0.0253	0.0353
			lb-ft²	0.033	0.100	0.190	0.301	0.491	0.600	0.838
Weight (approximate)		m	kg	16	26	34	47		64	80
			lbs.	35.3	57.3	75.0	103.4		141.1	176.4

1) The minimum displacement $V_{g\,min}$ is infinitely adjustable between $V_{g\,0}$ and 0.8 • $V_{g\,max}$. **Indicate in the order: $V_{g\,min}$ = ...cm³ !**

2) Intermittent max. speed: overspeed at high-idle and over-running travel operation, t < 5 sec. and Δp < 2200 psi (150 bar).

Output Drive

Permissible axial and radial loading on drive shaft. The values given are max. values and not permissible for continuous operation.

Size			28	55	80	107	140	160	200
Distance of F_q from shaft shoulder	a	mm	12.5	15	17.5	20	22.5	22.5	25
		in	0.49	0.59	0.69	0.79	0.89	0.89	0.98
Maximum perm. radial load	$F_{q\,max}$	N	5696	10440	13114	15278	17808	20320	22896
		lbs.	1281	2347	2948	3435	4003	4568	5147
Radial load/unit of operating pressure	F_q /bar	N/bar	14.2	23.2	29.1	34.0	39.6	45.2	50.9
	F_q / psi	lb/psi	0.22	0.36	0.45	0.53	0.61	0.70	0.79
Maximum perm. axial load when stationary or in bypass operation	$\pm F_{ax\,max}$	N	315	500	710	900	1030	1120	1250
		lbs.	70.8	112.4	159.6	202.3	231.6	251.8	281.0
Maximum perm. axial load/unit of operating pressure	$\pm F_{ax\,perm}$/bar	N/bar	4.6	7.5	9.6	11.3	13.3	15.1	17.0
	$\pm F_{ax\,perm}$/psi	lb/psi	0.07	0.12	0.15	0.18	0.21	0.23	0.26

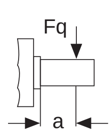
Definitions

a = Distance of F_q from shaft shoulder

$F_{q\,max}$ = Maximum perm. radial load

F_q /psi (bar) = Radial load/unit oper. pressure (with min. pinion dia $D_{R\,min}$ and $V_{g\,max}$) for gear drive ($D_{R\,min}$ = 2.5 x $D_{shaft\,end}$)

= required preload/unit operating pressure (radial load) to transmit torque with V-belt drive (DIN 7753) (with min. disc dia $D_{K\,min}$ and $V_{g\,max}$) ($D_{K\,min}$ = 5 x $D_{shaft\,end}$)



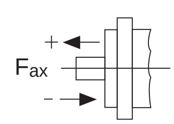
$\pm F_{ax\,max}$ = max. perm. axial load when stationary or in bypass operation

$\pm F_{ax\,perm}$/psi = max. perm. axial load/unit operating pressure
$\pm F_{ax\,perm}$/bar

The effective direction of the permissible axial load must be taken into consideration:

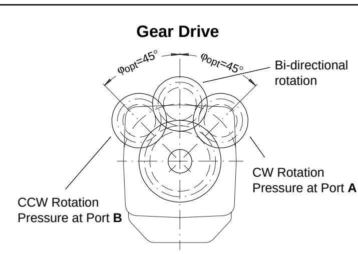
$-F_{ax\,max}$ = increased bearing life

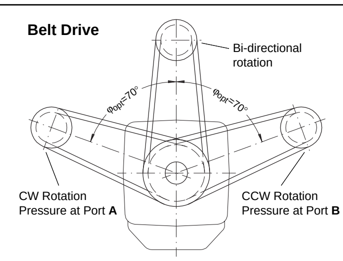
$+F_{ax\,max}$ = reduced bearing life (avoid if possible)



Optimal Force Direction of F_q

By means of appropriate force directions of F_q the bearing load caused by internal rotary group forces can be reduced. An optimum life expectancy of the bearing can be reached.





Technical Data

Speed, Displacement, Pressure, Torque

Diagram 1

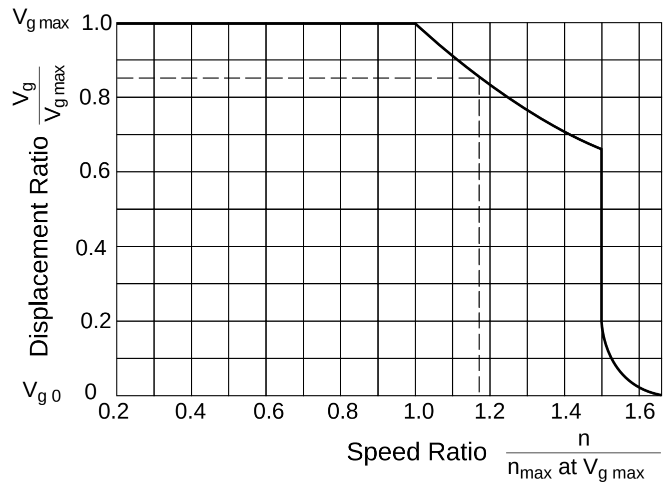
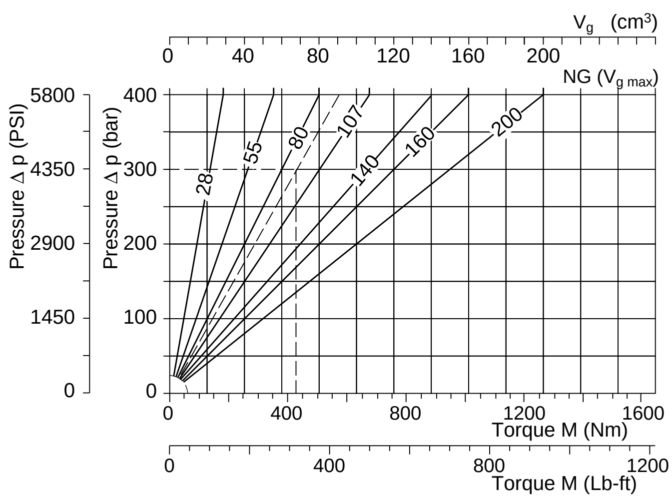


Diagram 2



Example

Given:
- Size 107
- Speed n = 3860 rpm
- n_{max} at $V_{g\,max}$ (see table of values)
- Pressure Δp = 4350 psi (300 bar)

Required:
- Max. perm. displacement
- Torque

Solution:
Speed ratio

$$\frac{n}{n_{max} \text{ at } V_{g\,max}} = \frac{3860}{3300} = 1.17$$

From diagram 1:
Displacement ratio

$$\frac{V_g}{V_{g\,max}} = 0.85$$

Therefore displacement $V_g = 0.85 \bullet V_{g\,max}$
$= 0.85 \bullet 107\ cm^3 = 91\ cm^3$

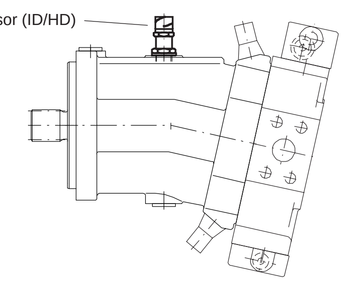
From diagram 2 displacement Vg = 91 cm^3 at pressure Dp = 4350 psi (300 bar) gives a torque of approximate. 320 lb-ft (435 Nm) (theoretical values, without considering efficiency).

Speed Sensor (D)

Version A6VM. . . D ("with provisions for speed sensor") includes toothed collar on the rotary group.
A speed-proportional signal is produced by means of the rotating, toothed rotary group which can be picked up by a suitable sensor and fed back for evaluation.
The speed sensor can be screwed into the upper drain port. An additional adapter piece is necessary for the drain ports in order to install the speed sensors (M18 x 1.5).

Size	28	55	80	107	140	160	200
No. of teeth	42	54	58	67	72	75	80
length of thread (mm)	19.9	19.9	19.9	19.9	31.9	31.9	31.9

The speed sensor is not included in standard supply;
Suitable sensors: ***order separately!***
– Inductive impulse detector ID (see RA 95038)
– Hall effect speed sensor HD (see RA 95042)



Reference Formulas

Input Flow
$$Q = \frac{V_g \bullet n}{231 \bullet \eta_v} \qquad \left(Q = \frac{V_g \bullet n}{1000 \bullet \eta_v}\right)$$

Output Torque
$$M = \frac{V_g \bullet \Delta p \bullet \eta_{mh}}{24 \bullet \pi} \qquad \left(M = \frac{1.59 \bullet V_g \bullet \Delta p \bullet \eta_{mh}}{100}\right)$$

Output Power
$$P = \frac{M \bullet n}{5252} = \frac{Q \bullet \Delta p \bullet \eta_t}{1714} \qquad \left(P = \frac{2\pi \bullet M \bullet n}{60000} = \frac{M \bullet n}{9549} = \frac{Q \bullet \Delta p \bullet \eta_t}{600}\right)$$

Output Speed
$$n = \frac{Q \bullet 231 \bullet \eta_v}{V_g} \qquad \left(n = \frac{Q \bullet 1000 \bullet \eta_v}{V_g}\right)$$

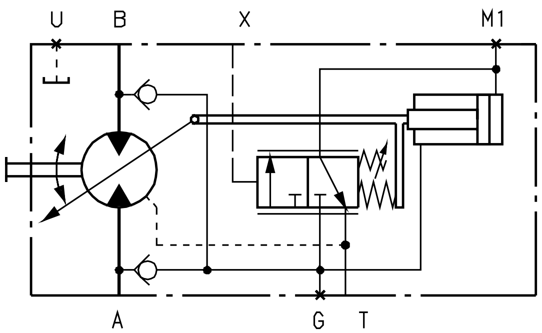
V_g = Geo. displacement - in^3 (cm^3)
M = Torque - lb-ft (Nm)
Δp = Pressure drop - psi (bar)
n = Speed - rpm
η_v = Volumetric Efficiency
η_{mh} = Mechanical hydraulic efficiency
η_t = Total efficiency ($\eta_t = \eta_v \times \eta_{mh}$)
Q = Flow - gpm (L/min)
P = Drive Power - hp (kW)

HD Hydraulic Control Pilot Pressure Related

The pilot pressure related hydraulic control allows infinite variation of the motor displacement in relation to a pilot pressure signal. The control function is proportional to the pilot pressure applied at port X.

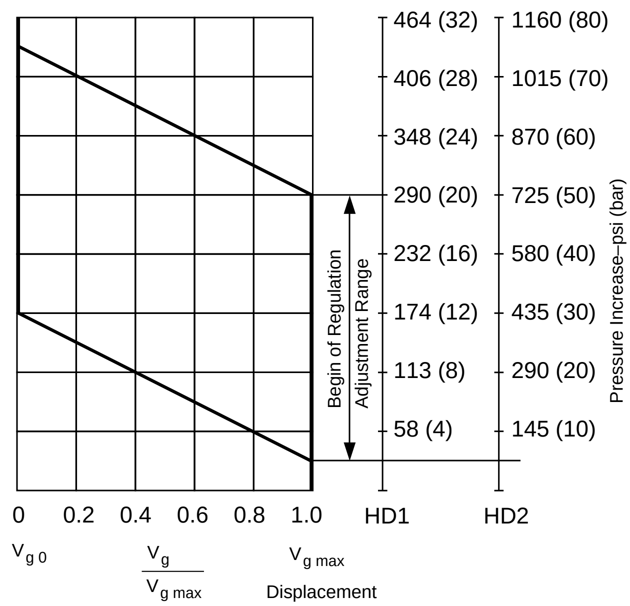
HD1
Pilot pressure increase ($V_{g\,max}$ - $V_{g\,0}$) . . . . Δp_S = 145 psi (10 bar)
Start of control, adjustable . . between 30–300 psi (2–20 bar)
Standard setting: start of control at 45 psi (3 bar)
end of control at 185 psi (13 bar)

HD2
Pilot pressure increase ($V_{g\,max}$ - $V_{g\,0}$) . . . . Δp_S = 360 psi (25 bar)
Start of control, adjustable . . . . . between 70–725 psi (5–50 bar)
Standard setting: start of control at 145 psi (10 bar)
end of control at 500 psi (35 bar)
When ordering please state required start of control in clear text, e.g. start of control at 45 psi (3 bar).



HD1; HD2

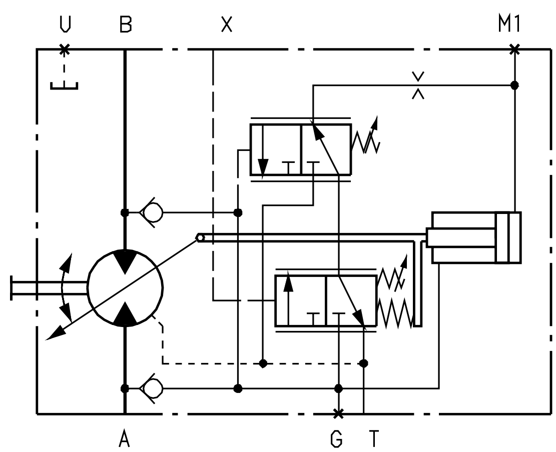
The required control oil is taken from the high pressure side; for this, a minimum operating pressure of 220 psi (15 bar) is necessary. If it is necessary to operate the control at an operating pressure of < 220 psi (15 bar), a boost pressure of min. 220 psi (15 bar) must be applied at port G via an external check valve.
Max. perm. pilot pressure . . . . 1450 psi (100 bar)



Standard version:
Start of control at $V_{g\,max}$ (max. torque, min. speed)
End of control at $V_{g\,min}$ (min. torque, max. speed)

Variation: Constant Pressure Control (D)

The constant pressure control is superimposed on the HD function. Should system pressure rise as a result of the load torque or reduction of the motor swivel angle, when the setting of the constant pressure control is reached the motor is swivelled out to a higher angle.
As a result of the increased displacement and consequent pressure reduction, the control deviation is eliminated. By increasing the displacement the motor produces a higher torque at a constant pressure.
Setting range of constant pressure control valve:
1160...5800 psi (80...400 bar).



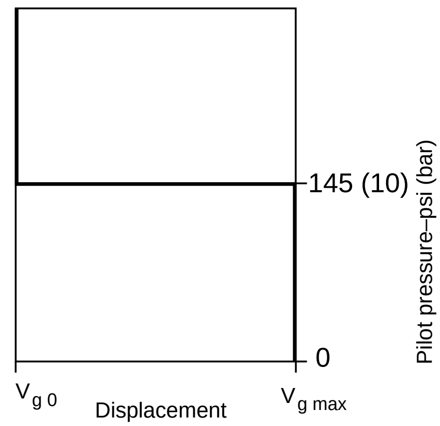
HD1D;HD2D

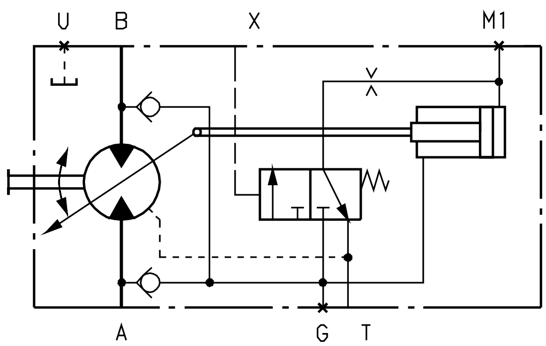
Control Characteristics	Units	HD1	HD2	HD1D	HD2D
Adjustable range: pilot pressure at “X” for	psi	30	70	30	70
control begin	(bar)	(2-20)	(5-50)	(2-20)	(5-50)
Pilot pressure increase (Δp) for displacement	psi	145	360	145	360
adjustment V_{max} to V_{min}	bar	(10)	(25)	(10)	(25)
Maximum allowable pilot pressure at “X”	psi	1450	1450	1450	1450
	(bar)	(100)	(100)	(100)	(100)
Minimum system pressure required at port A, B,	psi	220	220	220	220
or G for correct control function	bar	(15)	(15)	(15)	(15)

HZ Hydraulic Two-Position Control

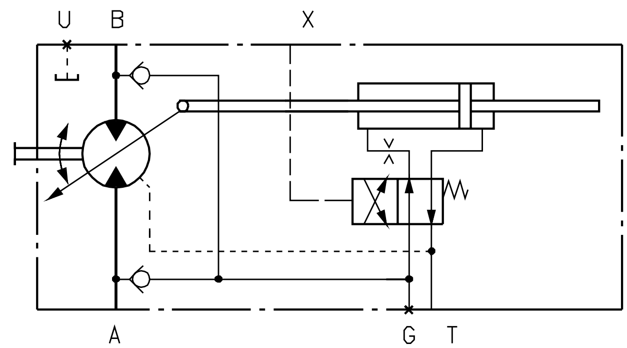
The hydraulic two-position control allows the displacement to be set to $V_{g\,min}$ or $V_{g\,max}$ by applying or venting pilot pressure at port X.
The required control oil is taken from the high pressure side; for this, a minimum operating pressure of 220 psi (15 bar) is necessary. If it is necessary to operate the control at an operating pressure of < 220 psi (15 bar), a boost pressure of min. 220 psi (15 bar) must be applied at port G via an external check valve.

Standard version
Pilot pressure at port X = 0 psi motor set to $V_{g\,max}$
Pilot pressure at port X ≥ 145 psi (10 bar) motor set to $V_{g\,min}$





HZ1
Size 55, 80, 107, 140, 160, 200



HZ3
Size 55, 80, 107

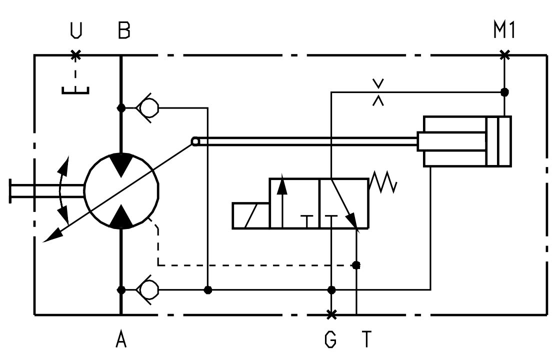
EZ Electrical Two-Position Control with Switching Solenoid

The electrical two-position control with switching solenoid allows the displacement to be set to $V_{g\,min}$ or $V_{g\,max}$ by energizing or de-energizing the solenoid.

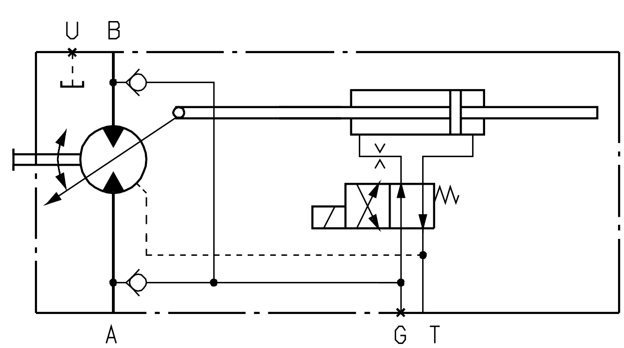
Solenoid de-energized motor set to $V_{g\,max}$
Solenoid energized motor set to $V_{g\,min}$

EZ1, EZ3	switching solenoid 12 V DC, 26W (EZ1) 30W (EZ3)
EZ2, EZ4	switching solenoid 24 V DC, 26W (EZ2) 30W (EZ4)

The required control oil is taken from the high pressure side; for this, a minimum operating pressure of 220 psi (15 bar) is necessary. If it is necessary to operate the control at an operating pressure of < 220 psi (15 bar), a boost pressure of minimum 220 psi (15 bar) must be applied at port G via an external check valve.



EZ1, EZ2
Size 55, 80, 107, 140, 160, 200



EZ3, EZ4
Size 55, 80, 107

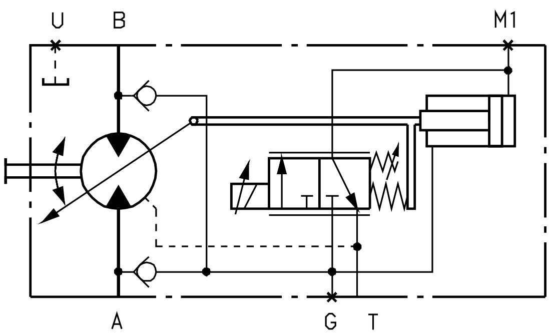
EP Electrical Control with Proportional Solenoid

The electrical control with proportional solenoid allows infinite variation of the motor displacement in relation to an electrical signal.
The control function is proportional to the electrical control current applied.

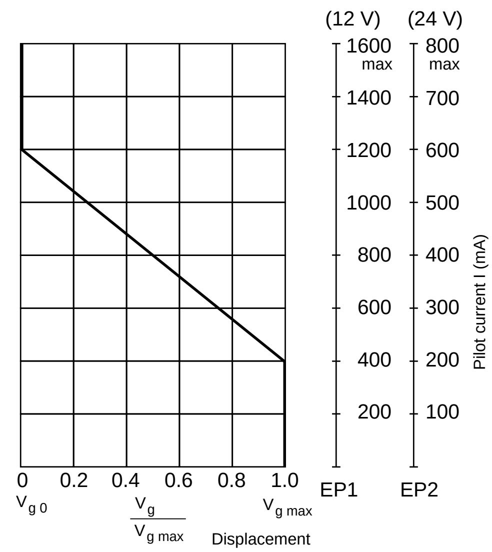
Standard version:
Start of control at $V_{g\,max}$ (max. torque, min. speed)
End of control at $V_{g\,min}$ (min. torque, max. speed)

Model	Control Voltage (DC)	Control Current Start – End of Control
EP1	12 V	400mA – 1200mA
EP2	24 V	200mA – 600mA

The required control oil is taken from the high pressure side; for this, a minimum operating pressure of 15 bar is necessary. If it is necessary to operate the control at an operating pressure of < 220 psi (15 bar), a boost pressure of min. 220 psi (15 bar) must be applied at port G via an external check valve.
Adjustment of the control speed or limiting of the displacement (limiting of swivel) range by electrical means is possible using the following control devices:
Proportional amplifier PV . . . . see RA 95023
Chopper amplifier CV . . . . see RA 95029
Proportional solenoid driver MDSD . . . . . . see RA 29864
Multi purpose controller EDA . . . . see RA 29895

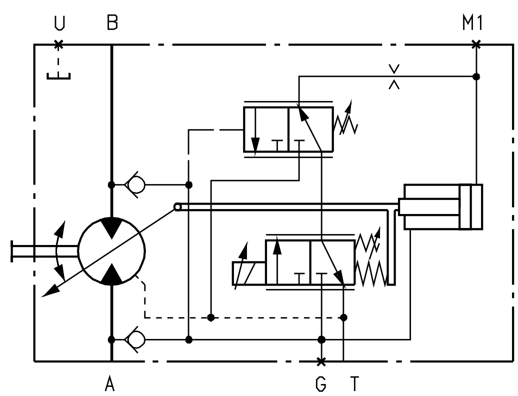


EP1, EP2



Variation: Constant Pressure Control (D)

The constant pressure control is superimposed on the EP function. Should system pressure rise as a result of the load torque or reduction of the motor swivel angle, when the setting of the constant pressure control is reached the motor is swivelled out to a higher angle.
As a result of the increased displacement and consequent pressure reduction, the control deviation is eliminated. By increasing the displacement the motor produces a higher torque at a constant pressure.
Setting range of constant pressure control valve 1160...5800 psi (80...400 bar).



EP1D, EP2D

Control Characteristics	Units	EP1	EP2	EP1D	EP2D
Control voltage	Vdc	12	24	12	24
Control current for control begin	mA	400	200	400	200
pressure override adjustment range	psi	-	-	1160-5800	1160-5800
	(bar)	-	-	(80-400)	(80-400)
Minimum system pressure required at port A, B,	psi	220	220	220	220
or G for correct control function	bar	(15)	(15)	(15)	(15)

HA Automatic Control High Pressure Related

With the automatic, high pressure related control, setting of the displacement is effected automatically as a function of the operating pressure.

Start of control at $V_{g\,min}$ (min. torque, max. speed)
End of control at $V_{g\,max}$ (max. torque, min. speed)

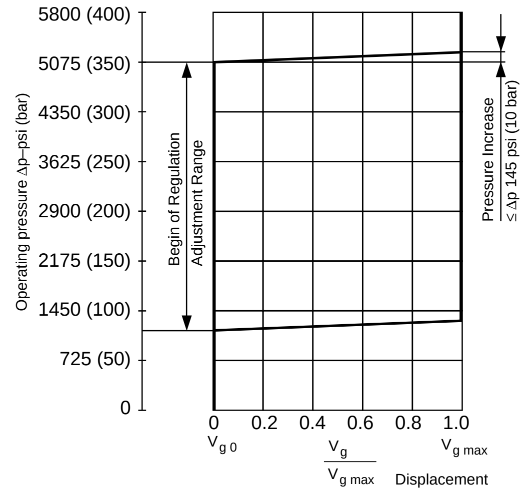
This control device measures the operating pressure at A or B internally (no pilot line required) and swivels from $V_{g\,min}$ to $V_{g\,max}$ once the pressure setting of the control is reached.

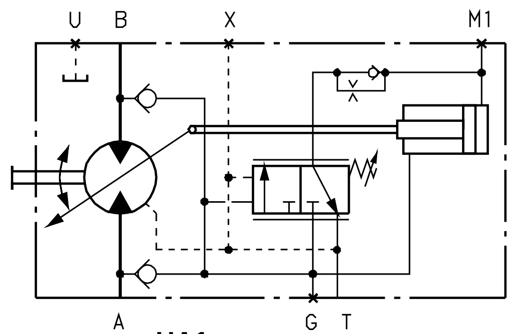
HA1
Version with virtually no pressure increase from start of control to end of control.

Pressure increase ($V_{g\,min}$ to $V_{g\,max}$) ≤ Δp 145 psi (10 bar)

Start of control adjustable between 1160–5100 psi (80–350 bar)
(State required setting in clear text when ordering)

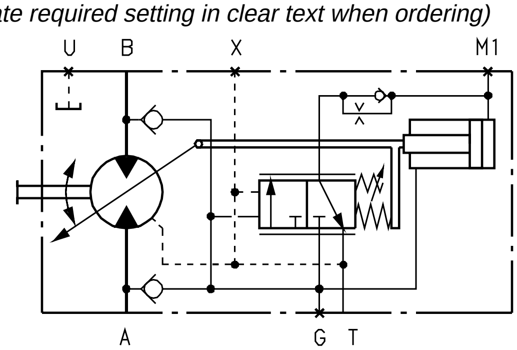
HA1



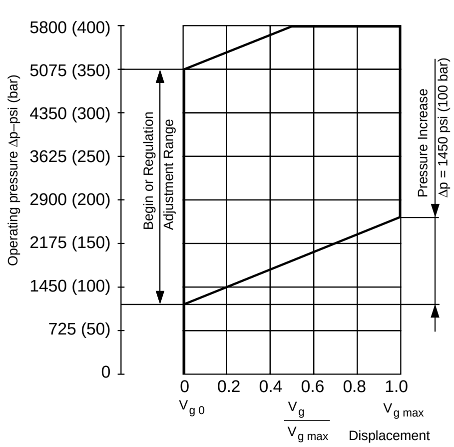


HA1
Size 55, 80, 107, 140, 160, 200

HA2
Version with pressure increase from start to end of control.
Pressure increase ($V_{g\,min}$ to $V_{g\,max}$) = Δp 1450 psi (100 bar)
Start of control adjustable between 1160–5100 psi (80 ...350 bar)
(State required setting in clear text when ordering)



HA2



Variation: Hydraulic Override of Pressure Setting (HA1T, HA2T)
On versions HA1, HA2 the pressure setting (start of control) can be influenced by applying a pilot pressure at port X.

The pressure setting is reduced by 250 psi per 14.5 psi pilot pressure. (i.e. –Pilot pressure to high pressure ratio: 1:17)

Example:

Pilot pressure at port X	0 psi (0 bar)	150 psi (10 bar)
Pressure setting	4350 psi (300 bar)	4350 psi (300 bar)
Start of control	4350 psi (300 bar)	1885 psi (130 bar)

If the override is only required to set the max. displacement (motor swivel to $V_{g\,max}$), a pilot pressure of up to 1450 psi (100 bar) max. is permissible.

Pressure Override

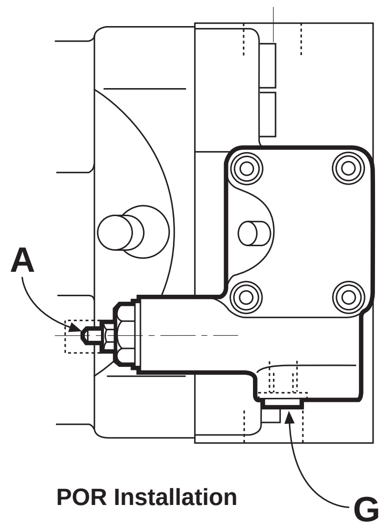
Control Description

Motors fitted with this option allow remote control of the motor displacement until system pressure reaches the pressure setting of the pressure override (POR) valve. When this occures, displacement adjusts automaticly towards maximum angle, until the product of displacement and set (system) pressure satisfies the output torque demand on the motor.

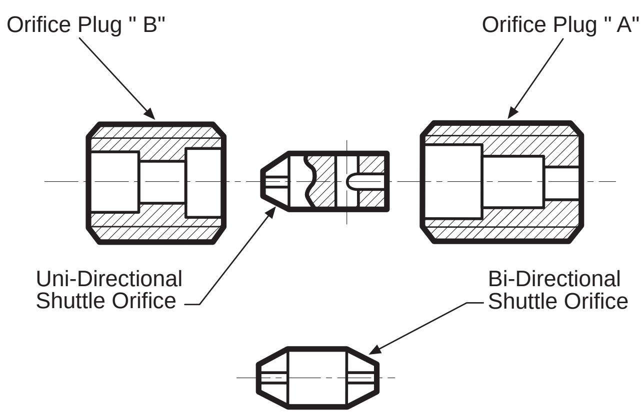
System pressure greater than the set pressure of the POR valve will keep the motor at maximun displacement, even if the HD,EP control signal is set to send the motor to minimum displacement.

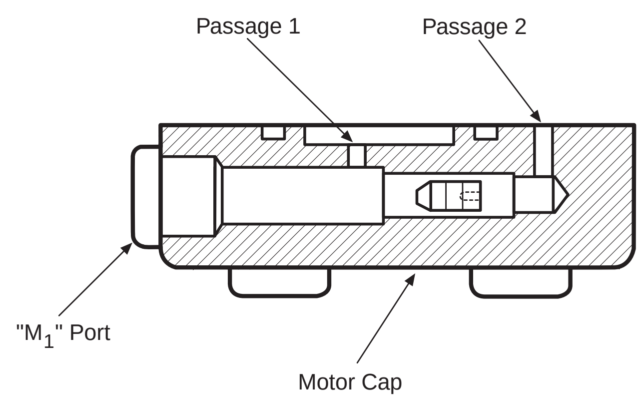
Adjustment Proceedure

Turn adjustment screw “A” in so that the POR does not function then set HD begin point as describe on pg. 21. Then with the HD control commanding the motor towards minimum displacement raise the pressure at the “G” port to the desired POR setting. Then turn adjustment screw A until the pressure at M_1 is less than 1/2 of “G” port. Turning adjustment screw “A” CW raises pressure at “M_1”, turning adjustment screw “A” CCW lowers pressure at “M_1”.



POR Installation





There are two types of self-cleaning swivel-time orifices available, a uni-directional and a bi-directional. This means that one type of shuttle orifice will control flow in one direction and will free flow in the other. The second type of shuttle orifice will control flow in both directions. Both types of shuttle orifices are shown above.

A swivel-time orifice kit is made up of two orifice plugs and one shuttle orifice. This kit is inserted into the "M_1" port of the motor cap (see page 26 for "M_1" port location). There is only one way to properly insert the swivel-time kit. First, thread orifice plug "A" into the "M_1" port until it bottoms. **Caution:** Do not overtighten this orifice plug. Next, insert the shuttle orifice in it's proper orientation for desired flow control. Finally, thread orifice plug "B" into the "M_1" port until it is tightly against orifice plug "A". Plug port "M_1".

The bi-directional shuttle orifice can be inserted with either tapered end in first. It's orientation does not affect flow control. The orientation of the uni-directional shuttle is important. With the uni-directional shuttle assembled into the motor cap as shown above, controlled flow will be from passage 2 to passage 1 (into the stroking piston). Free flow will occur from passage 1 to passage 2 (out of the stroking piston). To reverse flow control, rotate the uni-directional shuttle orifice 180°. The orifice plug “B” requires a 5mm Allen Wrench and orifice plug “A” requires a 6mm Allen Wrench.

Note: When using a uni-directional shuttle orifice, it will typically be assembled to control motor swivel time from minimum to maximum displacement. Contact Rexroth for more details.

Installation

The AA6VM motor may be mounted in any position. When mounting in a shaft up position, special considerations regarding the case drain line may be required to ensure the motor bearings are always immersed in oil.

The AA6VM is usually face mounted to a final drive gear box with the shaft engaging a mating female splined gear hub or spline adapter. The large drive shaft bearings permit vee or toothed belt pulleys, or gear pinions to be mounted directly to the drive shaft. (Consult Rexroth for radial and axial force limitations.) The motor may also be used to transmit power via a universal drive shaft. The case drain line should be connected to the highest case drain port so that the motor always remains full of oil.

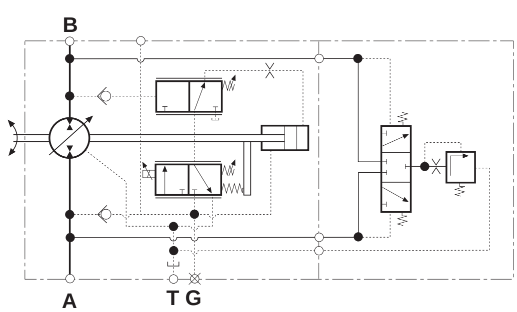
For mobile applications, the oil reservoir capacity required (in U.S. gallons) is generally .75 to 1 times the charge pump flow (in U.S. gallons per minute) for a one pump, one motor transmission. The heat exchanger should be located between the pump case drain and the reservoir, and sized to accept the full flow of the charge pump at the maximum anticipated drive speed.

To accommodate slight shaft misalignment and to dampen vibration, use of a flexible coupling is recommended. The motor user should work closely with the coupling manufacturer in selecting and applying a suitable coupling . When flexible couplings, Veebelts or toothed timing belts are to be used, the coupling halve, gear or pulley, should be secured to the drive shaft using a spacer between the coupling and the shoulder on the drive shaft, and locking the coupling to the shaft by using a set screw into the threaded hole in the end of the shaft. If this is not possible, as when mounting the motor to a drive gearbox, Optimoly Paste White T multipurpose lubricating paste or equivalent must be applied to the shaft to avoid fretting corrosion of the spline.

Motor Flushing

A flushing valve is usually required when a motor will be operated for extended periods of time at high speed and/or high pressure conditions.

A flushing valve is available for manifold mounting on the rear cover of an AA6VM motor. This valve provides a regulated flow of oil from the low pressure side of the loop into the motor case. This oil is used to cool and flush the motor bearings.
Note: Consult Rexroth application engineer to determine if a motor flushing valve is required for your application.



EP1 and EP2 Control with Flushing Valve

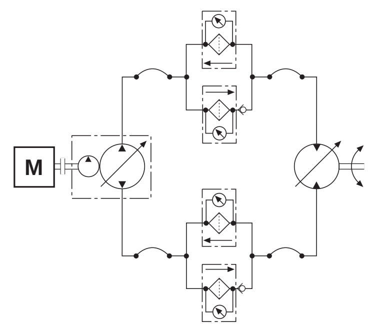
Filtration

The fluid should be filtered prior to system start-up, and continuously during operation to achieve and maintain a cleanliness level of ISO 18/15 (This corresponds approximately to NAS 1638 class 9, or SAE [1963] Class 6.) This recommendation should be considered a minimum, as better cleanliness levels will significantly increase component life.

Each application should be analyzed to determine the proper method of filtration needed to maintain the required cleanliness levels, as contaminant generation and ingression can vary greatly,depending on the configuration and complexity of the system. For particular system requirement, or for application outside these parameters, a Rexroth Applications Engineer should be consulted.

Pre-Start Procedure
This should be performed prior to start-up a new installation, or for a system in which new or overhauled components have been fitted.

1. Ensure that hydraulic reservoir piping and pressure hoses are cleaned and flushed.
2. Fill the reservoir through fill pump and filter.
3. If there is any doubt regarding the absolute cleanliness of the system, fit high pressure bi-direction filters in high pressure lines as shown in following diagram. the filters are in addition to the installed suction and return filters.



4. Check that all filters have elements of the correct rating and the filter housing are filled with the hydraulic fluid to be used in the system.
5. Where possible, fill the high pressure lines.
6. Open suction line valves.
7. Fill pump and motor case to the highest drain or vent port.
8. Check that all pressure connections are secure.
9. Ensure all mechanical gear boxes have the correct oil type and are filled to the prescribed level.
10. Fully back off all high pressure relief valves and then reset one half turn against the spring.
11. Fit 10,000 psi pressure gauges to each high pressure line.
12. Fit 500 psi pressure gauges to charge and pilot circuits.
13. Fit 100 psi pressure gauge to pump case drain port.
14. Fit vacuum gauge to the charge pump suction line, as close as possible to suction port.
15. Release brakes and jack up the driving wheels. Winches should be started without the cable fitted.
16. Ensure that the fluid temp. in the reservoir is 45˚F or higher.
17. Ensure that the motor minimum displacement (maximum speed) is set correctly as shown on page 23.

Start-Up Procedure

The following procedure has been developed based on experience with most types of applications, however certain applications may require a departure from or variation to this procedure.

For the start-up of new or overhauled installations.

1. If the prime mover is:

   Internal combustion engine: (Diesel, gasoline or LP)- Remove the coil wire, close the injector rack or leave the gas turned off and turn the engine over until the charge pressure reaches 50 psi or more.

   Electric Motor: Jog the starting circuit until the charge pressure reaches 50 psi or more.

2. Start the prime mover, and if possible, maintain a pump speed of approximately 750 rpm for 5 minutes. This will allow the system to be filled.

3. Listen for any abnormal noises.

4. Check for oil leaks.

5. Run prime mover to 1800 rpm. (Adjust to the design speed if less than 1800 rpm.)

6. Set charge and pilot pressure as required for the application. (Refer to circuit schematic)

7. Bleed the pilot lines by loosening the connections on the motor “X” port(s) and then actuate the remote control unit in both directions until oil seeps from the connections. Also bleed the pilot lines to the pump (if any).

8. Retighten all connections.

9. Operate the control to work the hydrostatic transmission at approximately 20% of maximum speed.

10. Deaerate system by venting a bleed valve or by cracking the highest connection until fluid seeps out without bubbles.

11. Check fluid level and add fluid if necessary.

12. Continue operating transmission and gradually increase to full speed, still with no load.

13. With controls neutralized, check for creep in neutral. If evident, center the control in accordance with the instructions in the pump service manual.

14. Check that the controls are connected so that the transmission operates in the correct direction related to the control input.

15. Continue to monitor all pressure gauges and correct any irregularities.

16. Apply brakes and set high pressure relief valves (and pressure override if installed) to levels required for the application by stroking the pump to approximately 20% of maximum displacement.

17. Check security of high pressure connections.

18. Check oil level and temperature.

19. Remove and inspect high pressure filter elements, if so equipped. Replace with new elements.

20. Operate transmission under no load conditions for about 15 minutes to stabilize the temperature and remove any residual air from the fluid.

21. Again remove and inspect high pressure filter elements, “if so equipped.” If clean, the high pressure, bi-direction filters may be removed from the circuit. If contamination is still evident, fit new elements and continue flushing until the system is clean.

22. Replace the elements in the charge pump suction or pressure filter, whichever is installed.

23. Operate the transmission under full and normal load conditions.

24. Erratic operation may indicate there is still air trapped in the system. By working the pump control to one or both sides the remaining air can be eliminated. The system is free of air when all functions can be operated smoothly and when the oil in the reservoir is no longer aerated. (Usually less than 1 hour of operation)

Note:

If, after following the Pre-Start and Start-up procedures, the transmission does not perform correctly, refer to the relevant sections of the trouble-shooting procedures on pages 17, 18 & 19.

Troubleshooting Procedure

To aid in troubleshooting, refer also to the Hydrostatic Transmission Pump Service Manual. Procedure assumes gauges are installed.

This procedure was written to aid the troubleshooter in following a logical approach to a system fault.

1. Transmission does not Drive with the Prime Mover Running

1.1	Is there oil in the reservoir?	No Yes	Fill reservoir. Proceed to step1.2.
1.2	Is engine clutch engaged?	No Yes	Engage clutch. Proceed to step 1.3.
1.3	Is the hydraulic piping in accordance with the hydraulic circuit?	No Yes	Correct the piping. Proceed to step 1.4.
1.4	Is the pump direction of rotation correct?	No Yes	Fit pump having the correct direction of rotation. Proceed to step 1.5.
1.5	Is there a broken pipe, loose fitting or burst hose?	No Yes	Proceed to step 1.6. Repair the fault.
1.6	Are the brakes released?	No Yes	Check brake release circuit or mechanism. Proceed to step 1.7.
1.7	Is there any charge pressure?	No Yes	Proceed to step 1.10. Proceed to step 1.8.
1.8	Is the charge circuit at the recommended pressure level while the pump is running at normal operating speed?	No Yes	Proceed to step 1.9. Proceed to step 1.19.
1.9	Can the charge pressure be adjusted at the charge pressure relief valve?	No Yes	Proceed to step 1.10. Adjust charge pressure and proceed to step 1.19.
1.10	Is the suction line shut-off?	No Yes	Open valve Proceed to step 1.11.
1.11	Is the charge pump suction pressure within the recommended limits?	No Yes	Proceed to step 1.12. Proceed to step 1.16.
1.12	Is the suction filter element plugged.	No Yes	Proceed to step 1.13. Replace filter element
1.13	Does the reservoir design ensure that suction pipe is always covered with oil.	No Yes	Correct the reservoir design. Proceed to step 1.14.
1.14	Is the suction pipe size adequate for the flow?	No Yes	Run at lower speed and return to point 1.7, or rework suction piping. Proceed to step 1.15.
1.15	Is the reservoir air breather blocked or undersized?	No Yes	Proceed to step 1.16. Clean or Replace air breather.
1.16	Remove charge pressure relief valve cartridge and inspect. Is it damaged?	No Yes	Refit cartridge and proceed to step 1.17. Fit a new cartridge and return to step 1.7.
1.17	Remove and inspect charge pump assembly. Is it damaged?	No Yes	Proceed to step 1.18. Repair or replace damaged components and return to step 1.7.
1.18	Is the charge pump installed for correct direction of rotation?	No Yes	Refit charge pump. Return to step 1.7. With proper charge pressure, and transmission still does not operate, proceed to step 1.19.
1.19	Is control medium connected to pump control? Hydraulic pilot pressure mechanical cable or linkage. 12 or 24 volts dc, electrical current.	No Yes	Connect appropriate medium and check that control signal is actually being applied to the pump stroker. Proceed to step 1.20.
1.20	Is maximum displacement selected on the variable motors? (If not done automatically)	No Yes	Select maximum displacement. Proceed to step 1.21.
1.21	Actuate the control in both directions. Does pump stroke? Does it go to full stroke?	No Yes	Refer to the pump service manual and then proceed to step 1.22. Operate the transmission.
1.22	Is it possible to adust high pressure relief valves?	No Yes	Replace high pressure relief valve cartridges and return to step 1.21. Adjust high pressure relief valves
1.23	Actuate control in both directions. Does transmission run?	No Yes	Check if motor sizing is adequate for application. Check for excessive motor leakage and replace motor if defective. Check for mechanical faults in the drive beyond the motor shaft. Operate the transmission.

Troubleshooting Procedure

2. Transmission Drive is Sluggish or Erratic

2.1	Is the control medium in good condition? For example: control medium is not in good condition if: The hydraulic pilot pressure lines have air in them, the manual control cable or linkage is sticking, or the electrical control current is fluctuating. (pump and/or motor)	No	Rectify the control fault. Bleed pilot lines. Lubricate or free the cable or linkage. Check control current.
		Yes	Proceed to step 2.2.
2.2	Are the brakes fully released?	No	Check brake release circuit or mechanism.
		Yes	Proceed to step 2.3.
2.3	Is the pump stroking time correct for the application?	No	Correct pump stroking time.
		Yes	Proceed to step 2.4.
2.4	With hydraulic pilot control, is the contol curve of remote pilot valve correctly matched to the motor?	No	Change spring to suit.
		Yes	Proceed to step 2.5.
2.5	Does the charge pressure fluctuate more than 30 psi when stroking the pump?	No	Proceed to 2.9
		Yes	Proceed to step 2.6.
2.6	If the charge pump output is used to operate auxilary functions, do these other functions cause fluctuations in charge pressure?	No	Proceed to 2.8
		Yes	Proceed to step 2.7.
2.7	Isolate the auxilary function and run the transmission. Are the charge pressure fluctuations reduced or eliminated?	No	Proceed to 2.8
		Yes	Operate transmission and return to step 2.1.
2.8	Are there system pressure fluctuations which are syncronous with the charge pressure flucuations?	No	Proceed to step 2.9.
		Yes	Determine the cause of system pressure fluctuations.
2.9	Is the motor stroking time correct for the application?	No.	Add motor stroking time adjustment valve or orifice to the variable motor, or modify the control circuit to provide desired stroking time.

3. Transmission Drives in One Direction Only

3.1	Is it possible that the control signal to one side of the pump does not work properly?	No	Proceed to step 3.2.
		Yes	Refer to pump sevice manual.
3.2	Check flushing valve (if installed). Is shuttle spool stuck in one position?	No	(Not installed).
		Yes	Remove flushing valve and clean or replace.
3.3	Switch releif valves. Does the transmission drive in the other direction only?	No	Proceed to step 3.4.
		Yes	Repair or replace releif valve on non-driving side.
3.4	Actuate control. Does the transmission run in both directions?	No	Check for mechanical faults in the drive beyond the motor shaft.
		Yes	Operate the transmission.

4. Transmission Drives in the Wrong Direction

4.1	To change direction at pump:	Switch the control signal lines or linkage to the pump control module or stroker.
4.2	To change direction at motor:	Switch the high pressure lines at ports A and B.

Troubleshooting Procedure

5. Insufficient Output Torque in One or Both Directions

5.1	Using the 0–10,000 psi gauges, is the load side of the loop required or design pressure?	No	Review steps 1.1 through 1.22.
		Yes	Proceed to step 5.2.
5.2	Is the motor receiving the hydraulic or electrical control signal on the control spool? (HD & EL)	No	Correct problem.
		Yes	Proceed to step 5.3.
5.3	Is the motor begin of stroke set correctly? For example, the output torque may be low if the begin of stroke is: HD & EL controls-set too low. HA-control-set too high.	No	Set begin of stroke per page 21.
		Yes	Proceed to step 5.4.
5.4	With a pressure gauge at port G, does G port pressure match system high pressure with either port A or B pressurized?	No	Replace faulty motor.
		Yes	Proceed to step 5.5.
5.5	Is output torque sufficient in both directions?	No	Check if motor sizing is adequate for application. Check for mechanical faults or improper design sizing in the drive beyond the motor shaft.
		Yes	Operate the transmission.

6. Transmission Drives at a High Noise Level

6.1	Are the drive gearboxes filled with correct grade of oil?	No	Fill gearbox with correct grade of oil to the prescribed level.
		Yes	Proceed to step 6.2.
6.2	Is the drive coupling correctly installed and aligned?	No	Install coupling per manufacturer's instructions and tolerances.
		Yes	Proceed to step 6.3.
6.3	Is rigid piping connected to the pump and motor?	No	Proceed to step 6.4
		Yes	Install short length of hose between pressure ports and the system piping.
6.4	Is the suction pressure at the charge pump inlet within recomended limits?	No	Return to step 1.7.
		Yes	Proceed to step. 6.5.
6.5	Is there air in the hydraulic oil? This may be indicated by foaming or milky colored oil.	No	Proceed to step 6.6.
		Yes	Deaerate the oil and inspect system for cause of air induction.
6.6	Is the hydraulic motor operating at excessive speed?	Yes	Check motor sizing in relation to available oil flow from the pump. check motor minimum displacement. See page 20.

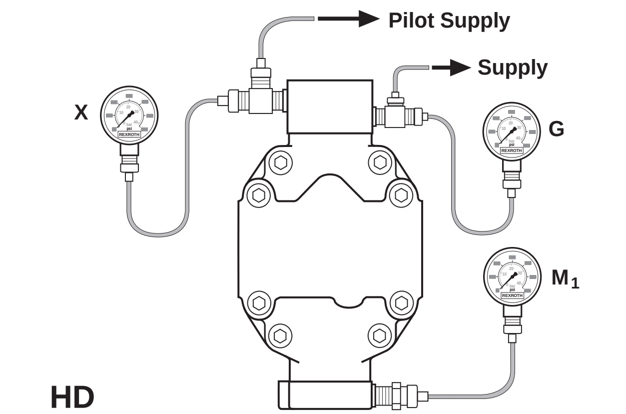
7. Transmission Operates at a Higher Than Normal Temperature

7.1	Is the operating temperature above 195˚F?	No	195˚F is the upper limit. If temp. is close to 195˚F the oil cooler may need to be cleaned.
7.2	Does temperature remain above 195˚F after cleaning oil cooler?	Yes	Proceed to step 7.3.
7.3	Is the hydaulic motor stalling intermittently?	No	Proceed to 7.4.
		Yes	Hydraulic oil is being heated through system releif valves. Shut down system and rectify cause of the motor stall.
7.4	Check differential pressure across oil cooler as compared to the manufacturer's specs at charge pump flow. Is ΔP higher than it should be? **Note:** See page 7 for case pressure rating.	No	Proceed to step 7.5
		Yes	Check piping from oil cooler to tank or plugged oil cooler.
7.5	Disconnect pump case drain from oil cooler and check flow from charge pump. Is flow normal?	No	Refer to charge pump removed and inspection procedure.
		Yes	Check oil cooler location.

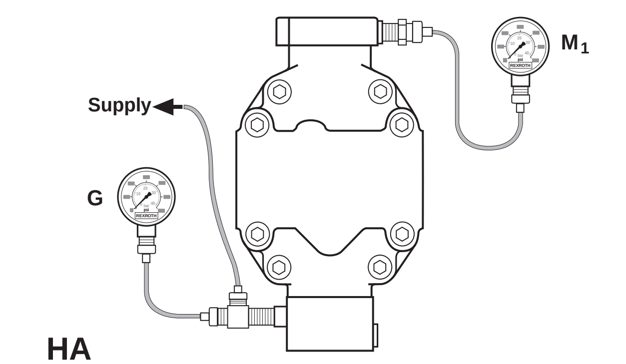
Begin of Stroke Adjustment, Gauge Method

Preparation for Adjustment

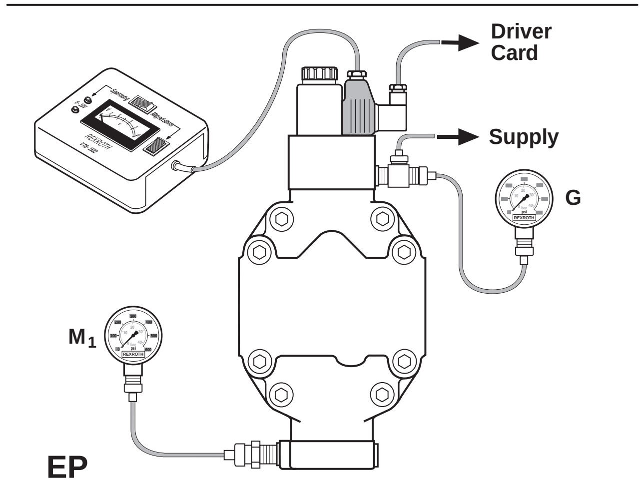
For the HD control tee the pilot supply line and a 750 psi gauge into the X port. Remove the plugs in G and M1 ports and connect a 10,000 psi gauge to each port.



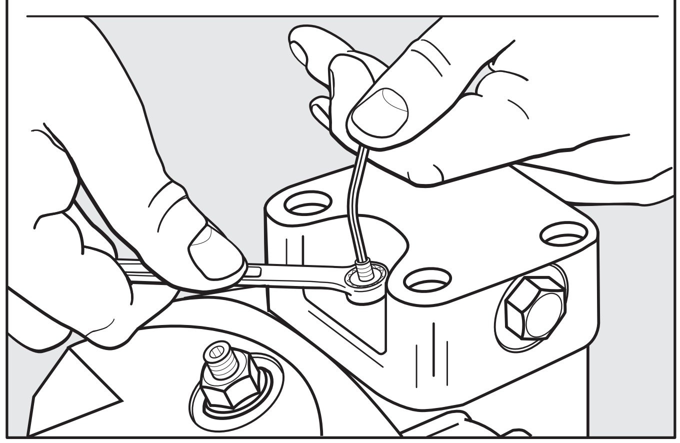
For the HA control remove the plugs from G and M1 ports. Then tee a 10,000 psi gauge with the supply line into G port and connect a 10,000 psi gauge to M1 port.



For the EP control remove the plugs from G and M1 ports. Tee a 10,000 psi gauge with the supply line into G port and connect a 10,000 psi gauge to M1 port. An ammeter is also required to adjust the control. It must be placed in the line that is feeding the motor solenoid. The control range for the 24 VDC solenoid is 200mA to 600mA. The control range for the 12 VDC solenoid is 400mA to 1200mA.



The begin of stroke adjustment screw, which is located on the rear housing as shown, will be used to set the begin of stroke. To allow for adjustment, break off the tamper resistant cap and back off the locknut while holding the adjusment screw with a 3mm hex wrench. The locknut requires a 10mm wrench.



Begin of Stroke Adjustment, Gauge Method

Adjustment Procedure for the HD Control

1. Lock or load motors and then bring pump on stroke until at least 600 psi loop pressure is developed. Or supply pressure to the G port with an external pressure sorce. **Caution:** Do not allow oil to flow over the high pressure relief valves for long periods of time, as excessive heat can be generated in the pump.

2. Apply a variable low pressure pilot signal at the gauged X port, either with the charge pump or an external source, eg. remote pilot controller or pressure reducing valve.

3. Gradually increase the pilot pressure at the X port while watching the stroking pressure on the M1 gauge. When the M1 pressure is approximatly 1/2 of G note the pilot pressure on the X gauge. This is the begin of stroke set point. The begin of control adjustment setting ranges from 29-290 psi on HD1 control and 72.5-725 psi on the HD2 control.

4. To change the begin of stroke set point turn the adjustment screw in (clockwise) to lower the setting and out (counter-clockwise) to increase the begin point setting.

5. Repeat steps 1 through 4 until the required begin of control set point is achieved and stable.

6. When the correct setting is reached, lock adjustment screw in place and adjust the pilot pressure above and below the begin point to check motor operation.

7. After obtaining the desired setting shut down the system, remove gauges, reinstall plugs and reconnect pilot line as it was originally.

Adjustment Procedure for the HA Control

1. Lock or load motors to accept pressure from either side of the loop. Gradually increase the loop pressure while watching stroking pressure on the M pressure gauge. This can be done with the main hydrostatic pump. Or by suppling pressure to the G port with an external pressure sorce. **Caution:** Do not allow oil to flow over the high pressure relief valves for long periods of time, as excessive heat can be generated to the pump.

2. When the M1 pressure is approximatly 1/2 of G note the loop pressure on the G gauge. This is the begin of stroke set point.

3. To change the setting turn the adjustment screw in (clockwise) to lower the begin point setting and out (counter clockwise) to increase the begin point setting.

4. Repeat steps 1 through 5 until the required begin of control set point is achieved and stable. The G port may require bleeding each time due to trapped pressure.

5. **Note:** The begin of control can be selected between 1160 and 5075 psi for HA1 control and HA2 control.

6. After obtaining the desired setting lock begin of stroke adjustment screw into place. Shutdown system, remove gauges, reinstall plugs in ports M1 and G. **Caution:** Port G may contain trapped pressure.

7. **Note:** If motor has control override option (T code) port X must be vented to tank during adjustment procedure i.e. X port must be free of any trapped pressure.

Adjustment Procedure for the EP Control

1. Lock or load motors to accept pressure from either side of the loop.and then bring pump on stroke until at least 600 psi loop pressure is developed. Or supply pressure to the G port with an external pressure sorce. **Caution:** Do not allow oil to flow over high pressure relief valves for long periods of time as excessive heat can be generated in the pump.

2. Gradually increase the amperage to the solenoid while watching the stroking pressure on the M1 gauge. When the M1 pressure is approximatly 1/2 of G read the ammeter. This is the begin of stroke set point.

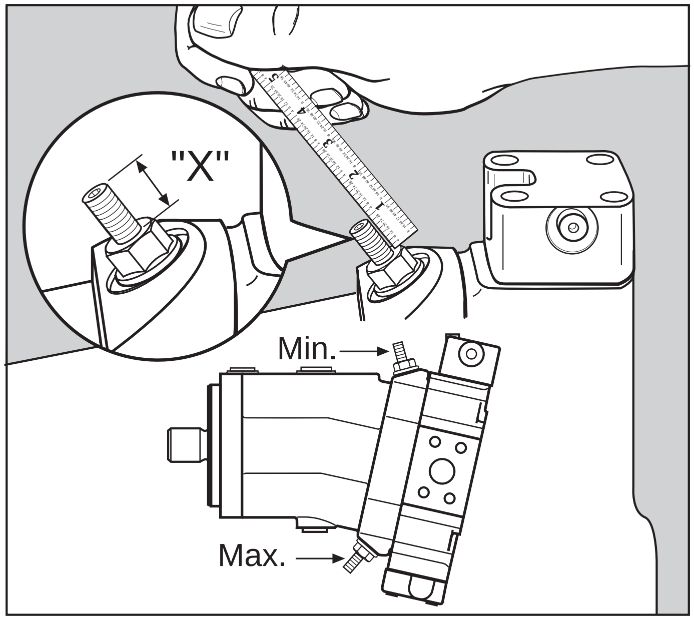
3. If the setting is different from the amperage rating shown in the table on page 8, readjust the setting by turning the adjustment screw in (clockwise) to lower the setting and out (counter clockwise) to increase the begin point setting

4. Repeat steps 1 through 3 until the required begin of control set point is achieved and stable.

5. When the correct setting is achieved, lock the adjustment screw in place, shut down the system. Remove gauges and ammeter reinstall plugs and solenoid connector.

Swivel Angle (Speed) Adjustment

Determine “X” dimension from corresponding chart (Minimum “page 23”) or (Maximum “below”) for desired displacement. Remove displacement screw from motor and compare overall length of screw to recommended screw length on chart for desired displacement. If the displacement screw in motor is not recommended length, modify “X” dimension in relation to the difference in actual and recommended screw length (Example: If the actual screw length is 10 mm longer than recommended, add 10 mm to the “X” dimension from chart.). Install screw into motor and tighten seal nut while maintaining “X” dimension..



Note: See page 8 for motor speed/displacement limitations. When designing a hydrostatic transmission for a vehicle or winch drive using these motors, we recommend a design speed of approximately 85% of the maximum speed at the reduced displacement. This allows for operating speeds up to the maximum under overrunning load conditions.

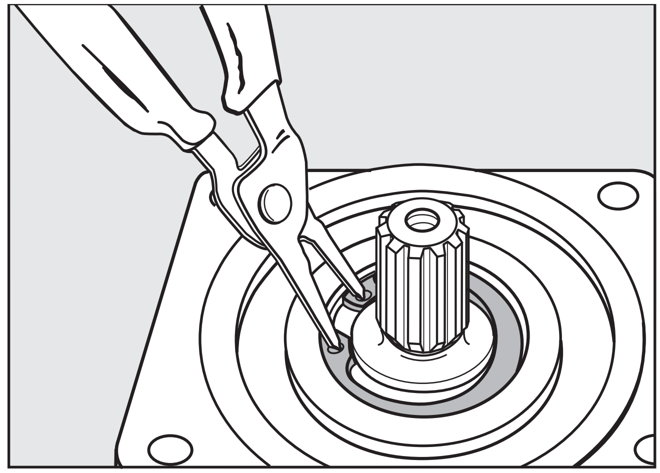
Motor Size	Allen Wrench	Wrench
55	5mm	17mm
80, 107, 160, 200	6mm	19mm

			AA6VM…/63 Maximum Angle (Degrees)													
Size	Specifications		25	24	23	22	21	20	19	18	17	16	15	14	13	12
28	Displacement	in^3	1.52	1.59	1.65	1.71	1.45	1.39	1.32	1.26	1.18	1.12	1.05	0.98	0.92	0.84
		cm^3	28.1	27.0	26.0	24.9	23.8	22.7	21.6	20.6	19.4	18.3	17.2	16.1	15.0	13.8
	Limiting Screw Size		M8 x 50							M8 x 60						
	Dimension “X”	in	0.66	0.61	0.56	0.50	0.45	0.40	0.35	0.69	0.64	0.59	0.54	0.49	0.44	0.39
		mm	16.8	15.4	14.1	12.8	11.5	10.2	8.9	17.6	16.3	15.0	13.7	12.4	11.1	9.8
55	Displacement	in^3	3.34	3.22	3.09	2.97	2.84	2.71	2.58	2.45	2.31	2.18	2.05	1.92	1.78	1.65
		cm^3	54.8	52.7	50.7	48.6	46.5	44.4	42.2	40.1	37.9	35.7	33.6	31.4	29.2	27.0
	Limiting Screw Size		M10 x 60							M10 x 70						
	Dimension “X”	in	0.80	0.74	0.67	0.61	0.54	0.48	0.42	0.74	0.68	0.62	0.56	0.49	0.43	0.37
		mm	20.3	18.7	17.1	15.4	13.8	12.2	10.6	18.9	17.3	15.7	14.1	12.4	10.8	9.4
80	Displacement	in^3	4.88	4.70	4.52	4.33	4.14	3.95	3.76	3.57	3.37	3.19	2.99	2.79	2.60	2.40
		cm^3	80.0	77.0	74.0	70.9	67.8	64.7	61.6	58.5	55.3	52.23	49.0	45.8	42.6	39.4
	Limiting Screw Size		M12 x 70									M12 x 80				
	Dimension “X”	in	1.02	0.94	0.87	0.80	0.72	0.65	0.58	0.50	0.43	0.75	0.68	0.61	0.54	0.46
		mm	25.8	24.0	22.1	20.3	18.4	16.5	14.7	12.8	11.0	19.1	17.3	15.4	13.6	11.7
107	Displacement	in^3	6.53	6.29	6.04	5.79	5.53	5.28	5.03	4.77	4.52	4.26	4.0			
		cm^3	107.0	103.0	98.9	94.9	90.7	86.6	82.4	78.2	74.0	69.8	65.5			
	Limiting Screw Size		M12 x 70						M12 x 80							
	Dimension “X”	in	0.81	0.74	0.65	0.57	0.50	0.42	0.73	0.65	0.57	0.49	0.41			
		mm	20.7	18.7	16.6	14.6	12.6	10.6	18.6	16.6	14.5	12.5	10.5			
160	Displacement	in^3	9.76	9.4	9.03	8.65	8.28	7.9	7.52	7.14	6.76	6.36				
		cm^3	160.0	154.0	148.0	142.0	136.0	130.0	123.0	117.0	111.0	104.0				
	Limiting Screw Size		M12 x 80				M12 x 90									
	Dimension “X”	in	0.78	0.69	0.59	0.50	0.80	0.71	0.62	0.52	0.43	0.34				
		mm	19.9	17.5	15.1	12.8	20.4	18.0	15.7	13.3	10.9	8.6				
200	Displacement	in^3	12.2	11.7	11.3	10.8	10.3	9.88	9.4	8.92						
		cm^3	200.0	193.0	185.0	177.0	170.0	162.0	154.0	146.0						
	Limiting Screw Size		M12 x 80				M12 x 90									
	Dimension “X”	in	0.78	0.68	0.58	0.48	0.78	0.67	0.58	0.48						
		mm	19.7	17.2	14.7	12.2	19.7	17.1	14.7	12.2						

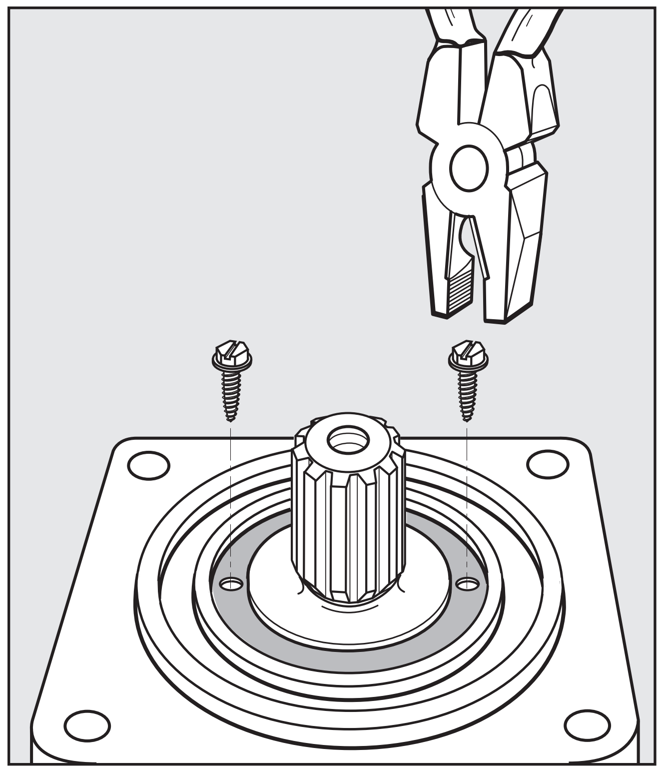
			AA6VM…/63 Minimum Angle (Degrees)																									
Size	**Specifications**		**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
28	**Displacement**	in^3	0	0.07	0.14	0.21	0.28	0.35	0.42	0.49	0.57	0.63	0.70	0.78	0.84	0.92	0.98	1.05	1.12	1.18	1.26	1.32	1.39	1.45	1.52	1.59	1.65	1.71
		cm^3	0	1.20	2.30	3.50	4.60	5.80	6.90	8.10	9.30	10.4	11.5	12.7	13.8	15.0	16.1	17.2	18.3	19.4	20.6	51.6	22.7	23.8	24.9	26.0	27.0	28.1
	Limit Screw Size		**M8 x 50**							**M8 x 60**							**M8 x 70**								**M8 x 80**			
	Dimension X	in	0.66	0.61	0.56	0.50	0.45	0.40	0.65	0.69	0.64	0.59	0.54	0.49	0.44	0.39	0.73	0.68	0.63	0.58	0.53	0.48	0.43	0.38	0.73	0.68	0.63	0.58
		mm	16.8	15.4	14.1	12.8	11.5	10.2	8.9	17.6	16.3	15.0	13.7	12.4	11.1	9.8	18.5	17.3	16.0	14.7	13.5	12.2	10.9	9.7	18.5	17.2	16.0	14.8
55	**Displacement**	in^3	0	0.14	0.27	0.41	0.55	0.69	0.82	0.96	1.10	1.24	1.37	1.51	1.65	1.78	1.92	2.05	2.18	2.31	2.45	2.58	2.71	2.84	2.97	3.09	3.22	3.34
		cm^3	0	2.30	4.50	6.80	9.00	11.3	13.5	15.8	18.1	20.3	22.5	24.7	27.0	29.2	31.4	33.6	35.7	37.9	40.1	42.2	44.4	46.5	48.6	50.6	52.7	54.8
	Limit Screw Size		**M10 x 60**							**M10 x 70**							**M10 x 80**						**M10 x 90**					
	Dimension X	in	0.80	0.74	0.67	0.61	0.54	0.48	0.42	0.74	0.68	0.62	0.56	0.49	0.43	0.37	0.68	0.63	0.57	0.51	0.44	0.38	0.72	0.65	0.59	0.53	0.47	0.41
		mm	20.3	18.7	17.1	15.4	13.8	12.2	10.6	18.9	17.3	15.7	14.1	12.4	10.8	9.40	17.2	16.0	14.4	12.9	11.3	9.7	18.2	16.6	15.0	13.5	12.0	10.5
80	**Displacement**	in^3	0	0.20	0.40	0.60	0.81	1.01	1.21	1.40	1.60	1.81	2.01	2.20	2.40	2.60	2.79	2.99	3.19	3.37	3.57	3.76	3.95	4.14	4.33	4.52	4.70	4.88
		cm^3	0	3.30	6.60	9.90	13.2	16.5	19.8	23.0	26.3	29.6	32.9	36.1	39.4	42.6	45.8	49.0	52.2	55.3	58.5	61.6	64.7	67.8	70.9	74.0	77.0	80.0
	Limit Screw Size		**M12 x 70**									**M12 x 80**					**M12 x 90**						**M12 x 100**					
	Dimension X	in	1.02	0.94	0.87	0.80	0.72	0.65	0.58	0.50	0.43	0.75	0.68	0.61	0.54	0.46	0.78	0.71	0.64	0.57	0.50	0.43	0.75	0.68	0.61	0.54	0.47	0.41
		mm	25.8	24.0	22.1	20.3	18.4	16.5	14.7	12.8	11.0	19.1	17.3	15.4	13.6	11.7	19.9	18.1	16.3	14.4	12.6	10.8	19.1	17.3	15.5	13.8	12.0	10.3
107	**Displacement**	in^3	0	0.27	0.54	0.81	1.08	1.35	1.62	1.89	2.15	2.42	2.69	2.95	3.21	3.48	3.73	4.00	4.26	4.52	4.77	5.03	5.28	5.53	5.79	6.04	6.29	6.53
		cm^3	0	4.40	8.80	13.3	17.7	22.1	26.5	30.9	35.2	39.6	44.0	48.3	52.6	57.0	61.2	65.5	69.8	74.0	78.2	82.4	86.6	90.7	94.9	98.9	103	107
	Limit Screw Size		**M12 x 70**						**M12 x 80**					**M12 x 90**					**M12 x 100**					**M12 x 110**				
	Dimension X	in	0.81	0.74	0.65	0.57	0.50	0.42	0.73	0.65	0.57	0.49	0.41	0.73	0.65	0.57	0.49	0.42	0.73	0.65	0.57	0.50	0.43	0.74	0.67	0.59	0.52	0.44
		mm	20.7	18.7	16.6	14.6	12.6	10.6	18.6	16.6	14.5	12.5	10.5	18.5	16.5	14.5	12.5	10.6	18.6	16.6	14.6	12.7	10.8	18.8	16.9	15.0	13.1	11.2
160	**Displacement**	in^3	0	0.40	0.81	1.21	1.61	2.01	2.42	2.82	3.22	3.61	4.01	4.41	4.80	5.20	5.59	5.98	6.35	6.79	7.14	7.52	7.90	8.28	8.65	9.03	9.40	9.76
		cm^3	0	6.60	13.2	19.8	26.4	33.0	39.6	46.2	52.7	59.2	65.7	72.2	78.7	85.2	91.6	98.0	104	111	117	123	130	136	142	148	154	160
	Limit Screw Size		**M12 x 80**				**M12 x 90**					**M12 x 100**				**M12 x 110**				**M12 x 120**					**M12 x 130**			
	Dimension X	in	0.78	0.69	0.59	0.50	0.80	0.71	0.62	0.52	0.43	0.73	0.64	0.55	0.46	0.76	0.67	0.57	0.48	0.79	0.70	0.61	0.52	0.43	0.74	0.65	0.56	0.48
		mm	19.9	17.5	15.1	12.8	20.4	18	15.7	13.3	10.9	18.6	16.2	13.9	11.6	19.2	16.9	14.6	12.3	20	17.7	15.4	13.2	10.8	18.7	16.5	14.2	12.1
200	**Displacement**	in^3	0	0.51	1.01	1.51	2.01	2.51	3.02	3.52	4.02	4.52	5.02	5.51	6.00	6.50	6.99	7.48	7.96	8.45	8.92	9.40	9.88	10.3	10.8	11.3	11.7	12.2
		cm^3	0	8.30	16.5	24.8	33.0	41.2	49.5	57.7	65.9	74.0	82.2	90.3	98.4	106	114	122	130	138	146	154	162	169	177	185	192	200
	Limit Screw Size		**M12 x 80**				**M12 x 90**				**M12 x 100**				**M12 x 110**				**M12 x 120**					**M12 x 130**				
	Dimension X	in	0.78	0.68	0.58	0.48	0.78	0.67	0.58	0.48	0.78	0.68	0.58	0.48	0.78	0.68	0.58	0.49	0.78	0.69	0.59	0.50	0.40	0.70	0.61	0.51	0.42	0.33
		mm	19.7	17.2	14.7	12.2	19.7	17.1	14.7	12.2	19.7	17.2	14.7	12.2	19.8	17.3	14.8	12.4	19.9	17.5	15.0	12.6	10.2	17.8	15.4	13.0	10.7	8.4

Shaft Seal Replacement

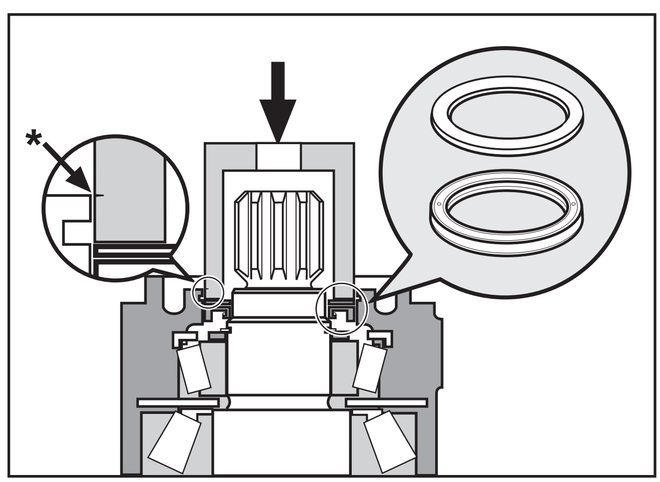
To replace the shaft seal first remove the snap ring and support ring.



Thread two sheet metal screws into the seal.



Press new shaft seal, support ring, and retaining ring into the housing. Take care to press to the proper depth.



Routine Maintenance

The AA6V variable motors are relatively maintenance free. Maintenance work is confined to the system, by way of oil changes and renewal of filter elements. Both of these measures promote system cleanliness. Monitoring and periodic maintenance of the system can prevent premature breakdowns and repairs. Under normal application conditions, the following maintenance intervals are suggested.:

Renewal of Filter Elements

a. After commissioning.
b. After 500 operating hours
c. Thereafter during a fluid change.
d. With suction filtration, the filter element should be renewed as soon as a charge pump inlet pressure of less than - 3.2 psig (0.8 bar absolute) becomes evident with the transmision in warm running condition.
e. With charge flow filtration, watch for high pressure differential across the filter element. (Refer to filter manufacturer's specifications)

Caution: Use only 10 micron, or finer, filter elements.

Note: Paper inserts cannot be cleaned; use throw-away cartridges (maintain a stock).

Hydraulic Fluid Change

a. After 500 operating hours (1st fluid change).
b. After 2000 operating hours (2nd fluid change).
c. Thereafter every 2000 operating hours or annually irrespective of operating hours achieved.

The fluid should be drained with the system warm from previous running. Before re-filling, the reservoir should be cleaned to remove any sludge.

Caution: Rags or other threading material must not be used.

The recommended interval between fluid changes is based on various factors and should be carried out according to the type of fluid, the degree of aging and contamination of the fluid. The water content is also a contributory factor.

Under application conditions with a heavy occurrence of dust or severe temperature fluctuations the intervals between fluid changes should be shortened accordingly.

Caution: Practical experience shows that most maintenance errors occur during an oil change due to:

a. Use of an unsuitable hydraulic fluid.
b. Use of fluid contaminated due to faulty storage.
c. Failure to clean reservoir.
d. Inadequate cleanliness when filling (dirty drums or containers).

Leakage Inspection

1. After commissioning.
2. The complete transmission (pump, motor and all pipelines, filters, valves, etc.) should be checked for leakage at regular intervals.

Caution: Leaking joints and connections must only be tightened in pressureless conditions.

Cleanliness Inspection

The oil tank breather should be regularly cleaned of dirt and dust to prevent clogging. The cooling surfaces should be cleaned at the same time.

Caution: If hose couplings are used in the high pressure lines, it is imperative that the utmost care be taken that no foreign bodies infiltrate the oil circuit when coupling and uncoupling (danger of damage to rotary group, and even possibility of total breakdown).

Fluid Level Inspection

Inspect fluid level in reservoir after commissioning, thereafter daily.

Caution: Top up only with specified fluid type. Do not mix fluids.

Hydraulic Fluids

Most good quality, mineral oil based, hydraulic fluids exhibiting the following characteristics are suitable for use in a Rexroth hydrostatic transmission.

Good antiwear performance
Resistant to oxidation degradation
Protection against rust and corrosion
Resistance to foaming
Ability to separate water rapidly
Suitable for widely varying temperature conditions
Good low temperature flow properties
Retains viscosity-temperature characteristics in service
Universally available

The prime consideration in the selection of hydraulic fluid is the expected oil temperatures extremes that will be experienced in service. These extremes should be considered when selecting a fluid, so that the most suitable temperature – viscosity characteristics are obtained.

The fluid chosen should permit the system to operate within the following viscosity ranges.

Maximum viscosity at start	7400 SUS	(1600 cSt)
Normal operating viscosity range	66...464 SUS	(12...100 cSt)
Optimum viscosity range	80...170 SUS	(16...36 cSt)
Absolute minimum viscosity	42 SUS	(5 cSt)

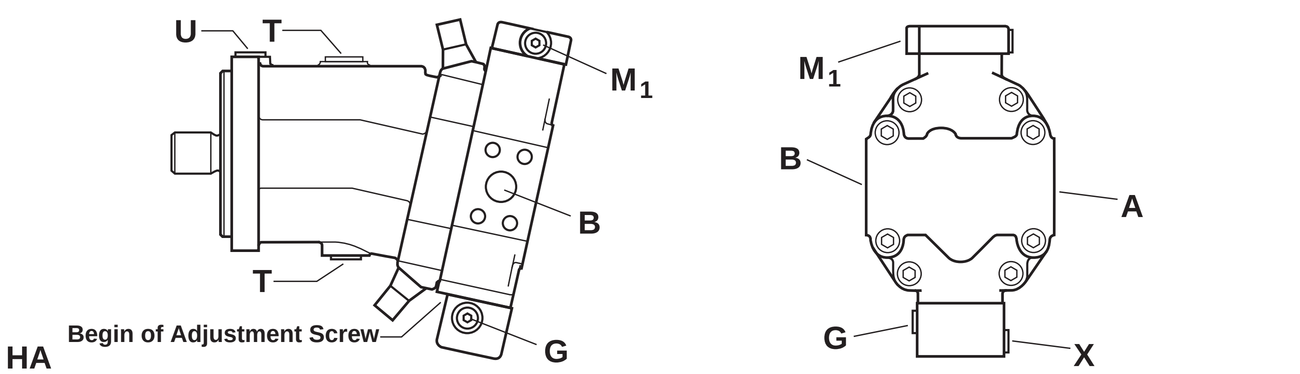
When the fluid viscosity is greater than 1000 SUS (216 cSt) the transmission should be operated at reduced speed until the oil has been warmed to a temperature of 40˚F (4.5˚C).

For applications that will operate near the extremes of viscosity and/or temperature, the fluid manufacturer should be consulted for assistance in selection of the most suitable type and grade of fluid for your application.

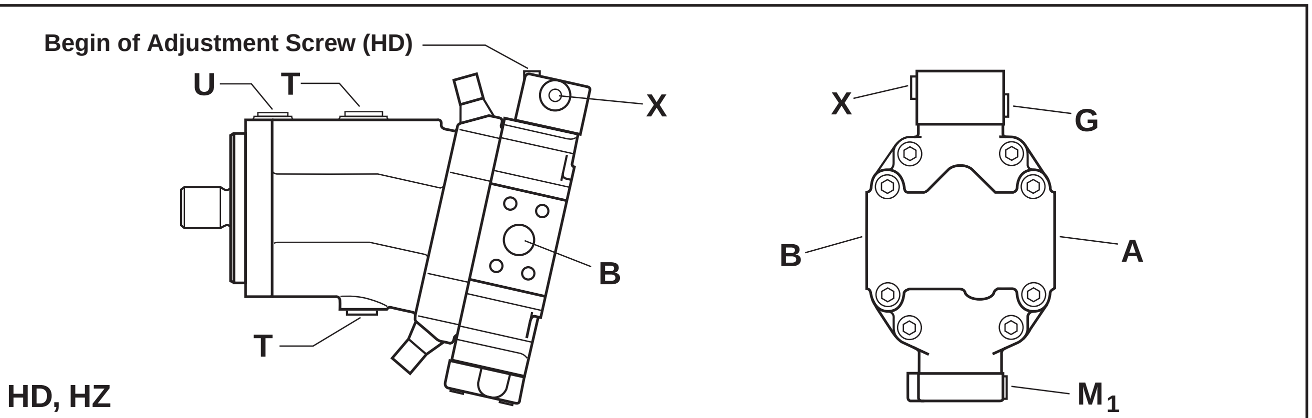
Rexroth strongly recommends the selection and use of fluids from reputable and established suppliers.

Port Information

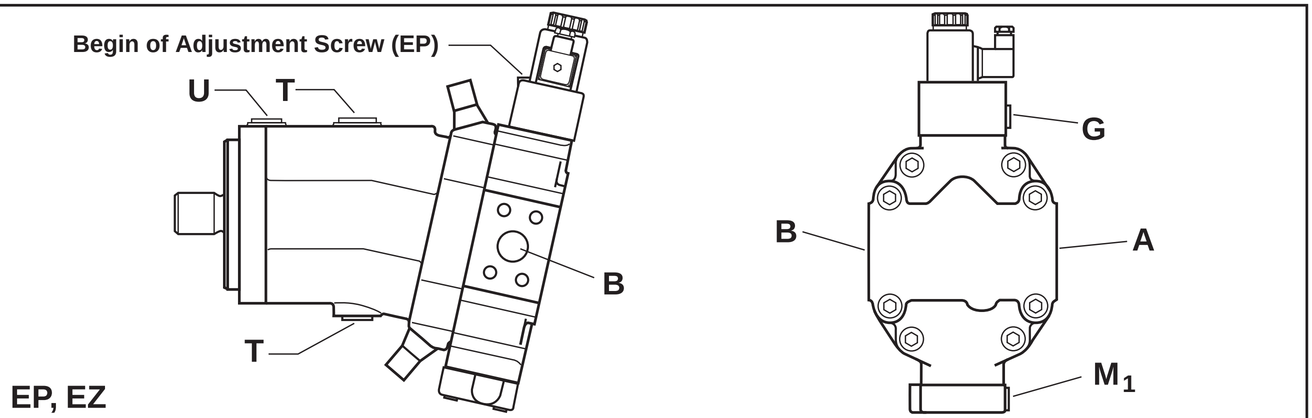
Port	Description	Control	55	80	107	160	200
A,B	High Pressure Flange Ports	ALL	3/4” SAE 6000 PSI	1” SAE 6000 PSI	1” SAE 6000 PSI	1 1/4” SAE 6000 PSI	1 1/4” SAE 6000 PSI
X	Pilot Pressure Port	HD,HA	9/16” - 18 UNF-2B	9/16” - 18 UNF-2B	9/16” - 18 UNF-2B	9/16” - 18 UNF-2B	9/16” - 18 UNF-2B
G	High Pressure Port	ALL	9/16” - 18 UNF-2B	9/16” - 18 UNF-2B	9/16” - 18 UNF-2B	9/16” - 18 UNF-2B	9/16” - 18 UNF-2B
M_1	Stroke Pressure Port	ALL	9/16” - 18 UNF-2B	9/16” - 18 UNF-2B	9/16” - 18 UNF-2B	9/16” - 18 UNF-2B	9/16” - 18 UNF-2B
T	Case Drain Port	ALL	1 1/16 - 12 UNF-2B	1 1/16 - 12 UNF-2B	1 1/16 - 12 UNF-2B	1 1/16 - 12 UNF-2B	1 1/16 - 12 UNF-2B
U	Case Drain Port	ALL	7/8 - 14 UNF-2B	7/8 - 14 UNF-2B	7/8 - 14 UNF-2B	7/8 - 14 UNF-2B	7/8 - 14 UNF-2B



HA



HD, HZ



EP, EZ

Replacement Parts

Seal Kit (FPM)

Motor	Part Number
55	5620-635-007
80	5630-635-007
107	5640-635-007
160	5650-635-007
200	5660-635-005

Shaft Seal (FPM)

Motor Size	Part number
55	5000-076-026
80	5000-076-010
107	5000-076-030
160	5000-076-012
200	5000-076-012

Limiting Screws

Size	Part Number
M8 x 50	60134-061
M8 x 60	60134-063
M8 x 70	60134-123
M8 x 80	H157647
M10 x 60	60134-002
M10 x 70	60134-003
M10 x 80	60134-004
M10 x 90	60134-122
M12 x 70	60134-011
M12 x 80	60134-007
M12 x 90	60134-008
M12 x 100	60134-009
M12 x 110	60134-010
M12 x 120	60134-121
M12 x 130	B907999

Proportional Solenoid

	Part Number
12 Volt DC	5604-080-002
24 Volt DC	5604-080-001

Nonprportional Solenoid

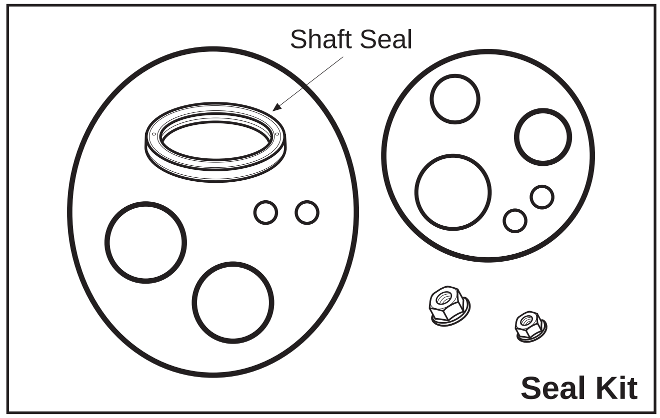
	Part Number
12 Volt DC	5406-580-002
24 Volt DC	5406-580-001

Plug In Connector

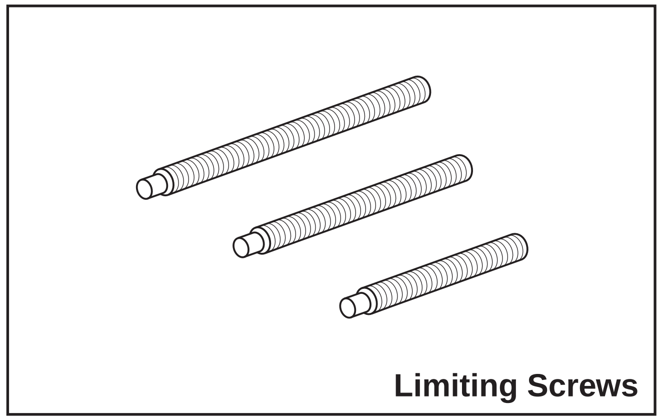
	Part Number
All Solenoids	5400-085-002

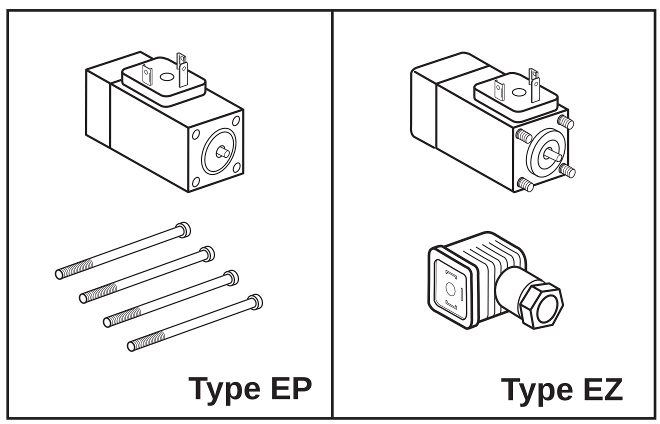
Ammeter With Sandwich Plug

	Part Number
All EL Controls	5956-001-018

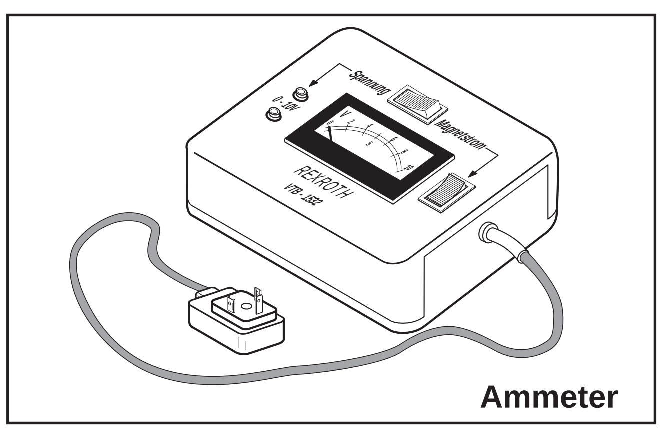


Seal Kit


Limiting Screws


Type EP

Type EZ



Ammeter

Specifications, descriptions, and illustrative material shown herein were as accurate as known at the time this publication was printed. Rexroth reserves the right to discontinue models or options at any time or to change specifications, materials, or designs without notice and without incurring obligation.

Optional equipment and accessories may add cost to the basic unit, and some options are available only in combination with certain models or other options.

DISTRIBUTED BY:

The Rexroth Corporation
Mobile Hydraulics Division, **1700 Old Mansfield Road, Wooster, OH 44691-0394 Tel. (330) 263-3400 Fax. (330) 263-3329**
Industrial Hydraulics Division, **2315 City Line Road, Bethlehem, PA 18017-2131 Tel. (610) 694-8300 Fax. (610) 694-8467**

Electric Drives and Controls | Hydraulics | Linear Motion and Assembly Technologies | Pneumatics | Service

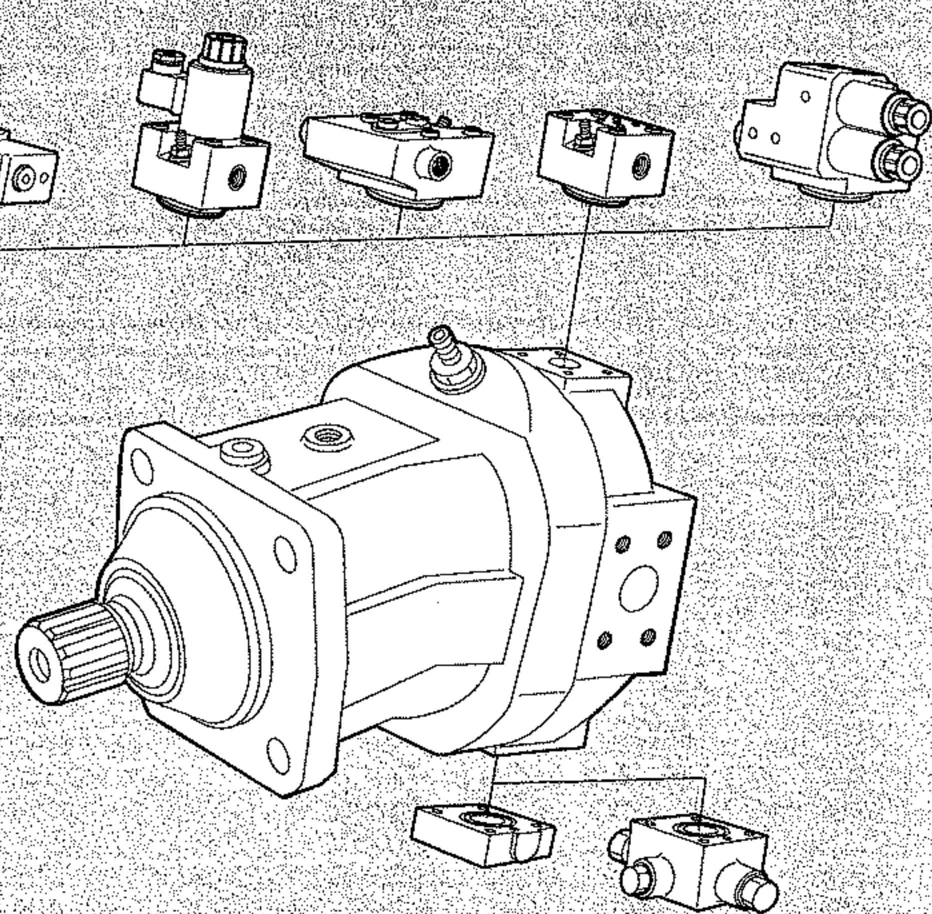
Rexroth
Bosch Group

Verstellmotor A6VM NG 28–200
Variable Displ. Motor A6VM NG 28–200
Baureihe/Series 63

RDE 91 604-11-R/03.06

R1

Reparaturanleitung / Repair Manual
Baugruppen / Assembly Groups



Vermeidung von Gefahren

Für einen sicheren Betrieb und um Schäden bei der Reparatur zu vermeiden, lesen Sie diese Reparaturanleitung sorgfältig und aufmerksam durch!

Für Personen- oder Maschinenschäden, die durch Nichtbeachtung dieser Reparaturanleitung entstehen, verfällt jegliche Gewährleistung von Bosch Rexroth AG.

1 Zu dieser Anleitung

Diese Anleitung unterstützt Sie bei der Reparatur, den Einstellungen und der Wiederinbetriebnahme von Rexroth A6VM Verstellmotoren. Diese Anleitung umfasst die folgenden Kapitel:

- „Sicherheit" auf Seite 7

  Hier erhalten Sie grundsätzliche Hinweise zum sicheren Umgang mit Verstellpumpen und zu deren Betrieb.

  Lesen Sie dieses Kapitel bevor Sie anfangen zu arbeiten.
- „Produktbeschreibung" auf Seite 11

  Hier erfahren Sie, wie Sie den Typ einer Verstellmotor feststellen. Ferner finden Sie hier eine Übersicht über die Funktionsweise und Informationen zur bestimmungsgemäßen Verwendung der Verstellmotor.

  Lesen Sie dieses Kapitel, um Ihr Grundwissen über die Verstellmotor aufzufrischen.
- „Austausch externer Baugruppen" auf Seite 15

  Dieses Kapitel erklärt Ihnen, wie Sie Baugruppen einer Verstellmotor austauschen.
- „Überprüfungen" auf Seite 25

  Dieses Kapitel erklärt Ihnen, wie Sie die Einstellarbeiten an einer Verstellmotor vornehmen.

Avoiding Dangers

To ensure safe operations and avoid damages during repairs, read this complete repair manual carefully and attentively.

Bosch Rexroth AG accepts no responsibility for personal injuries or damages to the machine that arise from disregarding this repair manual.

1 About this Manual

This manual supports you in the repair, adjustment and recommissioning of Rexroth A6VM variable displacement motors. The manual is structured as follows:

- "Safety" on page 7

  This chapter provides you with basic hints and tips regarding working with and operating variable pumps.

  Read this chapter before you start working.
- "Product Description" on page 11

  This chapter explains how you identify the variable displacement motor. Addtionally, it provides you an overview of the how the variable displacement motor and information regarding the correct usage.

  Read this chapter to refresh your knowledge of the variable pumps.
- "Exchanging External Subassemblies" on page 15

  Rexroth provides various replacement parts for repairs. This section provides you an overview of the available spare parts subassemblies.
- "Checking" on page 25

  Read this chapter to be able to restore the settings on an variable displacement motor after a repair.

1.1 Inhaltsverzeichnis

1.1 Contents

1.2 Gültigkeitsbereich dieser Anleitung

Diese Reparaturanleitung gilt für die Axialkolben-Verstellmotor A6VM der Bosch Rexroth AG. Informationen zu zugelassenen Druckflüssigkeiten entnehmen Sie den Angaben des Anlagenherstellers.

Diese Reparaturanleitung richtet sich an:

- Anlagenbetreiber,
- den autorisierten Fachbetrieb bzw. Händler,
- den Anlagenhersteller.

  Für den Anlagenhersteller sind zusätzlich auch die jeweilige Einbauzeichnung, das technische Datenblatt, die Betriebsanleitung und die Auftragsbestätigung der Bosch Rexroth AG verbindlich.

1.2 Validity of this Manual

This manual is valid for the Bosch Rexroth axial piston variable displacement motor A6VM. Refer to the system manufacturer for information about the allowed hydraulic fluids.

This repair manual is directed at:

- the system operator
- authorized dealers
- the system manufacturer

  For the system manufacturer, the installation drawing, the catalog sheet, the manual, and the confirmation of order from the Bosch Rexroth AG are also obligatory.

1.3 Wichtige Unterlagen

Bevor Sie mit den in dieser Anleitung beschriebenen Arbeiten anfangen, stellen Sie sicher, dass Sie folgende Unterlagen griffbereit haben:

- **Auftragsbestätigung**

  Die Auftragsbestätigung enthält die voreingestellten technischen Daten. Die Axialkolbenmaschine darf nur unter den in der Auftragsbestätigung angegebenen Werten und Bedingungen betrieben werden.

- **Einbauzeichnung**

  Die Einbauzeichnung der Axialkolbenmaschine enthält die Außenabmessungen, sämtliche Anschlüsse und den Schaltplan.

- **Technisches Datenblatt**

  Das technische Datenblatt RD 92 003 enthält u.a. die zulässigen technischen Daten für die Axialkolbenmaschine.

- **Gesamtschaltplan der Maschine bzw. Anlage**

  Der Hydraulikschaltplan und der elektrische Schaltplan der Maschine bzw. Anlage enthalten die Informationen zu den hydraulischen bzw. elektrischen Anschlüssen. Diese Daten brauchen Sie, um mit der Axialkolbenmaschine als Teil der Maschine bzw. Anlage zu arbeiten. Die Unterlagen erhalten Sie vom Maschinen- bzw. Anlagenhersteller.

- **RD 90 300-B: Allgemeine Betriebsanleitung für Axialkolbenmaschinen**

  Die allgemeine Betriebsanleitung unterstützt Sie bei Installation, Inbetriebnahme und Betrieb von Rexroth-Axialkolbenmaschinen.

- **Produktspezifische Betriebsanleitung**

  Die produktspezifische Betriebsanleitung enthält spezielle, für die Axialkolbenmaschine gültige Informationen. Informieren Sie sich bei Rexroth, ob es zu Ihrer Axialkolbenmaschine eine produktspezifische Betriebsanleitung gibt.

Folgende Rexroth-Druckschriften geben Ihnen weitere Informationen zu Installation und Betrieb der Axialkolbenmaschine:

- **RD 90 220: Druckflüssigkeiten auf Mineralölbasis**

  Beschreibt die Anforderungen an eine Druckflüssigkeit auf Mineralölbasis für den Betrieb mit Rexroth-Axialkolbenmaschinen und unterstützt Sie bei der Wahl einer Druckflüssigkeit für Ihre Anlage.

- **RD 90 221: Umweltfreundliche Druckflüssigkeiten HEES, HEPG, HETG für Axialkolbenmaschinen**

  Beschreibt die Anforderungen an eine umweltfreundliche Druckflüssigkeit für den Betrieb mit Rexroth-Axialkolbenmaschinen und unterstützt Sie bei der Wahl einer Druckflüssigkeit für Ihre Anlage.

- **RD 90 223: Axialkolbenmaschinen für den Betrieb mit HF-Druckflüssigkeiten**

  Enthält zusätzliche Informationen zum Einsatz von Rexroth-Axialkolbenmaschinen mit HF-Druckflüssigkeiten.

- **RD 90 300-03-B: Hinweise zum Einsatz von hydraulischen Antrieben bei tiefen Temperaturen**

  Enthält zusätzliche Informationen zum Einsatz von Rexroth-Axialkolbenmaschinen bei tiefen Temperaturen.

1.3 Important Documents

Before you start any of the procedures described in this manual, make sure you have the following documents:

- **Confirmation of order**

  The confirmation of order contains the values set during the commissioning by Rexroth. Before you can recommission the axial piston unit after a repair, you have to restore the values originally set by Rexroth.

- **Installation drawing**

  The installation drawing of the axial piston unit contains the sizes of all connections.

- **Technical data sheet**

  The technical data sheet RE 92 003 contains the maximum allowed performance data.

- **Hydraulic diagram / Wiring diagram**

  The hydraulic diagram and the wiring diagram of the unit or system contain the information related to the respective machine.You need this data to work with the axial piston as part of the machine or system. You can get this information from the unit or system manufacturer.

- **RE 90 300-B: General Manual for Axial Piston Units**

  The general manual supports you during the installation, initiation, and operation of Rexroth axial piston units.

- **Product Specific Manual**

  The product-specific manual contains information specially designed for the axial piston unit. Get in touch with Rexroth to find out if there is any product-specific information on your specific axial piston unit.

The following Rexroth publications provide additional information to the installation and operation of axial piston units:

- **RE 90 220: Mineral-oil Based Pressure Fluids**

  This publication describes the requirements on a hydraulic fluid for operation in an axial piston unit and supports you in the selection of a hydraulic fluid for your installation.

- **RE 90 221: Environmentally Acceptable Hydraulic Fluids HEES, HEPG, HETG for Axial Piston Units**

  Describes the demands on environmentally compatible, readily biodegradeable hydraulic fluids HEPG, HEES that can be used in Rexroth axial piston units and supports you by the choice of a hydraulic fluid for your system.

- **RE 90 223: Axial Piston Units for Use with HF Fluids**

  Provides additional information for the use of Rexroth axial piston units with HF hydraulic fluids.

- **RE 90 300-03-B: Instructions on the Use of Hydrostatic Drives at Low Temperatures**

  Provides additional information for the use of Rexroth axial piston units for low temperatures.

1.4 Gefahrenkennzeichnungen und Piktogramme

Diese Anleitung unterscheidet zwischen Kategorien von Gefahren gemäß ISO Guide 37:

⚠ GEFAHR

Weist auf hohes Risiko und die Gefahr von Tod oder schweren Verletzungen hin.

⚠ WARNUNG

Weist auf mittleres Risiko und die Gefahr von Verletzungen und schweren Sachschäden hin.

⚠ VORSICHT

Weist auf geringes Risiko und Sachschäden hin.

Hinweis

Kennzeichnet Informationen, die zum besseren Verständnis der Maschinenabläufe beitragen oder weist auf einen besonderen bzw. wichtigen Sachverhalt hin.

Tipp

Kennzeichnet Informationen, die zum effizienteren Arbeiten beitragen.

1.4 Danger Labels and Pictograms

This manual differentiates between the following categories of danger according to ISO Guide 37:

⚠ DANGER

Indicates high risk, mortal danger and serious injuries.

⚠ WARNING

Indicates middle risk, injuries or serious material damage.

⚠ CAUTION

Indicates low risk or material damage.

Note

Indicates information that contributes to a better understanding of the machine processes or indicates important information.

Tip

Indicates information that contributes to more efficient work.

2 Sicherheit

Lesen Sie dieses Kapitel sorgfältig durch, bevor Sie mit Arbeiten an der Verstellmotor beginnen.

Die Rexroth-Verstellpumpen sind im Sinne der Maschinenrichtlinie 98/37/EG Komponenten, die zum Einbau in eine Anlage bestimmt sind. Die Sicherheitsrichtlinien in dieser Anleitung beziehen sich nur auf die Verstellmotor. Beachten Sie zusätzlich die Sicherheitsrichtlinien des Anlagenherstellers.

Informieren Sie sich an Hand der allgemeinen Betriebsanleitung für Axialkolbenmaschinen über die bestimmungsgemäße Verwendung und die Sorgfaltspflicht des Betreibers und Bedieners.

2.1 Grundlegende Sicherheitshinweise

Befolgen Sie die folgenden Sicherheitshinweise und die des Anlagenherstellers genau, um Verletzungen und Gesundheitsschäden sowie Sach- und Umweltschäden auszuschließen.

⚠ GEFAHR

Lebensgefahr

Das Arbeiten an nicht stillgelegten Maschinen bzw. Anlagen stellt eine Gefahr für Leib und Leben dar.

Die in diesem Dokument beschriebenen Arbeiten dürfen nur an **stillgelegten Maschinen bzw. Anlagen** vorgenommen werden. Bevor Sie mit den Arbeiten beginnen:

- Stellen Sie sicher, dass der Antriebsmotor nicht eingeschaltet werden kann.
- Stellen Sie sicher, dass sämtliche kraftübertragenden Komponenten und Anschlüsse (elektrisch, pneumatisch, hydraulisch) gemäß den Herstellerangaben ausgeschaltet sind und nicht eingeschaltet werden können. Falls möglich, entfernen Sie die Hauptsicherung der Maschine bzw. Anlage.
- Stellen Sie sicher, dass die Maschine bzw. Anlage komplett hydraulisch entlastet ist (drucklos). Folgen Sie hierzu den Angaben des Maschinen- bzw. Anlagenherstellers.

⚠ WARNUNG

Verletzungsgefahr

Um Verletzungen zu vermeiden, beachten Sie bitte folgende Empfehlungen betreffend **Sicherheitskleidung**:

- Tragen Sie bei Arbeiten an Maschine bzw. Anlage Sicherheitsschuhe mit Stahlkappen.
- Tragen Sie bei Arbeiten mit gefährlichen Stoffen (beispielsweise Druckflüssigkeiten) Schutzhandschuhe und Schutzbrille.

2 Safety

Read through this chapter carefully before you start any work on the variable displacement motor.

The Rexroth variable displacement motor are in the sense of the machine guideline 98/37/EG components of a larger machine or system. The safety guidelines in this manual only cover the variable displacement motor. You must additionally follow the system manufacturer's safety guidelines.

Read the general manual for axial piston units to get more information on the designated use and the operator's obligation to exercise dilligence.

2.1 Basic Safety Information

Pay exact attention to the following safety information and that of the system manufacturer to eliminate injuries and health damages as well as damages to material or the environment.

⚠ DANGER

Danger to Life

Working on systems that have not been shut down is life-threatening.

The work described in this document can only be carried out on a **shut down system**. Before you start any of the tasks:

- Make sure that the engine / motor cannot be switched on.
- Make sure that all components and connections that carry energy (electrical, pneumatic, hydraulic) have been shut down according to the manufacturer's instructions and cannot be switched on. If possible, disable the main fuse.
- Make sure that the system is completely unloaded. Follow the instructions of the the system manufacturer.

⚠ WARNING

Danger of injuries

To avoid injuries, pay attention to the following regarding **safety clothing**.

- When working on the system, wear steel-toed safety shoes.
- When working with dangerous substances (for example, certain hydraulic fluids), wear protective gloves and protective glasses.

⚠ GEFAHR

Vergiftungs- und Verletzungsgefahr

Der Kontakt mit Drückflüssigkeiten ruft Gesundheitsschäden hervor (z.B. Augenverletzungen, Haut- und Gewebeschädigungen, Vergiftungen beim Einatmen).

- Überprüfen Sie vor jeder Inbetriebnahme die Leitungen auf Verschleiß bzw. Beschädigungen.
- Tragen Sie dabei Schutzhandschuhe und Schutzbrille.
- Wenn dennoch Druckflüssigkeit in die Augen gelangt oder in die Haut eindringt, konsultieren Sie unmittelbar einen Arzt.
- Beachten Sie beim Umgang mit Druckflüssigkeiten unbedingt die Sicherheitsangaben des Druckflüssigkeitsherstellers.

⚠ DANGER

Danger of poisoning or injuries

Contact with hydraulic fluids can cause health damage (eye injuries, skin damage, poisoning due to inhalation).

- Always check the hydraulic lines for wear and damage prior to putting the unit into operation.
- Always wear protective gloves and safety glasses.
- Should pressure fluid come into contact with your eyes or skin: Get medical help immediately!
- When handling hydraulic fluids, pay exact attention to the manaufacturer's safety instructions.

⚠ WARNUNG

Verbrennungsgefahr

Die Axialkolbenmaschine erwärmt sich während des Betriebs. Auch die Magnete an der Axialkolbenmaschine werden im laufenden Betrieb heiß. Finger und Hände können bei Berührung der Axialkolbenmaschine oder der Magnete schwere Brandverletzungen erleiden.

- Lassen Sie die Axialkolbenmaschine vor jedem Kontakt abkühlen.
- Schützen Sie sich mit hitzebeständigen Handschuhen und Schutzkleidung.

⚠ WARNING

Danger of burns

The variable displacement motor heats up during operation. The unit's solenoids get hot during operation. Fingers and hands can be badly burned when touching the variable displacement motor or solenoids.

- Let the variable displacement motor cool down prior to any contact.
- Protect yourself from burns by wearing safety gloves and protective clothing.

⚠ GEFAHR

Vergiftungs- und Verletzungsgefahr

Beim Suchen nach Leckstellen kann entweichende Druckflüssigkeit in die Haut eindringen und schwerste Vergiftungen und Verletzungen hervorrufen.

- Suchen Sie nur bei abgestellter und druckloser Maschine nach Leckstellen.

⚠ DANGER

Danger of poisoning

When looking for leaks, escaping hydraulic fluid can break into the skin and cause serious poisoning.

- Always use a piece of cardboard or paper to look for leaks.

⚠ WARNUNG

Verletzungs- und Beschädigungsgefahr

Durch falsch angeschlossene Komponenten können erhebliche Fehlfunktionen entstehen.

- Achten Sie auf korrekte Verrohrung gemäß Schaltplan.
- Führen Sie komponentenorientierte Funktionstests durch.

⚠ WARNING

Danger of injuries or damage

Incorrectly connected components can considerably impair the functionality of a hydraulic system.

- Make sure that the hydraulic lines are connected properly.
- Check the correct functioning of all components.

⚠ GEFAHR

Feuergefahr

Hydraulische Druckflüssigkeit ist brennbar.

- Halten Sie offenes Feuer von der Verstellmotor fern.

⚠ DANGER

Danger of fire

Hydraulic fluid is inflammable.

- Keep open fires away from the variable displacement motor.

⚠ WARNUNG

Gehörschäden

Die Geräuschemission von Axialkolbenmaschinen ist u.a. von Drehzahl, Betriebsdruck und Einbauverhältnissen abhängig. Es ist damit zu rechnen, dass der Schalldruckpegel bei normalen Einsatzbedingungen über 70 dBA steigt. Dies kann zu Gehörschäden führen.

- Schützen Sie sich stets mit Gehörschutz bei Arbeiten in der Nähe der Axialkolbenmaschine während des laufenden Betriebs.

⚠ WARNING

Danger of hearing loss

The noise emission produced by axial piston units depends on speed, operating pressure, and installation. During normal application conditions, over 70 dBA can be anticipated. This can lead to hearing damage.

- Always wear hearing protection when working in the vicinity of the variable displacement motor during operation.

⚠ WARNUNG

Umweltschäden

Druckflüssigkeiten sind wassergefährdende Flüssigkeiten. Das Austreten von Druckflüssigkeiten kann zu Grundwasservergiftung und Bodenverseuchung führen.

- Bringen Sie unter der Axialkolbenmaschine eine Auffangwanne an.
- Beseitigen Sie Leckstellen unverzüglich.
- Es sind stets die nationalen Gesetze und Vorschriften zu beachten. In Deutschland sind hydraulische Maschinen bzw. Anlagen „Anlagen zum Umgang mit wassergefährdenden Stoffen im Sinne des Wasserhaushaltsgesetzes (WHG)". Beachten Sie in diesem Zusammenhang besonders §1 und §19 WHG (§19g, 19i, 19i).
- Weitere Informationen finden Sie in den Rexroth-Druckschriften „Druckflüssigkeiten auf Mineralölbasis", RD 90 220, „Umweltschonende, biologisch schnell abbaubare Druckflüssigkeiten HEPG, HEES für Axialkolbenmaschinen", RD 90 221 und „Axialkolbenmaschinen für den Betrieb mit HF-Druckflüssigkeiten, RD 90 223.

⚠ WARNING

Risk of damage to the environment

Hydraulic fluid leakage leads to contamination of the ground and ground water.

- A basin for catching any hydraulic fluid must be placed under the variable displacement motor.
- Leaks must be cleaned up immediately.
- In Europe, hydraulic systems are considered "Systems using water-threatening substances" in the sense of the Water Management Law (WHG).Therefore, pay special attention to §1 and §19 WHG(§19g, 19i, 19l). Additionally pay attention to any national regulations and norms.
- Further information is available in the Rexroth publications „Mineral-oil based hydraulic fluids", RE 90 220. „Environmentally acceptable, rapid biologically degradable hydraulic fluids HEPG, HEES for axial piston units", RE 90 221 and „Axial piston units for operation with HF hydraulic fluids, RE 90 223.

2.2 Anforderungen an das Personal

Diese Reparaturanleitung richtet sich an **Fachkräfte mit Hydraulik-Fachwissen**, die an einer Service-Schulung bei Rexroth teilgenommen haben.

Als **Fachkraft** gilt, wer aufgrund seiner fachlichen Ausbildung und Erfahrung ausreichende Kenntnisse hat, sowie mit den einschlägigen Bestimmungen so weit vertraut ist, dass er

- die ihm übertragenene Arbeiten beurteilen kann,
- mögliche Gefahren erkennen kann,
- die notwendigen Maßnahmen zur Beseitigung von Gefahren ergreifen kann,
- Kenntnisse über die möglichen Gesundheitsgefahren von Druckflüssigkeiten hat
- und die erforderlichen Reparatur- und Montagekenntnisse hat.

Hydraulik-Fachwissen bedeutet, das Personal muss

- in der Lage sein, die Hydraulikpläne zu lesen und vollständig zu verstehen,
- insbesondere die Zusammenhänge bezüglich der eingebauten Sicherheitseinrichtungen vollständig verstehen
- und Kenntnisse über Funktion und Aufbau von hydraulischen Bauteilen haben.

2.2 Requirements on the Personnel

This repair manual is directed at **qualified personnel with specialized hydraulics know-how** who have taken part at a service training at Rexroth.

Qualified personnel is defined as persons who have sufficient knowledge on the basis of specialized training and experience, and are familiar with the relevant regulations, so that they are able to

- judge the delegated tasks,
- recognize possible dangers,
- take the necessary measures for the elimination of dangers,
- judge the possible health risks from hydraulic fluids,
- and have the required repair and installation know-how.

Specialized hydraulics know-how means that these persons must:

- be able to read and completely understand hydraulic plans,
- especially understand the connections regarding the installed safety equipment,
- and are familiar with the function and structure of hydraulic components.

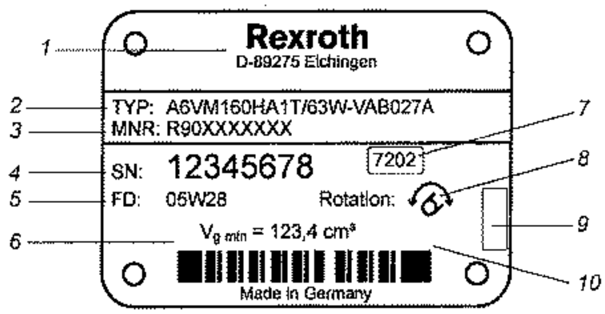
3 Produktbeschreibung

Dieses Kapitel gibt Ihnen einen allgemeinen Überblick über die Funktionalität der Rexroth A6VM Verstellmotor.

Machen Sie sich mit den Inhalten dieses Kapitels vertraut, bevor Sie mit Arbeiten an einer Verstellmotor beginnen.

3.1 Typschild

Die Verstellmotor ist am Typschild zu identifizieren:



Folgende Informationen finden Sie auf dem Typschild:

1 Hersteller
2 Typschlüssel
3 Materialnummer der Axialkolbenmaschine
4 Seriennummer
5 Fertigungsdatum
6 Drehzahl
7 interne Werksbezeichnung
8 Drehrichtung (bei Blick auf die Welle; hier: wechselnd)
9 vorgesehener Platz für Prüfstempel
10 Leistung

Stellen Sie sicher, dass Typ und Nenngröße der zu reparierenden Verstellmotor mit dieser Anleitung übereinstimmen.

3.2 Funktionsbeschreibung

Damit Sie in der Lage sind, Probleme an der Verstellmotor zu identifizieren und gezielt Reparaturen durchzuführen, sind Kenntnisse der Funktionsweise und des Aufbaus erforderlich. Dieser Abschnitt gibt Ihnen eine grobe Übersicht.

Die A6VM Verstellmotor ist eine Axialkolben-Verstellmotor in Schrägscheibenbauart für hydrostatische Antriebe im geschlossenen Kreislauf. Der Volumenstrom ist proportional zu der Antriebsdrehzahl und dem Verdrängungsvolumen. Durch die Verstellung der Schrägscheibe ist eine stufenlose Volumenstromänderung möglich.

3 Product Description

This chapter provides a general overview of the functionality of the A6VM variable displacement motor.

You should be familiar with the contents of this chapter before starting any work on the variable displacement motor.

3.1 Name Plate

The variable displacement motor can be identified on its type plate:

The following information can be found on the type plate:

1 Manufacturer
2 Ordering code
3 Material number of the axial piston unit
4 Serial number
5 Date of manufacturing
6 Speed
7 Internal manufacturing code
8 Direction of rotation (when facing the shaft; here: alternating)
9 Designated space for certification stamp
10 Power

Ensure that the variable displacement motor to be repaired is of the type and size covered by this manual.

3.2 Functional Description

To make sure that you are able to identify problems with a variable displacement motor and to carry out specific repairs, familiarity with how the unit functions and its assembly are required. This section provides you with a rough overview.

The variable displacement axial piston pump type A6VM in swashplate design is designed for closed circuit hydrostatic drives. The flow is proportional to the input drive speed and displacement. By adjusting the swashplate, it is possible to infinitely vary the flow.

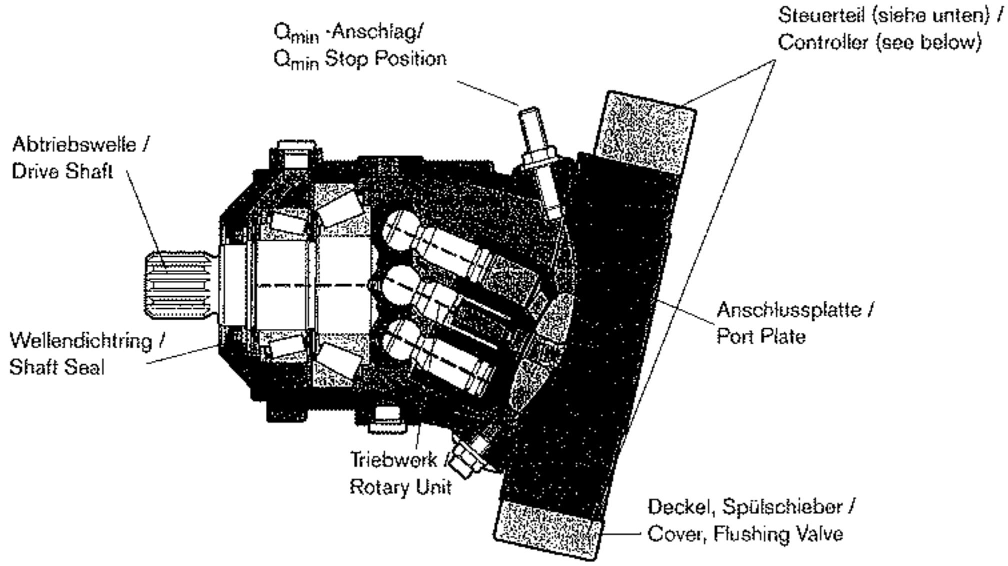
Schnittzeichnung

Die folgenden Schnittzeichnungen zeigen das Zusammenspiel der Komponenten des A6VM Verstellmotors.

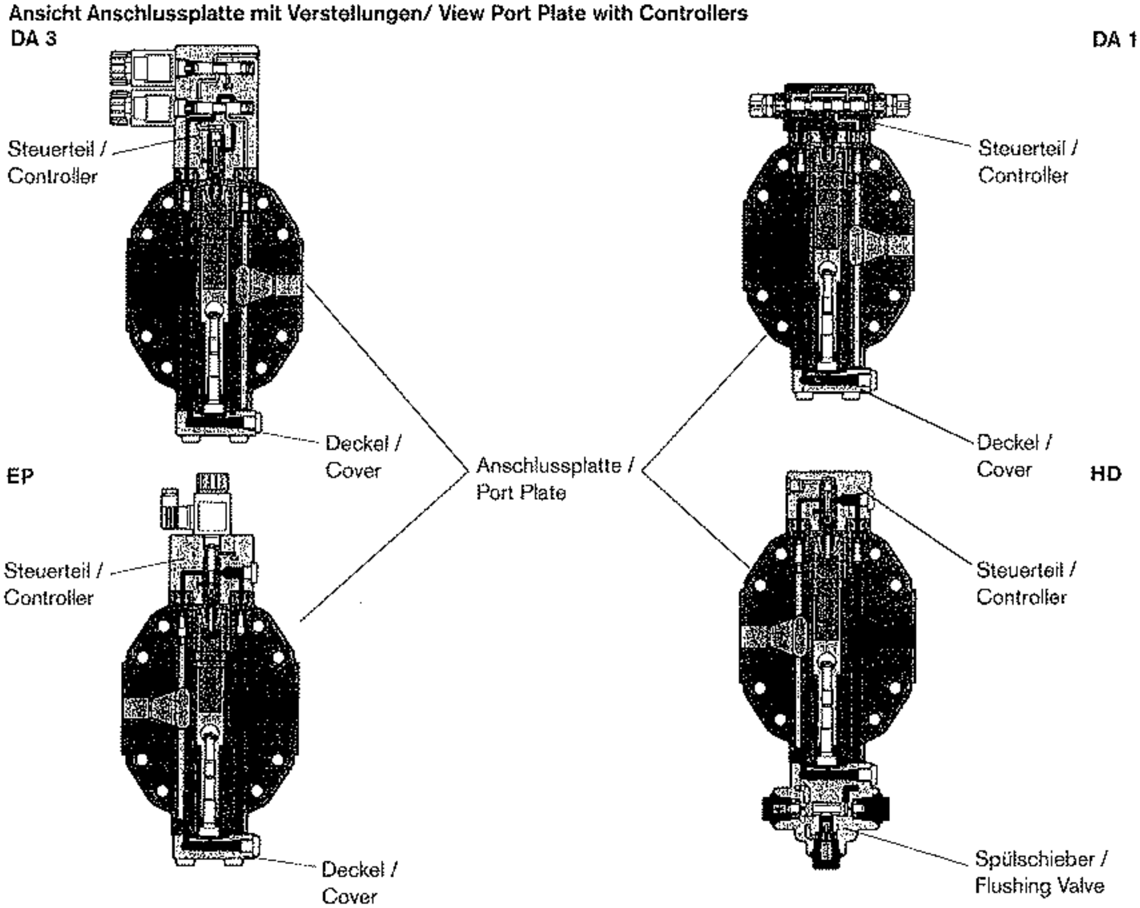
Sectional Drawing

The following drawings show the interrelation of the components of the A6VM variable displacement motor.

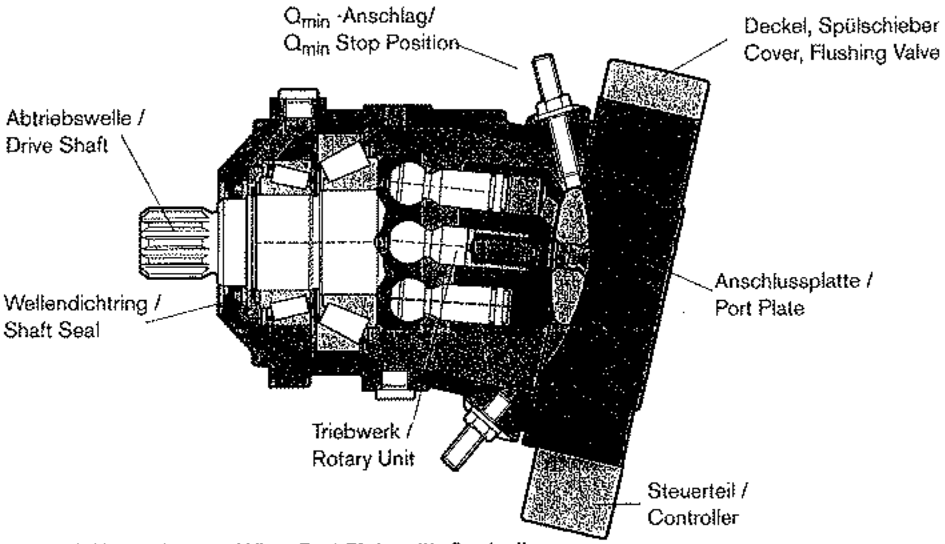
Seitenansicht / Side View



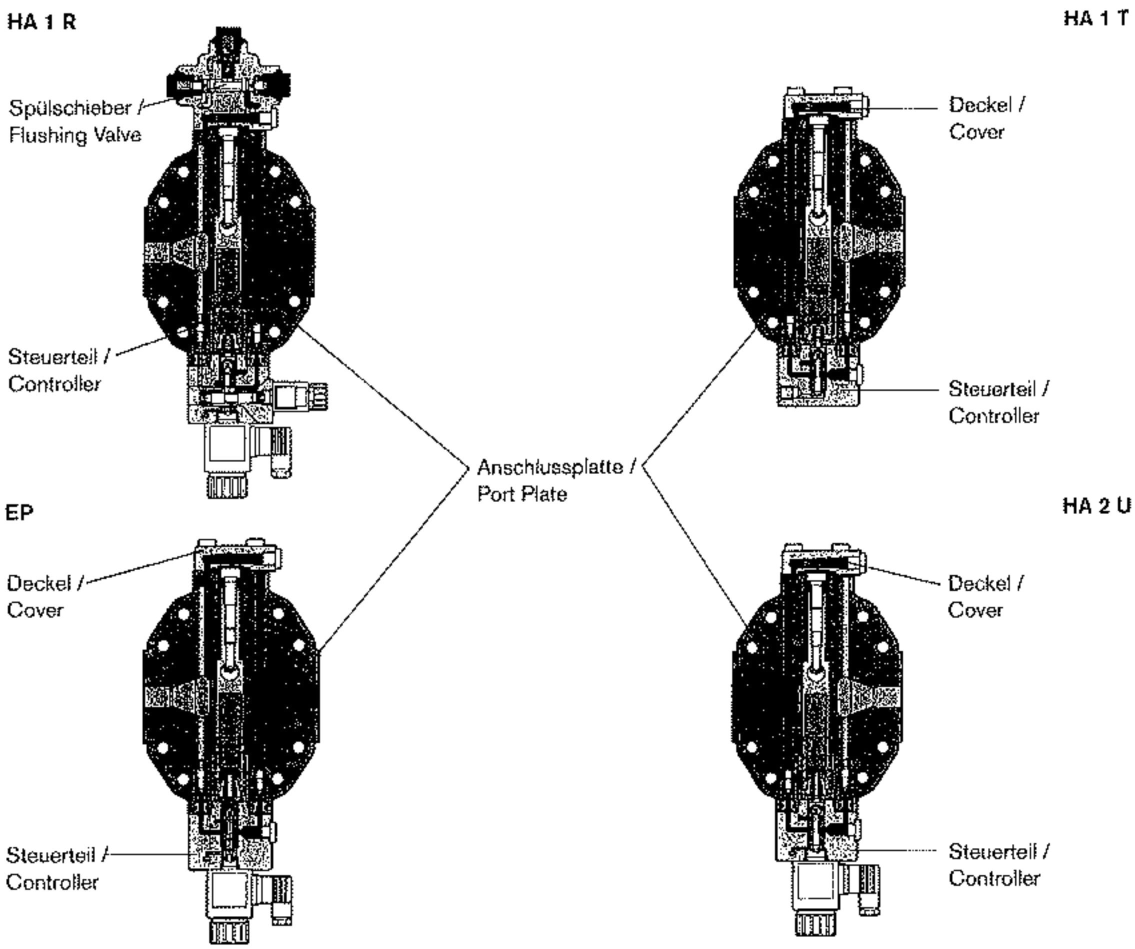
Ansicht Anschlussplatte mit Verstellungen/ View Port Plate with Controllers



Seitenansicht / Side View



Ansicht Anschlussplatte mit Verstellungen/ View Port Plate with Controllers



3.3 Technische Daten

Die technischen Daten der Verstellmotor finden Sie in der Auftragbestätigung. Ergänzend dazu ist das jeweilige technische Datenblatt. Für den A6VM Verstellmotor gilt das technische Datenblatt RD 92 003.

3.3 Technical Data

You can find the technical data for the variable displacement motor in the Confirmation of Order. This is supplemented by the unit's data sheet. For the A6VM variable displacement motor, the valid data sheet is RE 92 003.

4 Austausch externer Baugruppen

Dieses Kapitel beschreibt den Austausch von extern zugänglichen Baugruppen des Verstellmotors A6VM.

Der Austausch folgender Baugruppen wird beschrieben:

- Wellendichtring
- Dichtungen
- Steuerteil
- Deckel, Spülschieber

Hinweis

Alle in nachfolgenden Zeichnungen dargestellten Steuergeräte sind nur stellvertretend und müssen nicht der Konfiguration Ihrer Axialkolbenmaschine entsprechen.

⚠ WARNUNG

Gefahr von Verschleiß und Funktionsstörungen

Die Sauberkeit der Druckflüssigkeit und die Lebensdauer der Hydraulikanlage stehen in unmittelbarem Zusammenhang. Verschmutzung der Druckflüssigkeit führt zu Verschleiß und Funktionsstörungen. Insbesondere harte Fremdkörper in den Hydraulikleitungen, wie z. B. Schweißperlen und Metallspäne, können die Axialkolbenmaschine beschädigen.

Beachten Sie daher unbedingt folgende Hinweise:

- Achten Sie auf äußerste Sauberkeit. Die Axialkolbenmaschine muss schmutzfrei eingebaut werden. Verunreinigungen in der Druckflüssigkeit können die Funktion und Lebensdauer der Axialkolbenmaschine erheblich beeinträchtigen.
- Achten Sie besonders bei der Installation darauf, dass Anschlüsse, Hydraulikleitungen und Anbauteile (z. B. Messgeräte) sauber sind. Reinigen Sie diese gründlich, bevor Sie Anschlüsse öffnen. Stellen Sie sicher, dass auch beim nachfolgenden Verschließen der Anschlüsse keine Verunreinigungen eindringen.
- Verwenden Sie für die Beseitigung von Schmiermitteln und anderen starken Verschmutzungen geeignete flüssige Reinigungsmittel. Es darf kein Reinigungsmittel in das Hydrauliksystem eindringen.
- Verwenden Sie zur Reinigung keine Putzwolle oder fasernde Putzlappen.
- Verwenden Sie als Dichtungsmittel keinesfalls Hanf oder Kitt.

4 Exchanging External Assembly Groups

This chapter describes the replacement of the externally accessible assembly groups of the variable displacement motor A6VM.

The exchange of the following assembly groups is described:

- Shaft seal
- Seals
- Controller
- Cover, Flushing Valve

Note

All the following illustrations pictured controllers are only examples and do not have to completely correspond with the configrations of your axial piston unit.

⚠ WARNING

Danger of wear and malfunction

The durability of the hydraulic unit depends to a great extent on how clean the unit is kept. Dirt in the hydraulic fluid can lead to malfunctions. Especially hard foreign matter in the hydraulic conduits, for example, welding beads and cuttings, can damage the axial piston unit.

Therefore you should observe the following instructions:

- Make sure everything is kept extremely clean. The axial piston unit must be installed in a dirt-free environment. Contamination of the hydraulic fluid can lead to considerable wear and malfunctions of the axial piston unit.
- Espacially during the installation, you should make sure that ports, hydraulic conduits, and mounting components (for example, gauges) are clean. Clean these thoroughly before you open connections. After that, when sealing the ports, make sure that contaminating elements cannot enter the system.
- When removing grease and other dirt you should use appropriate liquid cleaning agents. Cleaning agents must not enter the hydraulic system.
- Do not use cotton waste or rags which lose threads.
- Never use hemp or putty as a sealant.

4.1 Wellendichtring austauschen

Dieser Abschnitt erklärt, wie Sie den Wellendichtring austauschen.

Benötigtes Sonderwerkzeug:

- Montagehülse

  Die Materialnummern sind je nach Motormodell verschieden:
  - A6VM28: Mat. nr. R909877507
  - A6VM55: Mat. nr. R909877508
  - A6VM80: Mat. nr. R909877507
  - A6VM107: Mat. nr. R909877508
  - A6VM160: Mat. nr. R909877507
  - A6VM200: Mat. nr. R909877508

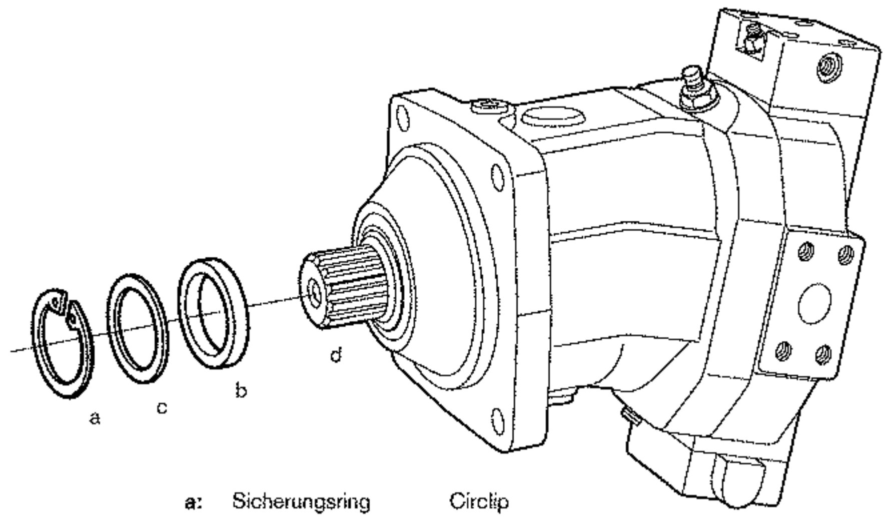
4.1 Exchanging the Shaft Seal

This section explains how you can replace the shaft seal.

Required Special Tools:

- Mounting sleeve

  The material number depends on the motor model:
  - A6VM28: Mat. no. R909877507
  - A6VM55: Mat. no. R909877508
  - A6VM80: Mat. no. R909877507
  - A6VM107: Mat. no. R909877508
  - A6VM160: Mat. no. R909877507
  - A6VM200: Mat. no. R909877508



a:	Sicherungsring	Circlip
b:	Wellendichtring	Shaft Seal
c:	Scheibe	Shim
d:	Triebwelle	Drive Shaft

Um den Wellendichtring auszutauschen:

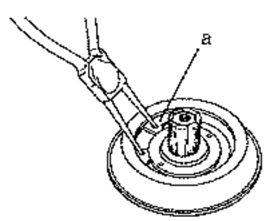
1 Kleben Sie die Triebwelle (d) ab, um Beschädigungen am Wellendichtring (b) zu vermeiden.

2 Entfernen Sie den Sicherungsring (a) und die Scheibe (c).

To exchange the shaft seal:

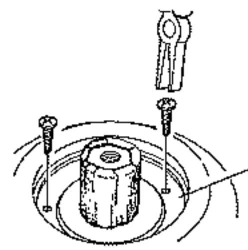
1 Mask the drive shaft (d) for protection against damage of the shaft seal (b).

2 Remove the safety ring (a) and the shim (c).



3 Drehen Sie Blechschrauben in die mit Gummi gefüllten Löcher des Wellendichtrings (b) und ziehen Sie den Wellendichtring mit einer Zange heraus.

3 Screw the tapping screw into the rubber lined holes of the shaft seal (b), and use pliers to pull the shaft seal out.

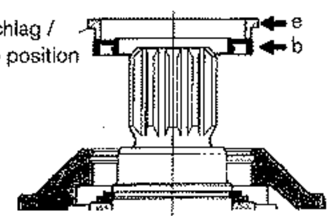


4 Fetten Sie den neuen Wellendichtring zwischen Dicht- und Staublippe leicht ein, um Trockenlauf zu vermeiden.

5 Pressen Sie den Wellendichtring (b) mit Hilfe der Montagehülse (e) (Sonderwerkzeug) auf Anschlag ein.

4 Grease the new shaft seal between the seal and dust lip to avoid a dry run.

5 Using the mounting sleeve (e) (special tool), press in the shaft seal (b) until it is in stop position.



6 Legen Sie die Scheibe (c) ein.

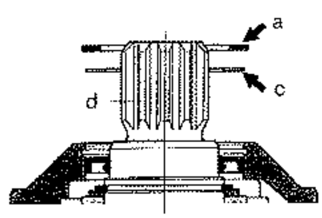
7 Führen Sie den Sicherungsring (a) so ein, dass er in die dafür vorgesehene Nut einrastet.

8 Entfernen Sie die Abklebung an der Triebwelle (d).

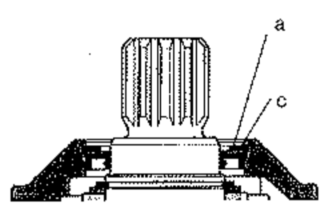
6 Place the shim (c).

7 Place the safety ring (a) that it locks into place in the respective slot.

8 Remove the mask on the drive shaft (d).



Ergebnis/Result



4.2 Dichtungen austauschen

Benötigtes Sonderwerkzeug: Keines

Dichtmutter austauschen

Um die Dichtmutter auszutauschen:

1 Messen und notieren Sie das Maß X der Dichtmutter (a) für die spätere Montage.
Entfernen Sie die Dichtmutter.

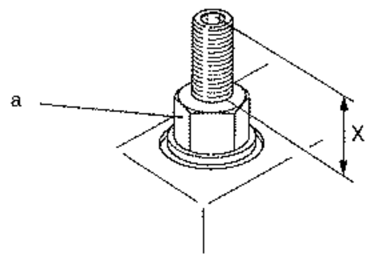
4.2 Exchanging Seals

Required Special Tools: none

Exchanging the seal nut

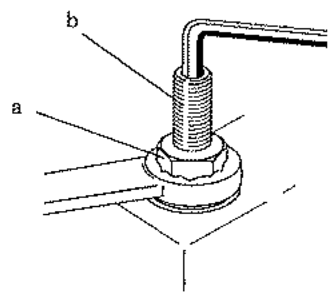
To exchange the seal nut:

1 Measure and write down the dimension X of the seal nut (a). You need this for the subsequent assembly.
Remove the seal nut.



2 Schrauben Sie die Dichtmutter (a) ein. Blockieren Sie die Stellschraube (b) während Sie die Dichtmutter festziehen.
Kontrollieren Sie das Maß X nach der Montage.

2 Screw in the seal nut (a) manually. Block the adjusting screw (b) while you tighten the seal nut.
Check the dimension X after assembly.



4.3 Steuerteil austauschen

Benötigtes Sonderwerkzeug: Keines

Einstellschraube entspannen

Um die Einstellschraube zu entspannen:

1 Messen und notieren Sie das Maß X der Einstellschraube (a) für die spätere Montage.

2 Drehen Sie die Einstellschraube heraus bis die Einstellhülse (b) am Gehäuse des Steuerteils (c) anliegt.

4.3 Exchanging the Controller

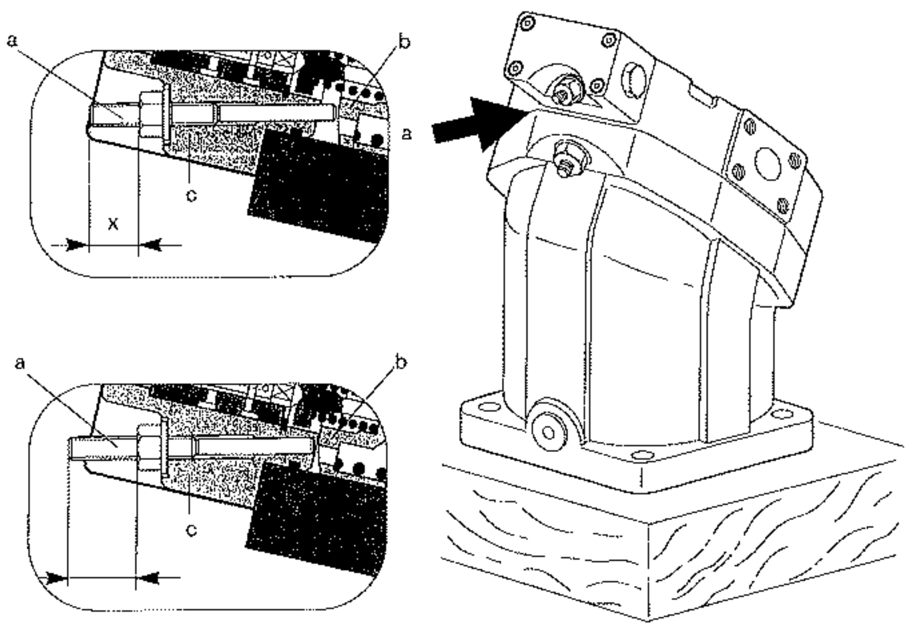
Required Special Tools: none

Release the set screw

To release the tension of the set screw:

1 Measure and write down the dimension X of the adjustment screw (a). You need this for the subsequent assembly.

2 Unscrew the adjustment screw until the adjustment sleeve touches the housing of the contoller (c).



Steuerteil entfernen

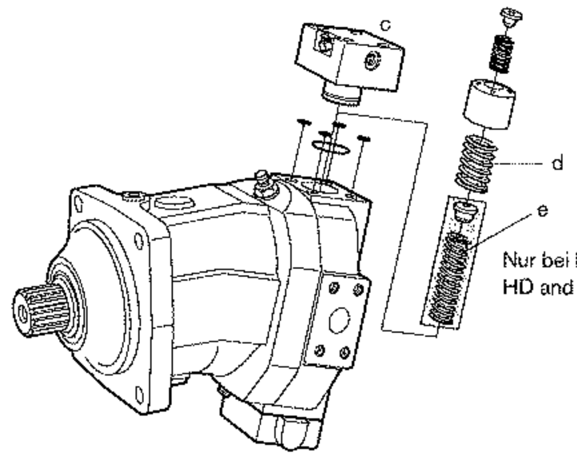
Um das Steuerteil zu entfernen:

1 Lösen Sie die Befestigungsschrauben des Steuerteils (c) und entfernen Sie dieses. Beachten Sie, dass die Federn (d) und (e) unter Vorspannung stehen!

Removing the Controller

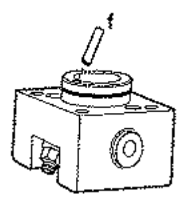
To remove the controller:

1 Remove the fastening screw of the controller (c). Pay attention that the springs (d) und (e) are under initial tension!



2 Kontrollieren Sie den Zylinderstift (f). Er sitzt nun lose im Gehäuse des Steuerteils. Die Einstellschraube wird nicht entfernt.

2 Inspect the cylinder pin. It is not fixed in the housing of the controller. Do not remove the adjustment screw.



3 Kontrollieren Sie O-Ring, O-Ring-Nut und das Gehäuse.

4 Tauschen Sie die Dichtungen aus.

3 Inspect the O-ring, O-ring groove, housing.

4 Exchange the seals.

Steuerteil austauschen

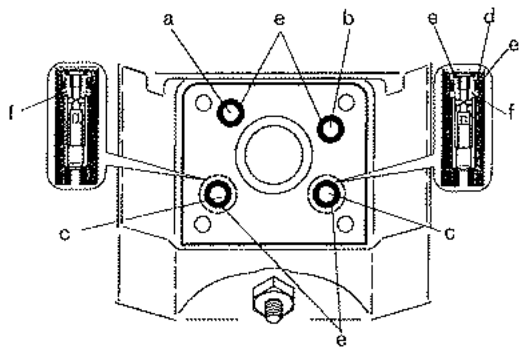
Um das neue Steuerteil zu montieren:

1 Schrauben Sie das neue Steuerteil fest. Achten Sie dabei auf den Zylinderstift, der lose in der Führung der Einstellschraube sitzt.

Exchange the Controller

To exchange the controller:

1 Screw in the new controller. Pay attention to the cylinder pin, which is not fixed in the track of the set screw.



a:	Hochdruck - kleine Stellkolbenseite	High pressure - small control piston side
b:	Stelldruck	Control pressure
c:	Hochdruck - A/B	High pressure - A/B
d:	Stützring	Back up ring
e:	O-Ring	O-ring
f:	Rückschlagventil	Check valve

2 Drehen Sie die Einstellschraube bis zum Maß X ein.

3 Kontrollieren Sie Maß X nach der Montage.

Nach der Montage des Steuerteils muss der Regelbeginn überprüft werden, siehe „Überprüfungen" auf Seite 25.

2 Screw in the adjustment screw until dimension X is reached.

3 Check dimension X after assembly.

After installing the control unit, the begin of regulation must be checked. Please refer to „Checking", page 25.

4.4 Deckel abdichten

Um den Deckel abzudichten:

1 Schrauben Sie den Deckel ab.

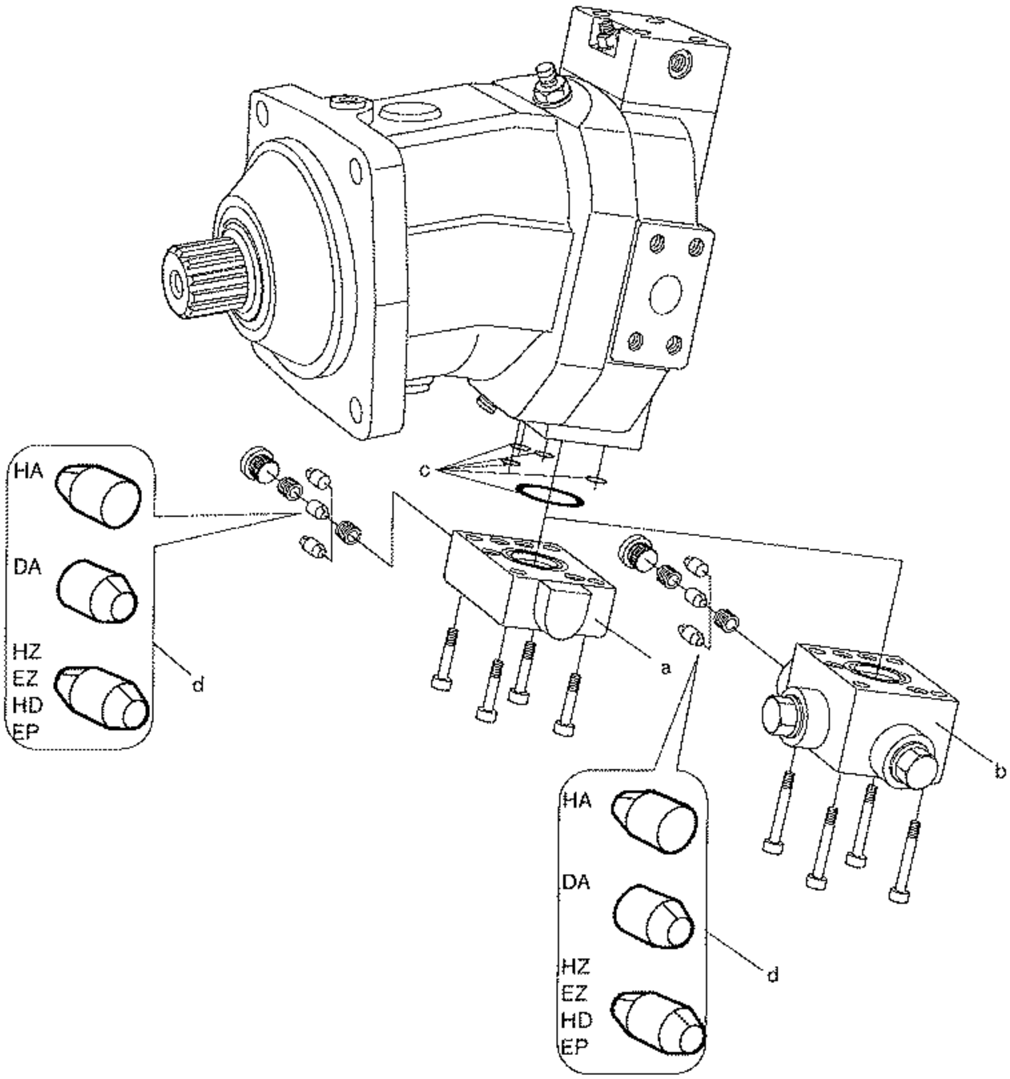
Beispiel: Motor mit HD-Verstellung

4.4 Sealing the Cover

To seal the cover:

1 Unscrew the cover.

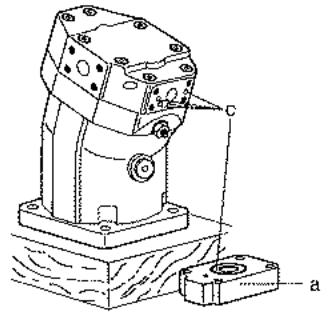
Example: Motor with HD-displacement



a:	Deckel	Cover
b:	Spülventil	Flushing valve
c:	O-Ring	O-ring
d:	Einbauvariante Drosselstift nach Werksauftrag	Installation type Throttle pin as to production order

O-Ringe austauschen

Exchanging the o-rings

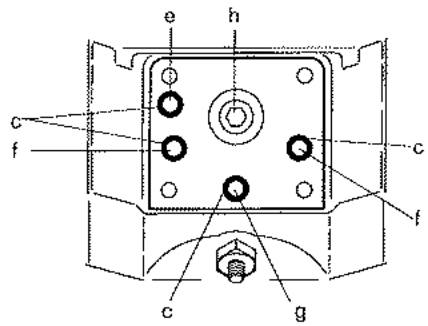


2 Prüfen und ersetzen Sie die O-Ringe (c).

2 Inspect and replace the o-rings (c).

O-Ringe

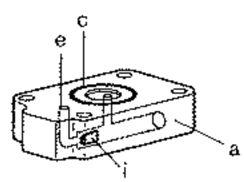
O-Rings



c:	O-Ring	O-ring
e:	Stellölzulauf	Input flow of oil control
f:	Hochdruck bzw. Niederdruck	High pressure/Low pressure
g:	Lecköl	Leckage oil
h:	Stellkolben	Control piston

Deckel

Cover



a:	Deckel	Cover
c:	O-Ring	O-ring
e:	Stellölzulauf	Input flow of oil control
i:	Drosselstift	Throttle pin

Beachten Sie, dass die Einbaulage des Drosselstifts (i) je nach Steuerteil verschieden sein kann

Pay attention that the throttle pin (i) can be in different post assembly positions.

5 Überprüfungen

Bei der ersten Inbetriebnahme nach einer Reparatur müssen Sie die ursprünglichen Einstellungen der Verstellmotor kontrollieren. Dieses Kapitel erklärt folgende Überprüfungen:

- Regelbeginn Motorverstellung EP
- Regelbeginn Motorverstellung HD
- Regelbeginn Motorverstellung HA
- Regelbeginn Motorverstellung DA1/4, DA2, 3, 4, 5, 6

Führen Sie alle Überprüfungen bei Betriebstemperatur durch.

Wenn die überprüften Werte von den ursprünglichen Einstellungen abweichen, setzen Sie sich bezüglich der Einstellung bitte mit dem Rexroth-Service in Verbindung.

⚠ WARNUNG

Verletzungsgefahr

Arbeiten an der Verstellmotor bei Betriebstemperatur sind gefährlich.

- Beachten Sie die Sicherheitshinweise (siehe „Sicherheit" auf Seite 7).

⚠ WARNUNG

Gefahr von Verschleiß und Funktionsstörungen

Die Sauberkeit der Druckflüssigkeit und die Lebensdauer der Hydraulikanlage stehen in unmittelbarem Zusammenhang.

- Achten Sie bei Überprüfungen darauf, dass Messanschlüsse, Schläuche und Messgeräte sauber sind. Reinigen Sie diese gründlich bevor Sie die Messpunkte öffnen und mit den Einstellarbeiten beginnen.
- Stellen Sie sicher, dass auch beim nachfolgenden Verschließen der Messpunkte keine Verunreinigungen eindringen.

5 Checking

When starting up for the first time after a repair, you must check the original settings of the variable displacement motor. This chapter describes the following checkings:

- Begin of regulation variable displacement motor control EP
- Begin of regulation variable displacement motor control HD
- Begin of regulation variable displacement motor control HA
- Begin of regulation variable displacement motor control DA1/4, DA2,3,4,5,6

Carry out checkings at operating temperature.

If the checked values differ from the original settings, please contact Rexroth in terms of adjusting the settings.

⚠ WARNING

Danger of injuries

Working on the variable displacement motor at operating temperature is dangerous.

- Pay exact attention to the safety advice (refer to "Safety", page 7).

⚠ WARNING

Danger of wear and malfunction

The durability of the hydraulic unit depends to a great extent on how clean the unit is kept.

- When checking settings, you should make sure that gauge ports, hydraulic conduits, and und gauges are clean. Clean these thoroughly before you open gauge ports and begin adjusting settings.
- After that, when sealing the ports, make sure that contaminating elements cannot enter the system.

5.1 Regelbeginn überprüfen Motorverstellung EP

Dieser Abschnitt erklärt, wie Sie den Regelbeginn der Verstellung EP überprüfen können.

Einstellüberprüfung

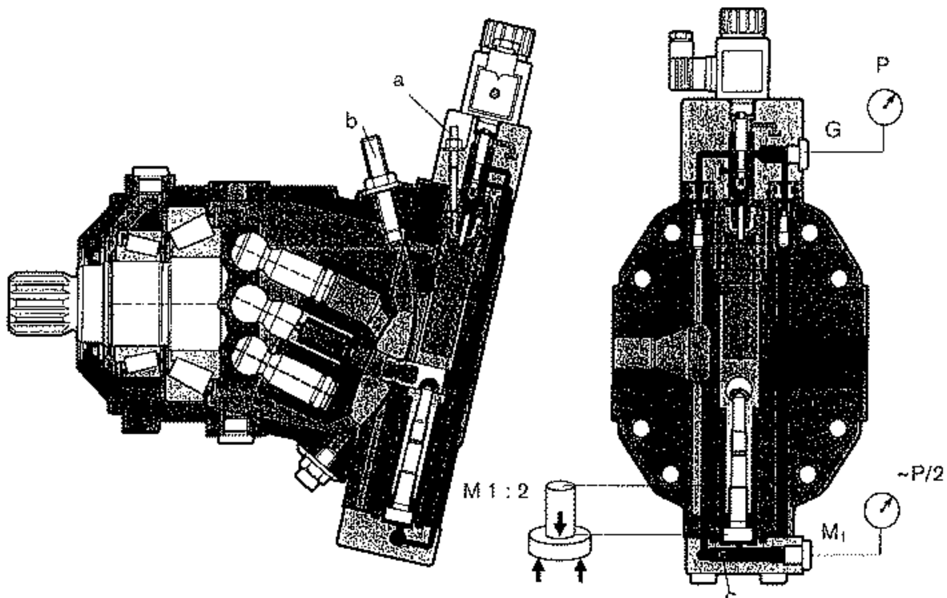
(Regelbeginn von Vg_{max} - Vg_{min})

5.1 Checking Begin of Regulation Control EP

This section describes how to check the beginn of regulation the control EP.

Setting test

(Begin of regulation of Vg_{max} - Vg_{min})



a:	Einstellschraube- Regelbeginn	Set screw - Begin of control
b:	Vg_{min}	Vg_{min}
G:	Betriebsdruck	Operating pressure
M_1:	Stelldruck	Control pressure
c:	Drossel	Throttle

Sicherheitsbestimmungen beachten!

Einstelldaten nach Werksauftrag!

Blockzustand (Straßengang und festgebremst).

A6VM - EP Vg_{max} - Vg_{min}

- Manometer „G" = 600 bar
- Manometer „M_1" = 600 bar
- Magnet = Multimessgerät

Regelbeginn

Beispiel: 200/400 mA

1 Manometer an M_1 beachten!
2 Strom erhöhen bis an M_1 die Hälfte des Druckes von G ansteht → Regelbeginn
   - Einstellschraube **im Uhrzeigersinn → Regelbeginn früher**
   - Einstellschraube **gegen Uhrzeigersinn → Regelbeginn später**

Observe safety regulations!

Setting data as to production order

Blocked condition (travel mode and manual brake).

A6VM - EP Vg_{max} - Vg_{min}

- Pressure gauge „G" = 600 bar
- Pressure gauge „M_1" = 600 bar
- Solenoid = multi measuring device

Begin of regulation

Example: 200/400 mA

1 Observe pressure gauge at M_1!
2 Increase current till at M_1 half the pressure is generated from G → Begin of regulation
   - Setscrew turned **clockwise→ Begin of regulation earlier**
   - Setscrew turned **anti-clockwise → Begin of regulation later**

5.2 Regelbeginn überprüfen Motorverstellung HD

Dieser Abschnitt erklärt, wie Sie den Regelbeginn der Verstellung HD überprüfen.

Einstellüberprüfung

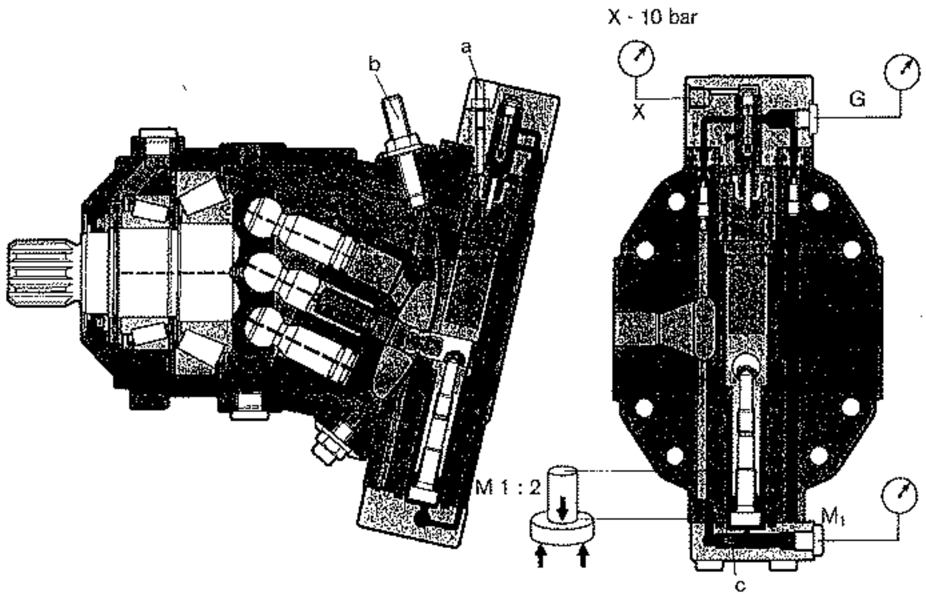
(Regelbeginn von Vg_{max} - Vg_{min})

5.2 Checking Begin of Regulation Control HD

This section describes how to check beginn of regulation the control HD.

Setting test

(Begin of regulation of Vg_{max} - Vg_{min})



a:	Einstellschraube- Regelbeginn	Set screw - Begin of control
b:	Vg_{min}	Vg_{min}
G:	Betriebsdruck	Operating pressure
M_1:	Stelldruck	Control pressure
c:	Drossel	Throttle
X:	Steuerdruck	Pilpt pressure

Sicherheitsbestimmungen beachten!

Einstelldaten nach Werksauftrag!

Blockzustand (Straßengang und festgebremst).

A6VM - HD Vg_{max} - Vg_{min}

- Manometer „G" = 600 bar
- Manometer „M_1" = 600 bar
- Manometer „X" = 60 bar

Regelbeginn

Beispiel: 10 bar Steuerdruck an X

1 Manometer an M_1 beachten!

2 Druckwert an X erhöhen bis an M_1 die Hälfte des Druckes von G ansteht → Regelbeginn
   - Einstellschraube **im Uhrzeigersinn → Regelbeginn früher**
   - Einstellschraube **gegen Uhrzeigersinn → Regelbeginn später**

Observe safety regulations!

Setting data as to production order

Blocked condition (travel mode and manual brake).

A6VM - HD Vg_{max} - Vg_{min}

- Pressure gauge „G" = 600 bar
- Pressure gauge „M_1" = 600 bar
- Pressure gauge „X" = 60 bar

Begin of regulation

Example: 10 bar pilot pressure at X

1 Observe pressure gauge at M_1!

2 Increase pressure value at X till at M_1 half the pressure is generated from G → Begin of regulation
   - Setscrew turned **clockwise → Begin of regulation earlier**
   - Setscrew **turned anti-clockwise → Begin of regulation later**

5.3 Regelbeginn überprüfen Motorverstellung HA

Dieser Abschnitt erklärt, wie Sie den Regelbeginn der Verstellung HA überprüfen können.

Einstellüberprüfung

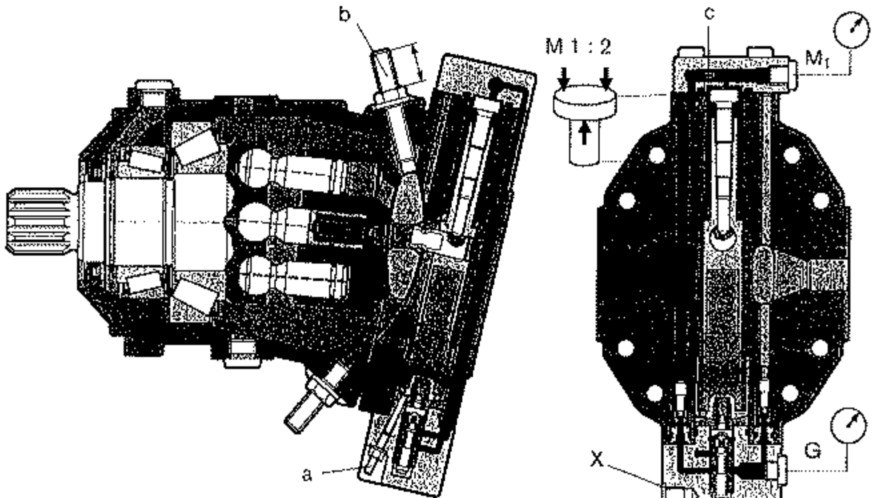
(Regelbeginn von Vg_{max} - Vg_{min})

5.3 Checking Begin of Regulation Control HA

This section describes how to check the begin of regulation the control HA.

Setting test

(Begin of regulation of Vg_{max} - Vg_{min})



a:	Einstellschraube- Regelbeginn	Set screw - Begin of control
b:	Vg_{min}	Vg_{min}
G:	Betriebsdruck	Operating pressure
M_1:	Stelldruck	Control pressure
c:	Drossel	Throttle
X:	Anschluß für Übersteuerung	Connection for overriding

Sicherheitsbestimmungen beachten!

Einstelldaten nach Werksauftrag!

Blockzustand (Straßengang und festgebremst).

Manometer 600 bar an G und M_1 anschließen.

Beispiel 1: Regelbeginn 200 bar

Betriebsdruck langsam erhöhen bis Manometer an G 200 bar

Stelldruck Manometer M_1

1/2 des Betriebsdruckes = ca. 100 bar

→ Regelbeginn

Nachjustierung des Stelldruckes an Einstellschraube - Regelbeginn

Hinweis

Drehen im Uhrzeigersinn - Regelbeginn früher.

Drehen gegen Uhrzeigersinn - Regelbeginn später.

Observe safety regulations!

Setting data as to production order

Blocked condition (travel mode and manual brake)

Connect pressure gauge 600 bar at G and M_1

Example 1: Begin of regulation 200 bar

Increase service pressure slowly till pressure gauge at G = 200 bar

Positioning pressure gauge M_1

1/2 of the sevice pressure = approx. 100 bar

→ Begin of control

Readjust positioning pressure at set screw - start of control

Note

Clockwise turning - begin of regulation earlier

Anti-clockwise turning - begin of regulation later

5.4 Regelbeginn überprüfen Motorverstellung DA1,4

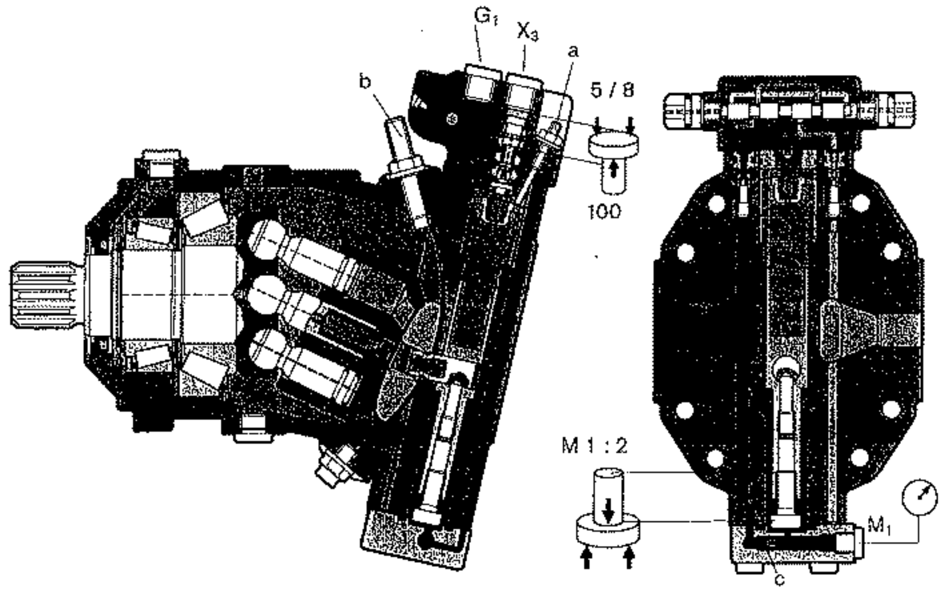
5.4 Checking Begin of Regulation Control DA1,4

Einstellüberprüfung

(Regelbeginn von Vg_{max} - Vg_{min})

Setting test

(Begin of regulation of Vg_{max} - Vg_{min})



a:	Einstellschraube- Regelbeginn	Set screw - Begin of control
b:	Vg_{min}	Vg_{min}
G:	Betriebsdruck	Operating pressure
M_1:	Stelldruck	Control pressure
c:	Drossel	Throttle

Um den Regelbeginn zu überprüfen:

1 Starten Sie die Brennkraftmaschine.

2 Achten Sie darauf, dass Manometer an den Messstellen G und M_1 des Motors angeschlossen sind bzw. schließen Sie diese an.

3 Schalten Sie den Fahrtrichtungsschalter auf „Vorwärts". Schalten Sie den Antrieb dabei in den Gang, in dem der Motor frei regeln darf, und bremsen Sie den Antrieb fest, indem Sie die Feststellbremse betätigen, Unterlegkeile benutzen oder gegen ein Hindernis fahren. Achten Sie dabei darauf, dass die Räder nicht durchdehen.

4 Erhöhen Sie den Betriebsdruck, bis Sie am Messanschluss G den Druck für den eingestellen Regelbeginn messen. Den Wert entnehmen Sie der Auftragsbestätigung.

5 Beobachten Sie den Druck am Messanschluss M_1:

Bei einem DA-Motor baut sich Druck an M_1 ab.

To check the begin of regulation:

1 Start the internal combustion engine.

2 Ensure that the manometer is connected at measuring points G and M1 of the motor, if not then connect it.

3 Set the travel direction switch to „Forwards".

Set the drive to the gear in which the motor has independent control and brake it using the service brake or chocks or come to a stop against an obstacle. Ensure that the wheels do not spin.

4 Increase the operating pressure until the pressure for the set start of control is detected at measuring connection G. Obtain the value from the order confirmation.

5 Note the pressure at measuring connection M1:

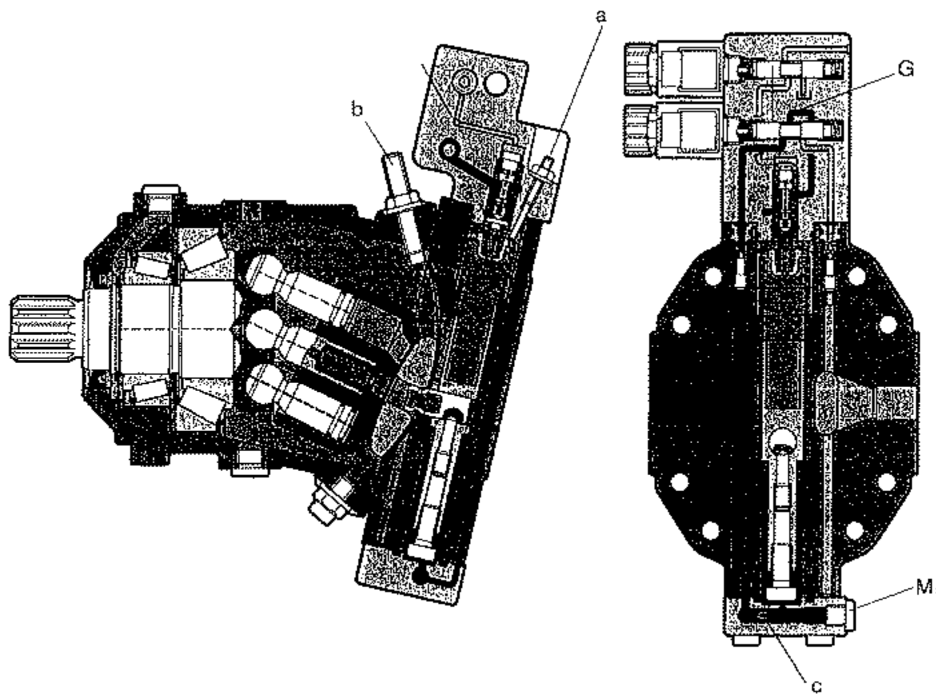
With a DA motor, the pressure at M1 drops.

Motorverstellungen DA2, 3, 5, 6

Einstellüberprüfung

Control DA2, 3, 5, 6

Setting test



a:	Einstellschraube- Regelbeginn	Set screw - Begin of control
b:	Vg_{min}	Vg_{min}
G:	Betriebsdruck	Operating pressure
M_1:	Stelldruck	Control pressure
c:	Drossel	Throttle

Um den Regelbeginn zu überprüfen:

1 Starten Sie die Brennkraftmaschine.

2 Achten Sie darauf, dass Manometer an den Messstellen G und M_1 des Motors angeschlossen sind bzw. schließen Sie diese an.

3 Schalten Sie den Fahrtrichtungsschalter auf „Vorwärts". Schalten Sie den Antrieb dabei in den Gang, in dem der Motor frei regeln darf, und bremsen Sie den Antrieb fest, indem Sie die Feststellbremse betätigen, Unterlegkeile benutzen oder gegen ein Hindernis fahren. Achten Sie dabei darauf, dass die Räder nicht durchdrehen.

4 Erhöhen Sie den Betriebsdruck, bis Sie am Messanschluss G den Druck für den eingestellten Regelbeginn messen. Den Wert entnehmen Sie der Auftragsbestätigung.

5 Beobachten Sie den Druck am Messanschluss M_1:

Bei einem DA-Motor baut sich Druck an M_1 ab.

To check the begin of regulation:

1 Start the internal combustion engine.

2 Ensure that the manometer is connected at measuring points G and M1 of the motor, if not then connect it.

3 Set the travel direction switch to „Forwards".

Set the drive to the gear in which the motor has independent control and brake it using the service brake or chocks or come to a stop against an obstacle. Ensure that the wheels do not spin.

4 Increase the operating pressure until the pressure for the set start of control is detected at measuring connection G. Obtain the value from the order confirmation.

5 Note the pressure at measuring connection M1:

With a DA motor, the pressure at M1 drops.

Die angegebenen Daten dienen allein der Produktbeschreibung. Eine Aussage über eine bestimmte Beschaffenheit oder eine Eignung für einen bestimmten Einsatzzweck kann aus unseren Angaben nicht abgeleitet werden. Die Angaben entbinden den Verwender nicht von eigenen Beurteilungen und Prüfungen. Es ist zu beachten, dass unsere Produkte einem natürlichen Verschleiß- und Alterungsprozess unterliegen.

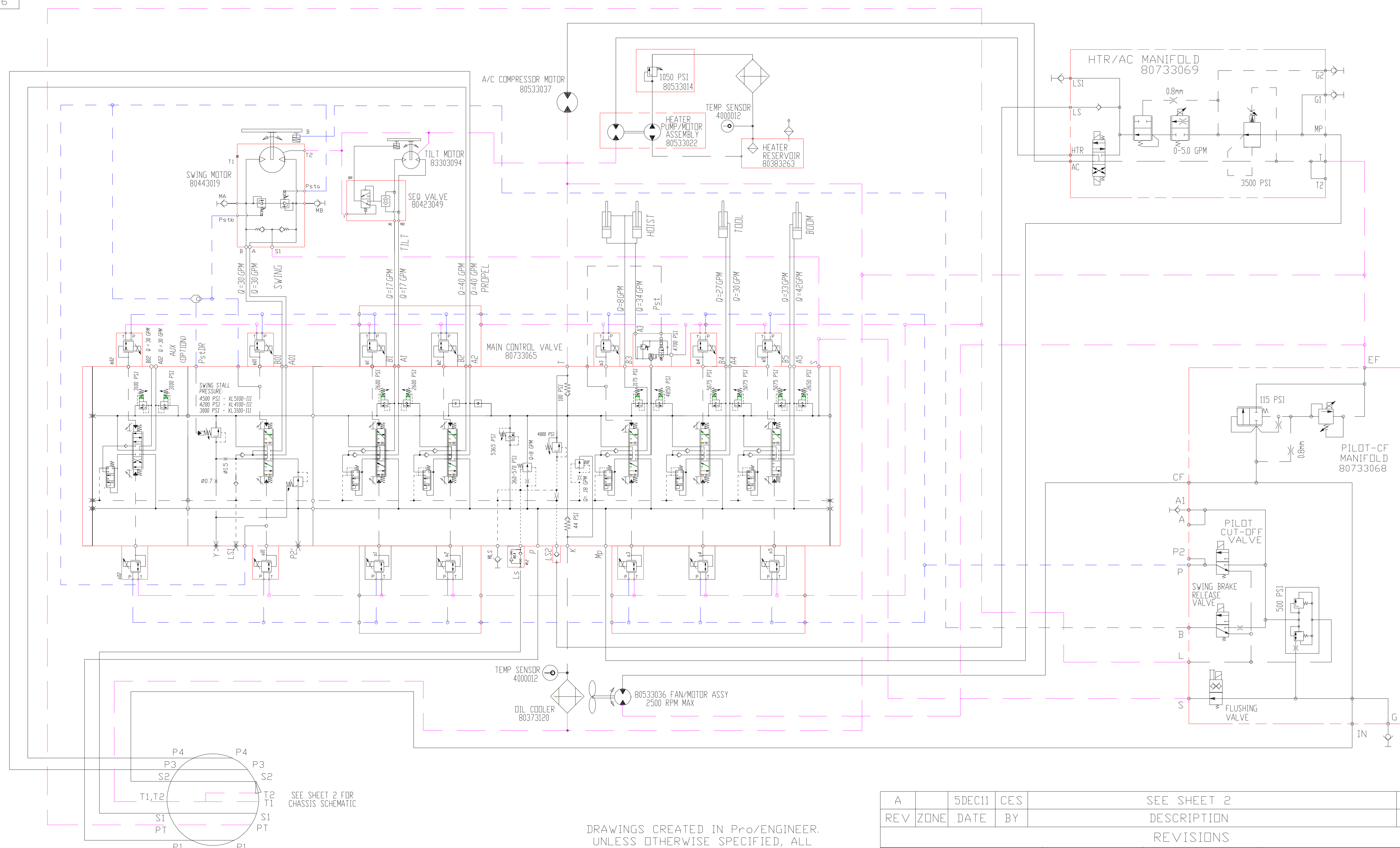
Änderungen vorbehalten.

Bosch Rexroth AG
Hydraulics
Produktsegment Axialkolbenmaschinen
Werk Elchingen
Glockeraustraße 2
89275 Elchingen, Germany
Telefon +49 (0) 73 08 82-0
Telefax +49 (0) 73 08 72-74
info.brm-ak@boschrexroth.de
www.boschrexroth.com/brm

The data specified above only serve to describe the product. No statements concerning a certain condition or suitability for a certain application can be derived from our information. The information given does not release the user from the obligation of own judgment and verification. It must be remembered that our products are subject to a natural process of wear and aging.

Subject to change.

DRAWING NUMBER
80709006



DRAWINGS CREATED IN Pro/ENGINEER.
UNLESS OTHERWISE SPECIFIED, ALL
DIMENSIONS ARE IN INCHES.

REVISIONS

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD
A		5DEC11	CES	SEE SHEET 2	110529	RDM

SPECIFICATIONS

DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994

ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1

UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.

ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED

THIRD ANGLE PROJECTION

NEXT ASSY

DO NOT SCALE DRAWING

DRAWN BY:	CES
DATE:	18Jan11
CHK'D. BY:	RDM
DATE:	18Jan11
E.R. NO.	SO 1818056
FINISH:	N/A
REF. DWG.	NONE
MACH. SURF.	125 MAX

GRADALL

TITLE: SCHEMATIC, HYDRAULIC, SERIES IV ON-HIGHWAY

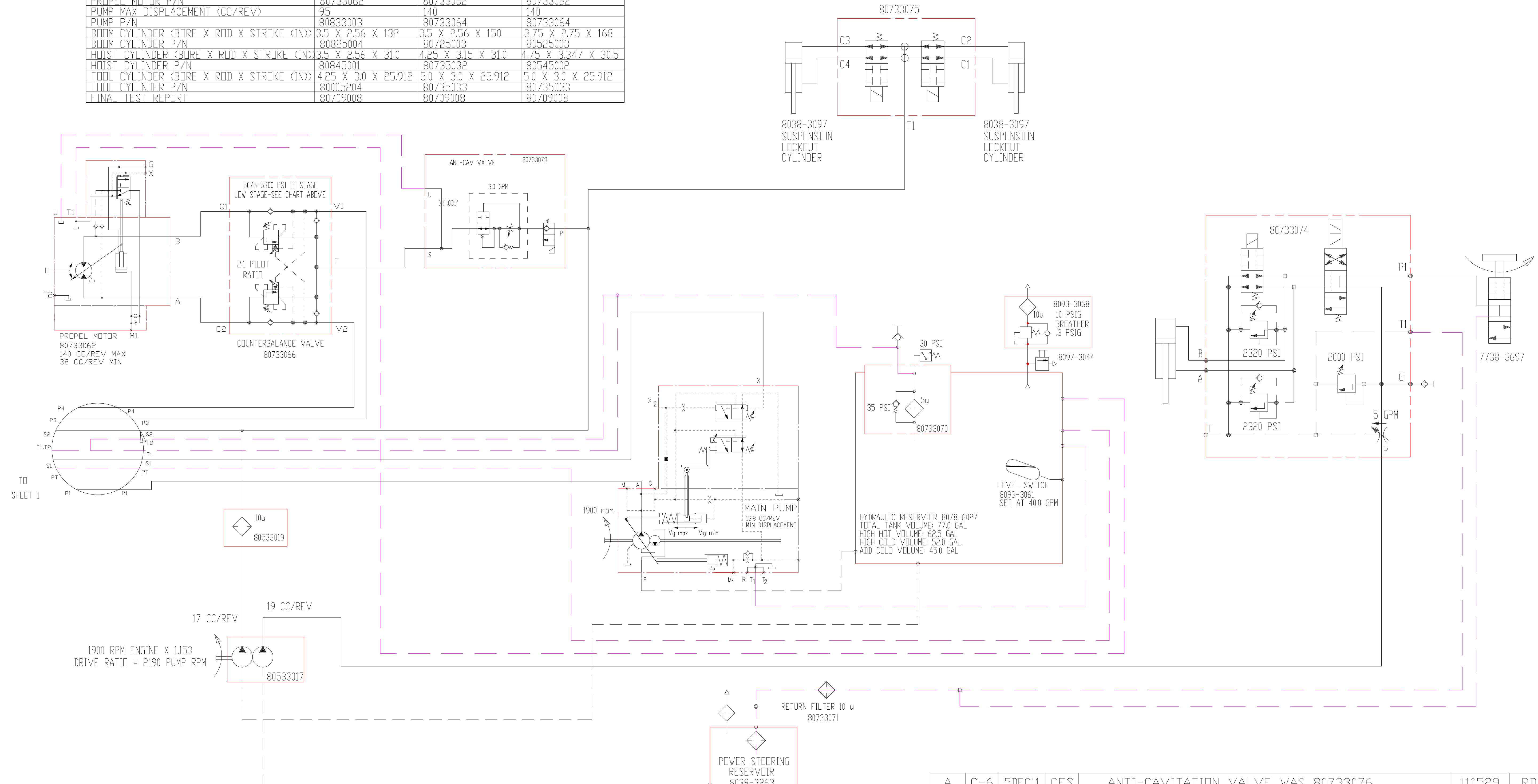
MATERIAL: N/A

SIZE	CAGE CODE:	DWG NO.	REV
D		80709006	A

SCALE: NONE | EST WT: N/A | SHEET: 1 OF 2

DRAWING NUMBER
80709006

DESCRIPTION	XL3100-IV	XL4100-IV	XL5100-IV
PROPEL BRAKING PRESSURE (LOW STAGE - PSI)	3000	3750	3750
PROPEL MOTOR P/N	80733062	80733062	80733062
PUMP MAX DISPLACEMENT (CC/REV)	95	140	140
PUMP P/N	80833003	80733064	80733064
BOOM CYLINDER (BORE X ROD X STROKE (IN))	3.5 X 2.56 X 132	3.5 X 2.56 X 150	3.75 X 2.75 X 168
BOOM CYLINDER P/N	80825004	80725003	80525003
HOIST CYLINDER (BORE X ROD X STROKE (IN))	3.5 X 2.56 X 31.0	4.25 X 3.15 X 31.0	4.75 X 3.347 X 30.5
HOIST CYLINDER P/N	80845001	80735032	80545002
TOOL CYLINDER (BORE X ROD X STROKE (IN))	4.25 X 3.0 X 25.912	5.0 X 3.0 X 25.912	5.0 X 3.0 X 25.912
TOOL CYLINDER P/N	80005204	80735033	80735033
FINAL TEST REPORT	80709008	80709008	80709008



DRAWINGS CREATED IN Pro/ENGINEER.
UNLESS OTHERWISE SPECIFIED, ALL
DIMENSIONS ARE IN INCHES.

REVISIONS

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD
A	C-6	5DEC11	CES	ANTI-CAVITATION VALVE WAS 80733076	110529	RDM

SPECIFICATIONS
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1

NEXT ASSY
DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.
ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED
THIRD ANGLE PROJECTION

DRAWN BY: CES
DATE: 18Jan11
CHK'D. BY: RDM
DATE: 18Jan11
E.R. NO. 110251
FINISH: N/A
REF. DWG. NONE
MACH. SURF. 125 MAX

GRADALL

TITLE: SCHEMATIC, HYDRAULIC, SERIES IV ON-HIGHWAY

MATERIAL: N/A
SIZE D | CAGE CODE: | DWG NO. 80709006 | REV A
SCALE: NONE | EST WT: N/A | SHEET: 2 OF 2

TORQUE-HUB®

Final Drives

ASSEMBLY-DISASSEMBLY MANUAL

FOR THE

S6A

UNIT

FAIRFIELD

GEARED FOR EXCELLENCE

INTRODUCTION

This manual is a step-by-step guide to assembly and disassembly of torque-hub units. It is designed for the customer or shop mechanic who is repairing a particular model of torque-hub final drive. Users of this manual should note that each part mentioned is followed by an indentification number enclosed in parentheses. These part numbers may be referred to in the Parts List section of this manual and on the cross-sectional view of this unit. A print of each tool discussed in this manual is shown in the Tooling section. Users should familiarize themselves with the procedures for roll and leak testing and bolt tightening and torquing found on the following two pages before getting started.

This manual includes the following sections.

1. Roll and Leak Testing Procedures
2. Bolt Tightening and Torquing Procedures
3. Disassembly Procedures
4. Sub-Assembly Procedures
5. Main Assembly Procedure
6. Drawings of all Essential Tools
7. Parts List
8. Cross-Sectional View of the Unit

SAFETY

Standard safety practices should be followed during the disassembly and assembly procedures described. Safety glasses and safety shoes should be worn. Heavy, heat resistant gloves should be used when heated components are handled. Be especially alert when you see the word CAUTION. This indicates that a particular operation could cause personal injury if not performed properly or if certain safety procedures are not followed.

ROLL and LEAK TESTING

Torque-hub units should always be roll and leak tested before disassembly and after assembly to make sure that the unit's gears and sealants are working properly. The following information briefly outlines what to look for when performing these tests.

THE ROLL TEST

The purpose of a roll test is to determine if the unit's gears are rotating freely and properly. You should be able to rotate the gears in your unit by applying a constant force to the roll checker. If you feel more drag in the gears only at certain points, then the gears are not rolling freely and should be examined for proper installation or defects. Some gear packages roll with more difficulty than others. Do not be concerned if the gears in your unit seem to roll hard as long as they roll with consistency.

THE LEAK TEST

The purpose of a leak test is to make sure that the unit is air tight. You can tell if your unit has a leak if the pressure gauge reading on your air checker starts to fall once the unit has been pressurized. Leaks will most likely occur at the main seal or wherever "O" rings or gaskits are located. The exact location of a leak can usually be detected by brushing a soap and water solution around the main seal and where "O" rings or gaskits meet the exterior of the unit then checking for air bubbles. If a leak is detected in a seal, "O" ring, or gaskit, the part must be replaced.

TIGHTENING and TORQUING BOLTS

If an air impact wrench is used to tighten bolts, extreme care should be taken to insure that bolts are not tightened beyond their indicated torque specification. <u>Never</u> use an impact wrench to tighten shoulder bolts, all shoulder bolts should be tightened by hand.

The following steps describe the proper procedure for tightening and torquing bolts or socket head cap screws in a bolt circle.

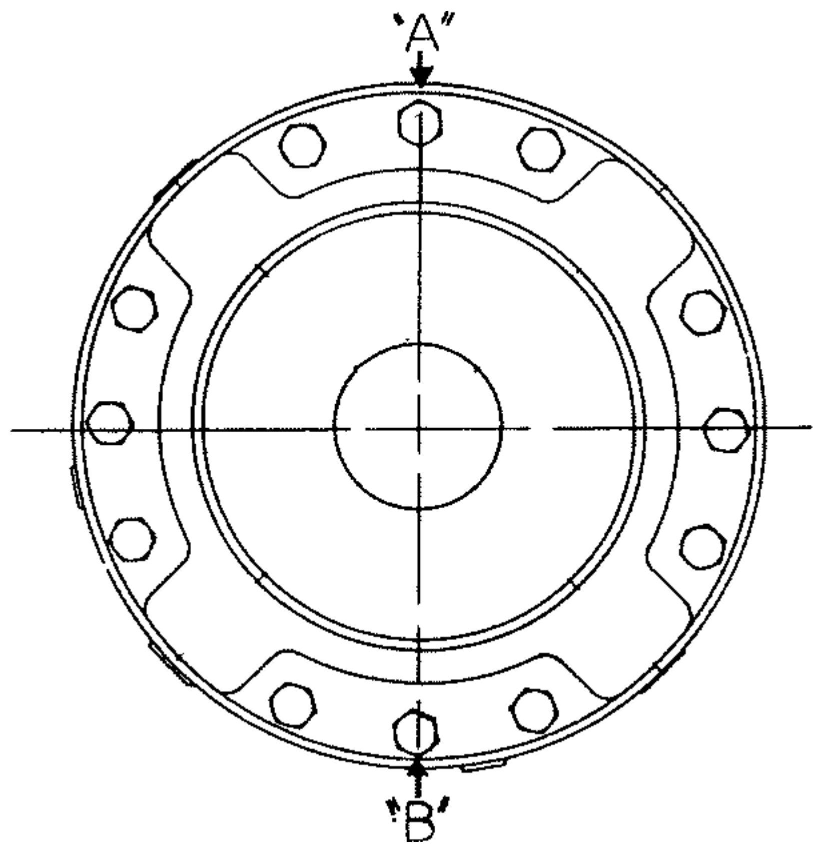
1. Tighten (but do not torque) bolt "A" until snug.

2. Go to the opposite side of the bolt circle and tighten bolt "B" until equally snug.

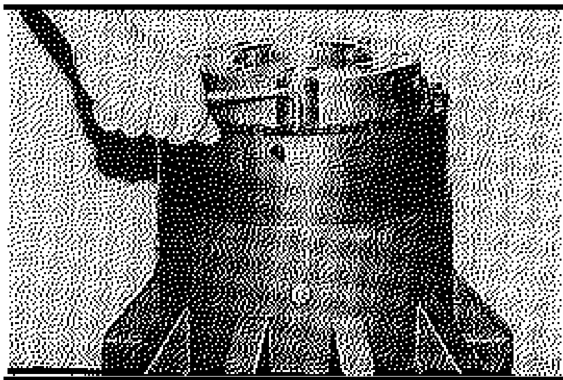
3. Continue around the bolt circle and tighten the remaining bolts.

4. Now use a torque wrench to apply the specified torque to bolt "A"

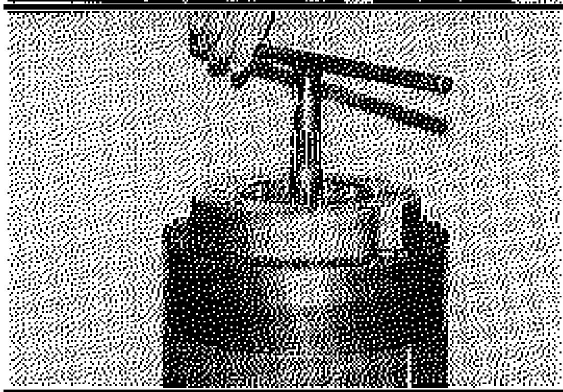
5. Continue around the bolt circle and apply an equal torque to the remaining bolts.



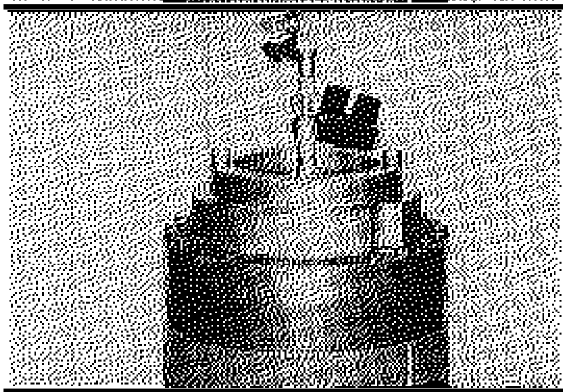
MAIN DISASSEMBLY



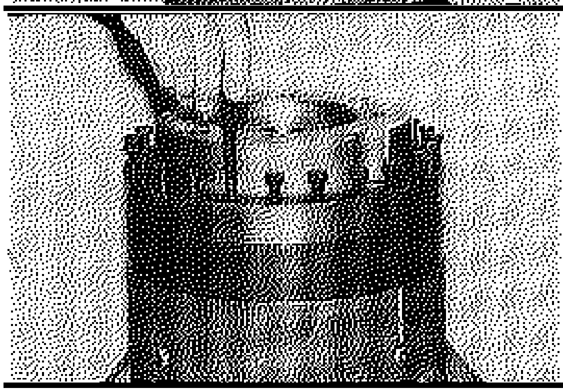
1. Remove **pipe plug (15)** from **cover(6)** and drain the oil from the unit.



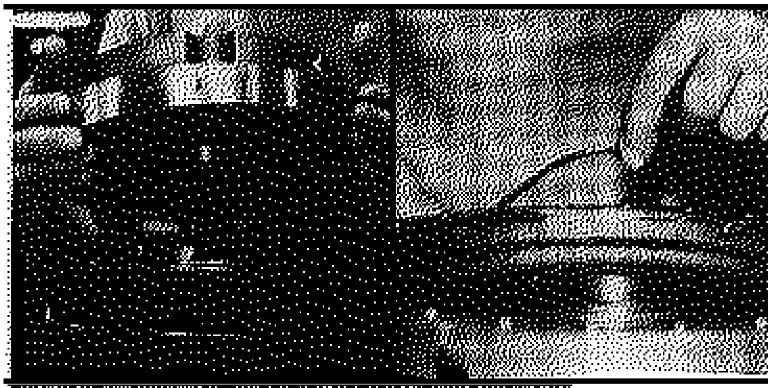
2. Roll test the unit in both clockwise and counterclockwise directions. Perform the same number of turns in each direction as the ratio of the unit. The ratio number is the same as the last two digits in the model number found on the ID tag of the unit.



3. Leak test the unit at a pressure of 5 psi for 2-3 minutes.



4. Remove all **24 grade 8 bolts(16)** from **cover(6).**

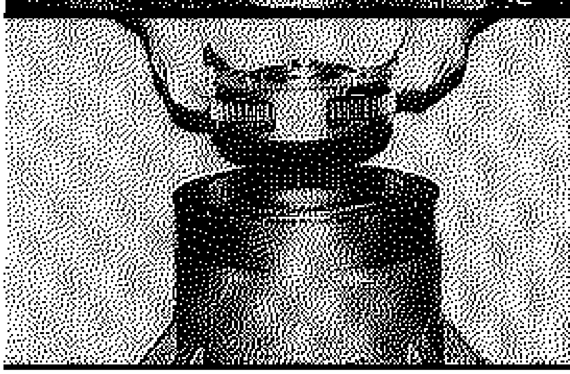


5. Lift **cover(6)** off of **hub(1G)** and remove **"O" ring(5)** from the counterbore in the cover. Discard the "O" ring.

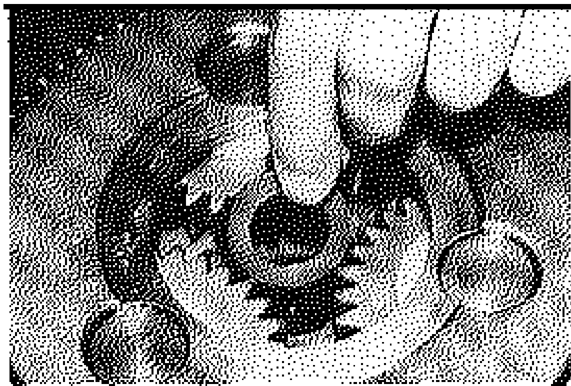
6. Remove small **thrustwasher(7)** from the counterbore in the center hole in **cover(6).**

7. Remove large **thrust washer(14), thrust bearing(13),** and large thrust **washer(12)** from the raised inside circular edge of **cover(6).**

8. Remove **input gear(8)** from mesh with the planet gears in **first stage carrier assembly(3).**

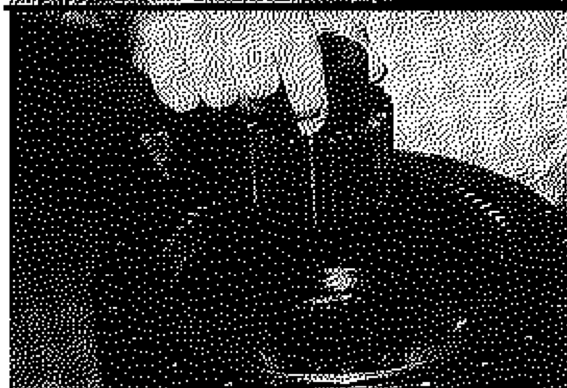


9. Lift out **first stage carrier assembly(3).**

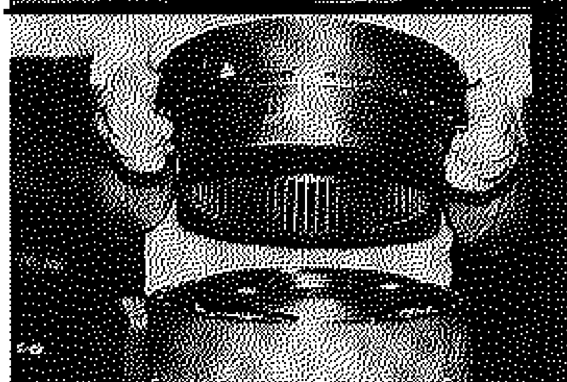


10. Remove small **thrust washer(9)** from the top of **second stage sun gear(11).**

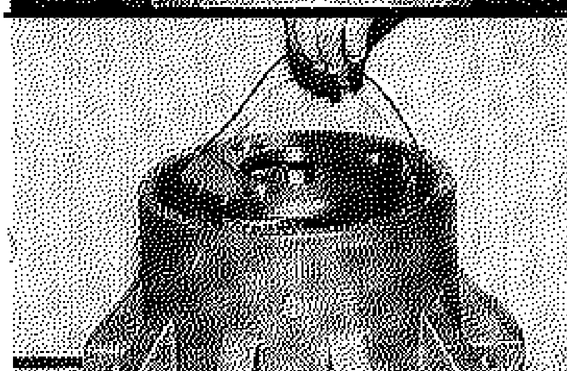
11. Remove **thrust bearing carrier(10),** large **thrust washer(14), thrust bearing(13),** and large **thrust washer(12)** from the counterbore of **second stage carrier assembly(2).**



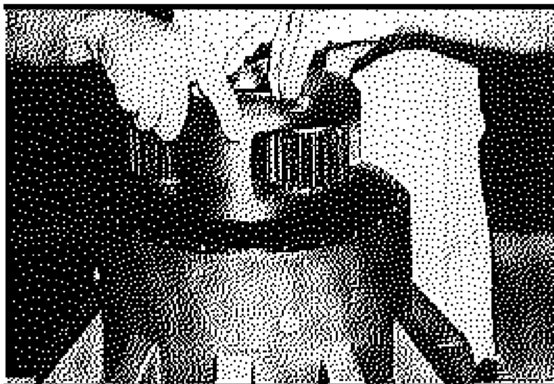
12. Remove **second stage sun gear(11)** from mesh with **second stage carrier assembly(2).**



13. Lift out **ring gear(4).**



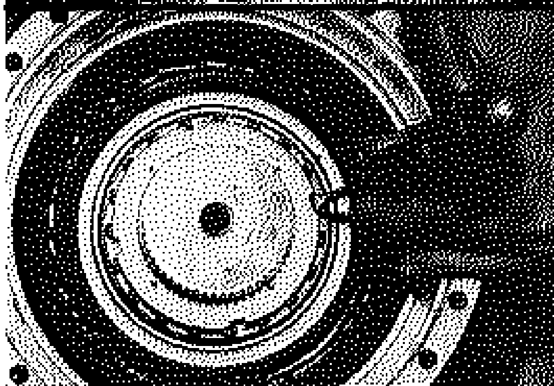
14. Remove **"O" ring(5)** from the counterbore in **hub(1G)** and discard.



15. Lift out **second stage carrier assembly(2)** from mesh with **output shaft(1A).**

16. Using retaining ring pliers, remove **retaining ring(1L)** from groove around the outside of **output shaft (1A).**

CAUTION: Safety glasses should be worn during this procedure.

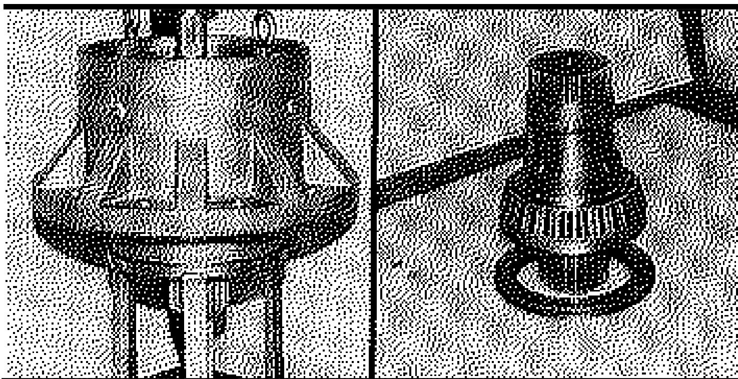


17. With a screwdriver or chisel and hammer, straighten out the tang on **lockwasher(1J)** which has been bent into the notch on **locknut(1K).**

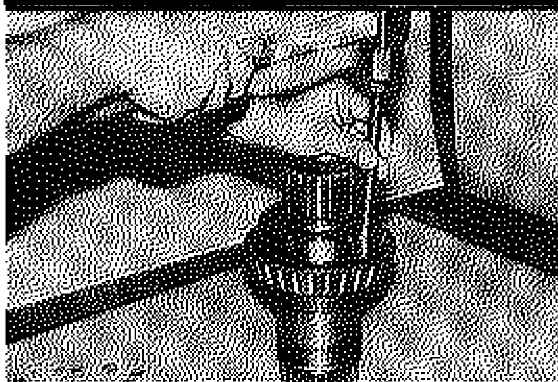
18. Using an AN-18 locknut wrench (tool no T-156766), loosen **locknuts (1K).** Remove the locknut from **output shaft(lA)** and discard.

NOTE: The output shaft must be held securely enough to resist turning when the locknut is loosened.

19. Remove **lockwasher(1J)** and **tanged washer(1H)** from **output shaft(1A).** Discard the lockwasher.

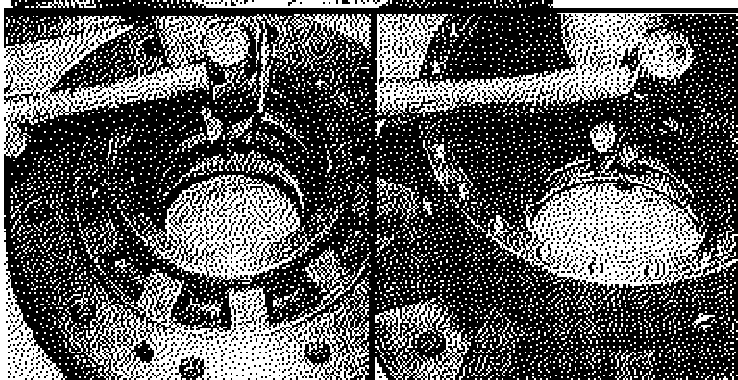


20. Raise **hub(1G)** above your work surface and support it from underneath in a manner that will allow **output shaft(1A)** to fall through the bottom. Press the output shaft out of the hub. The output shaft will come out with **bearing cone (1D)** attached and **seal(1B).** Discard the seal.

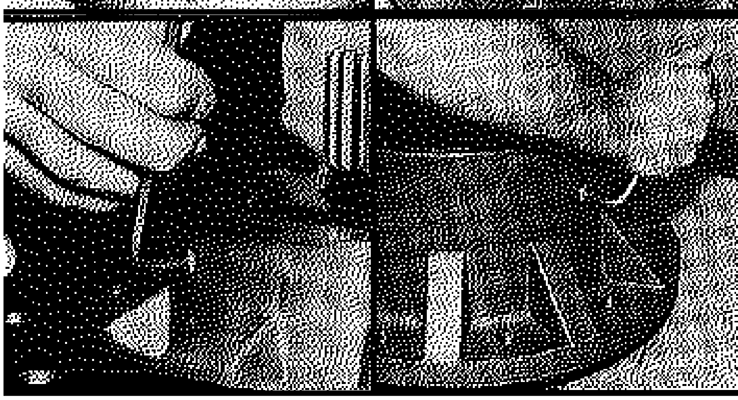


21. Remove **bearing cone (1D)** from **output shaft(lA).**

22. Lift bearing **cone(1F)** out of **hub(1G).**



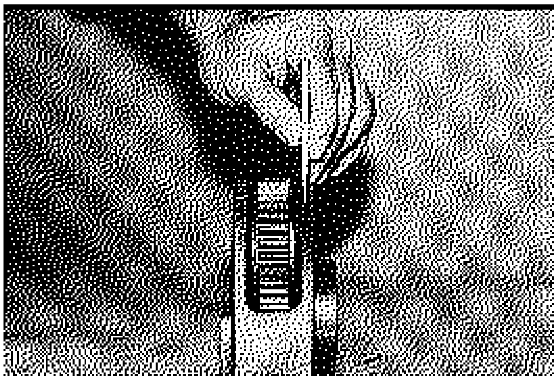
23. Using a soft punch and hammer, remove **bearing cups (1E) and (1C)** from **hub(1G).** Be very careful not to strike the counterbores of the hub where these cups are located when using the punch.



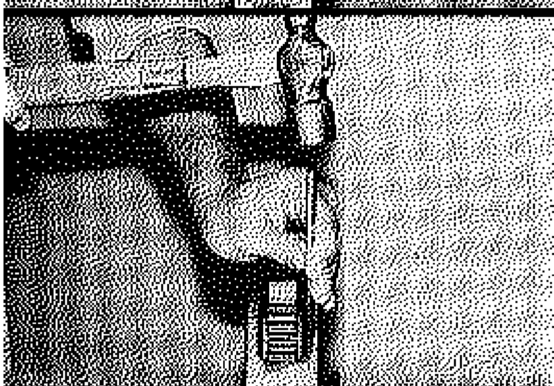
24. Remove all four **pipe plugs (1M), (1N), and (1P)** from **hub(1G).**

25. At this point the main disassembly is complete.

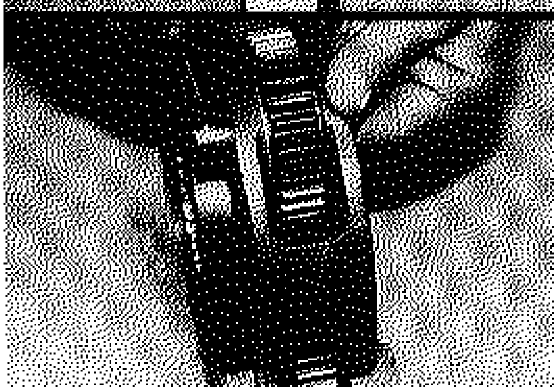
FIRST STAGE CARRIER DISASSEMBLY



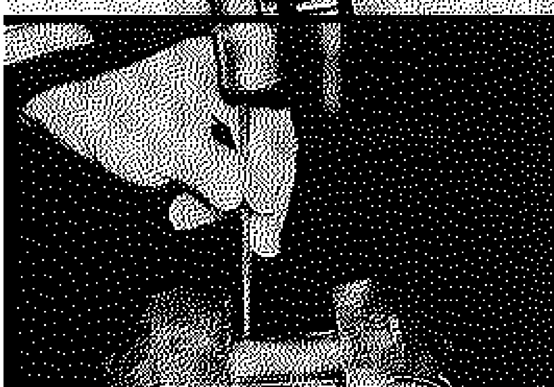
1. Locate **dowel pin(3D)** which holds **planes shaft(3E)** in **carrier housing (3A).**



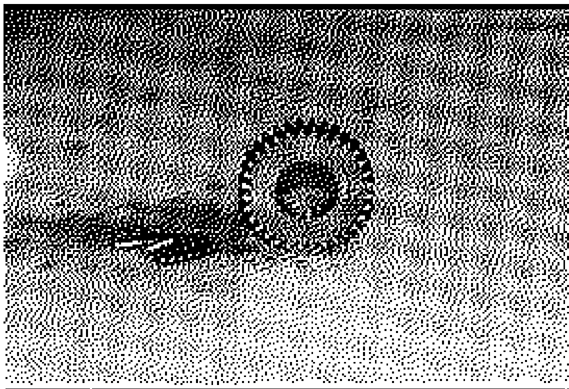
2. Drive the **dowel pin(3D)** down into **planes shaft(3E)** until it bottoms against the carrier housing. If the dowel pin is not completely driven into the planet shaft, damage to the carrier could occur when the shaft is removed.



3. Remove **planet shaft(3E)** from carrier housing(3A). The four **thrust washers(3B)** and **planet gear(3F)** will slide off.



4. Using an alignment punch and hammer, drive **dowel pin(3D)** out through the end of the dowel pin hole in **planet shaft(3E)** that it originally went into.

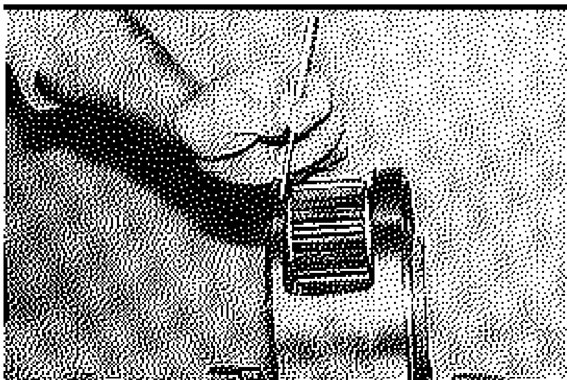


5. Remove **needle rollers(3C)** from inside **planet gear(3F).**

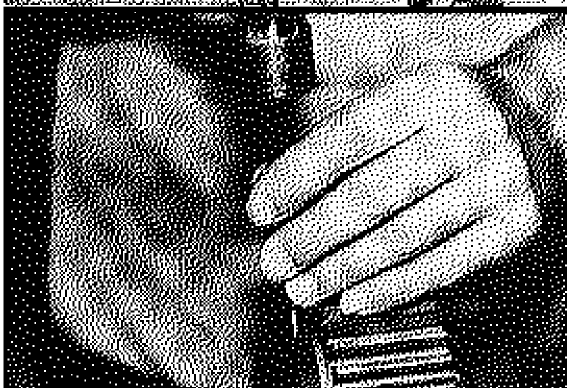
6. Repeat steps 1-5 to remove the two remaining planet gears.

7. At this point the first stage carrier disassembly is complete.

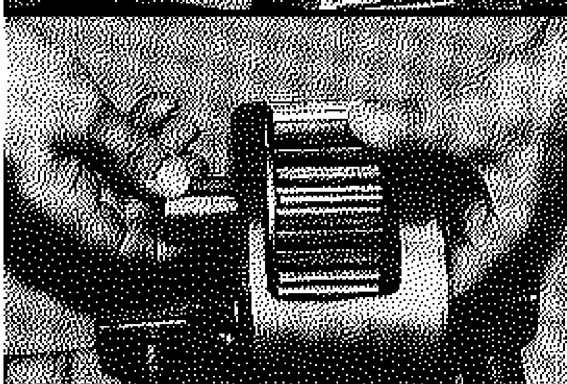
SECOND STAGE CARRIER DISASSEMBLY



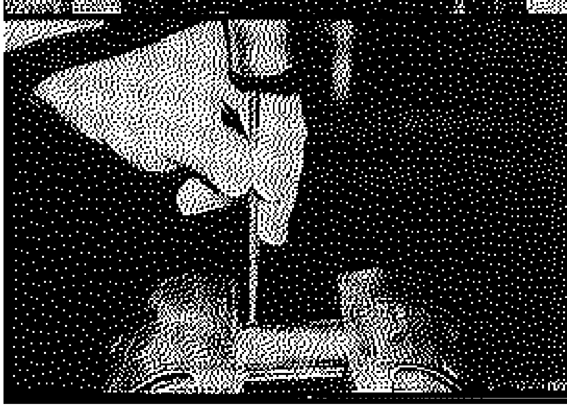
1. Locate **dowel pin(2G)** which holds **planet shaft(2E)** in **carrier housing (2A).**



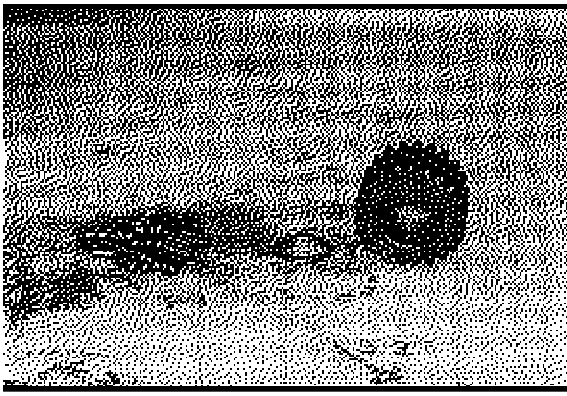
2. Drive **dowel pin(2G)** down into **planets shaft(2E)** until it bottoms against the carrier housing. If the dowel pin is not completely driven into the planet shaft, damage to the carrier could occur when the shaft is removed.



3. Remove **planet shaft(2E)** from **carrier housing(2A).** The four **thrust washers(2B)** and **planet gear(2F)** will slide off.



4. Using an alignment punch and hammer, drive **dowel pin(2G)** out through the end of the dowel pin hole in **planet shaft(2E)** that it <u>originally</u> went into.

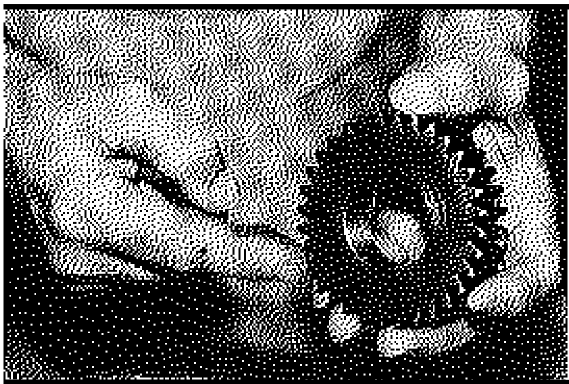


5. Remove **needle rollers(2C)** and **spacer(2D)** from inside **planes gear(2f)**

6. Repeat steps 1-5 to remove the two remaining planets gears.

7. At this point the second stage carrier disassembly is complete.

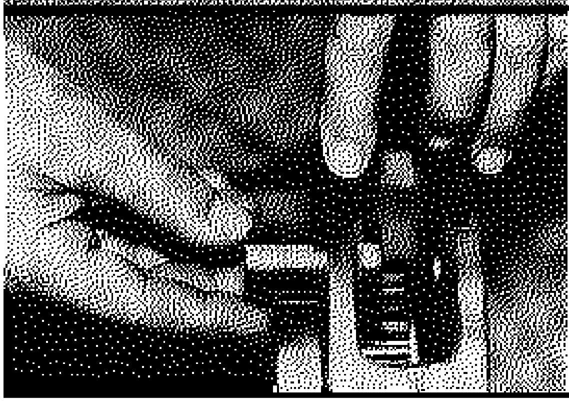
FIRST STAGE CARRIER SUB-ASSEMBLY



1. Apply grease to the inside of one **first stage carrier planes gear(3F).**

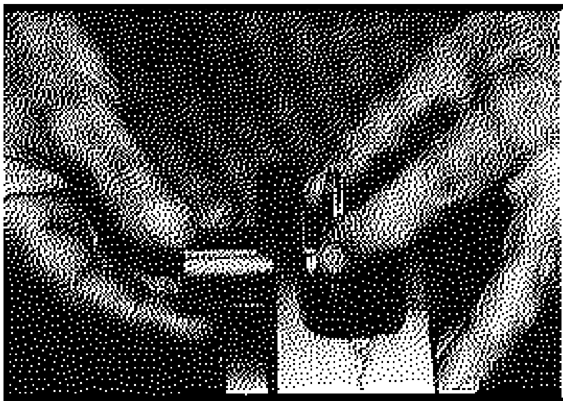
2. Line the inside of **planet gear (3F)** with **19 needle rollers(3C).**

3.Stand **first stage carrier housing(3A)** in an upright position.



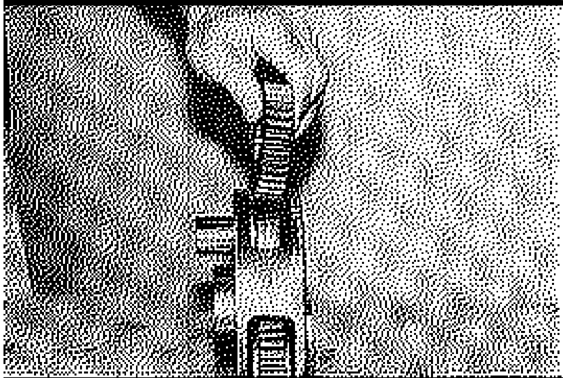
4. Insert a **planet shaft(3E)** into one of the planet shaft roles which has a dowel pin hole on **carrier housing(3A).** The end of the planet shaft that does <u>not</u> have the dowel pin hole should be inserted into the carrier housing <u>first</u>.

NOTE: One end of the dowel pin <u>hole</u> on the planet shaft has a chamfer or gradual slope. This end should be up to allow easy alignment.

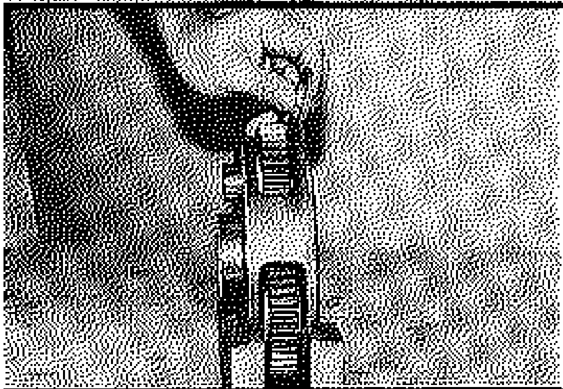


5. Place two **thrust washers(3B)** onto the end of **planet shaft(3E)** which has been inserted through the planet shaft hole in **carrier housing(3A).**

NOTE: Grease or petroleum jelly may be used to hold the washers together and in place on the planet shaft.

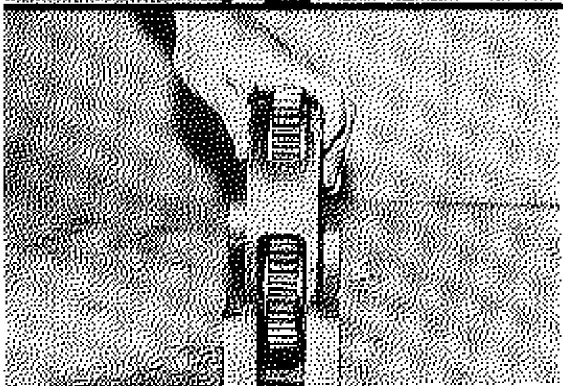


6. Following the thrust washers place **planet gear (3F),** with needle rollers, onto **planet shaft (3E).**

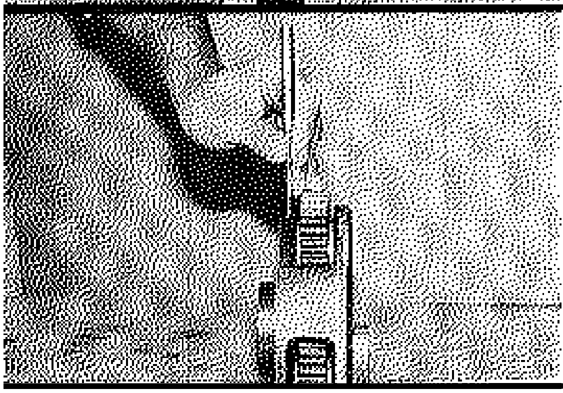


7. Following the planet gear, place two more **thrust washers(3B)** onto **planet shaft(3E).**

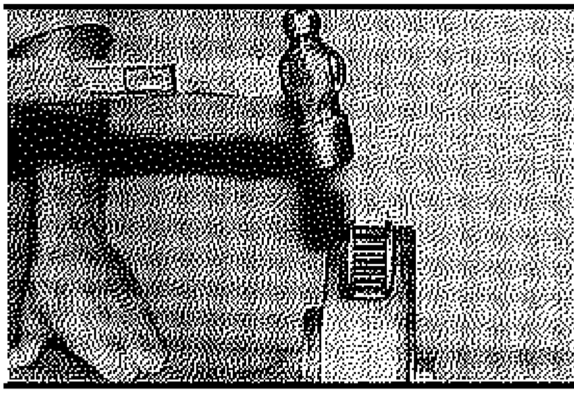
NOTE: Grease or petroleum jelly may be used to hold the washers together and in place on the planet shaft.



8. Now insert **planet shaft(3E)** through the opposite planet shaft hole on **carrier housing(3A).**



9. Using an alignment puch or similar tool, align the dowel pin holes on **carrier housing(3A)** and **planet shaft (3E).**

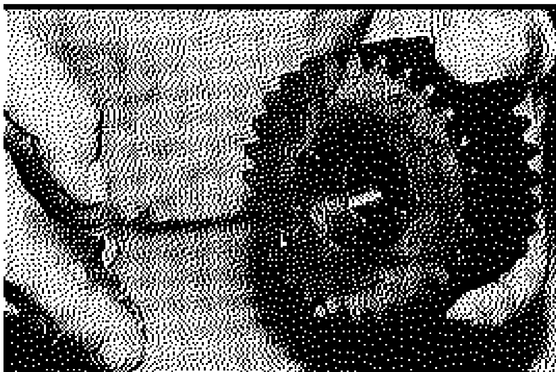


10. If you examine a **dowel pin (3D)** carefully, you will notice that one end is smaller than the other. Drive this end of the **dowel pin (3D)** down into the aligned dowel pin holes. It should be driven to just below (1/10 in.) the surface of the carrier housing.

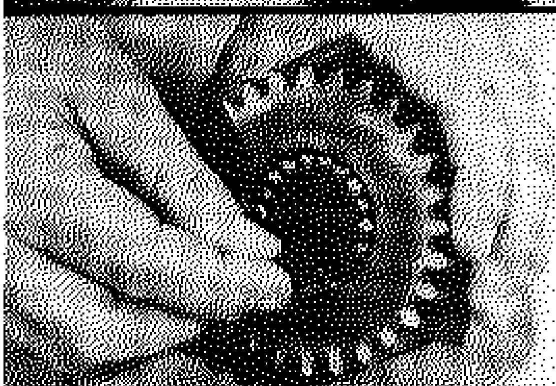
ll. Repeat the procedure in steps 1-10 for installation of the two remaining first stage planes gears(3F).

l2. At this point the first stage carrier sub-assembly is complete.

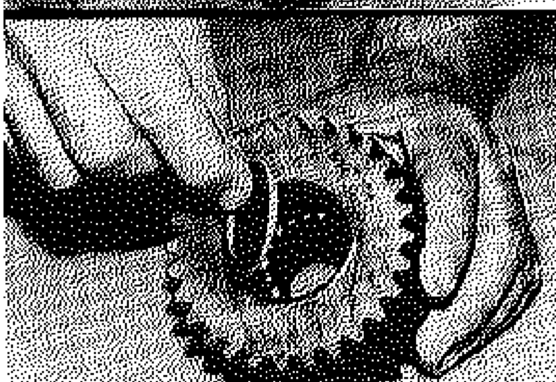
SECOND STAGE CARRIER SUB-ASSEMBLY



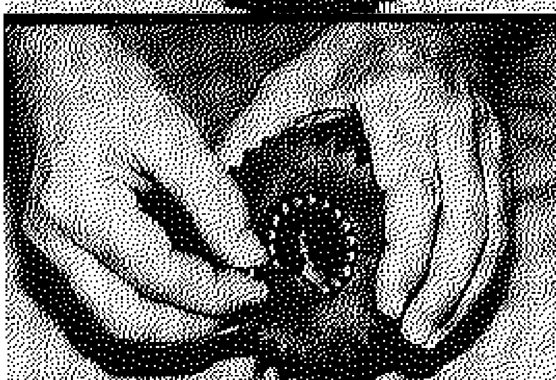
1. Apply grease to the inside of one **second stage planet gear(2F).**



2. Line one half of **planet gear(2F)** with 18 **needle rollers(2C).**

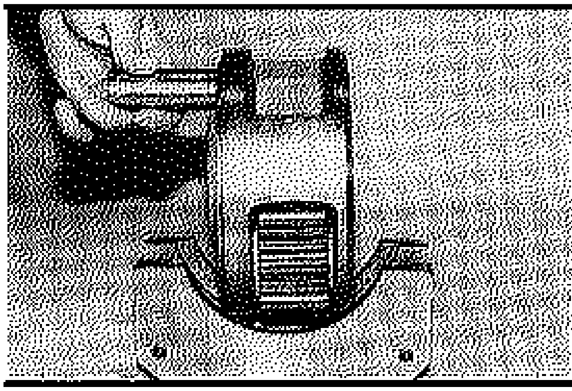


3. Place one **spacer(2D)** inside **planet gear(2F)** so that it rests on top of the **needle rollers (2C).**



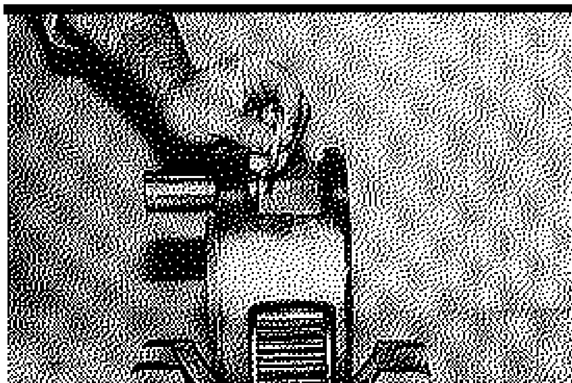
4. Line the remaining half of **planet gear(2F)** with 18 **needle rollers(2C).**

5. Stand second stage carrier housing(2A) in an upright position.



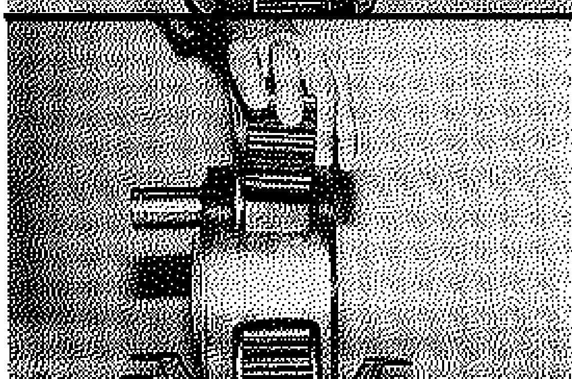
6. Insert **planet shaft(2E)** into a planet shaft hole that does <u>not</u> have a dowel pin hole on **carrier housing** (2A). The end of the planet shaft <u>with</u> the dowel pin hole should be inserted into the carrier housing first.

NOTE: One end of the dowel pin hole on the planet shaft has a chamfer or gradual slope. This end should be up to allow easy alignment.

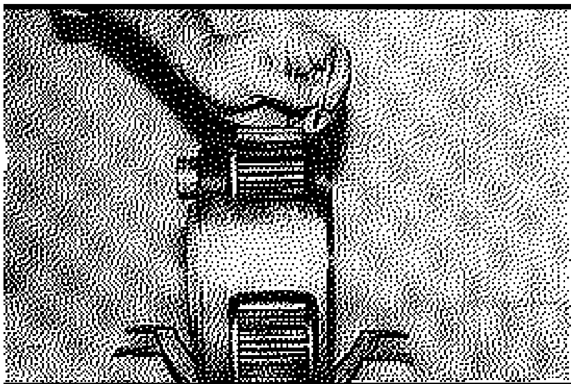


7. Place two **thrust washers(2B)** onto the end of the planet shaft which has been inserted through the planet shaft hole.

NOTE: Grease or petroleum jelly may be used to hold the washers together and in place on the planet shaft.

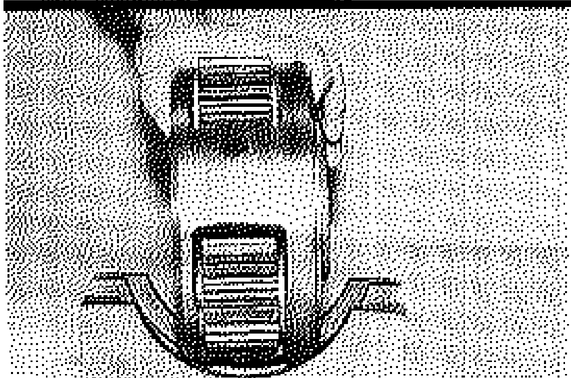


8. Following the thrust washers, place **planet gear(2F),** with needle rollers, onto **planes shaft(2E).**

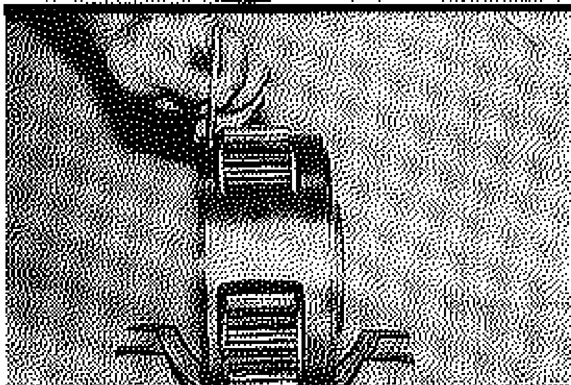


9. Following the planet gear, place two more **thrust washers(2b)** unto **planet shaft(2E).**

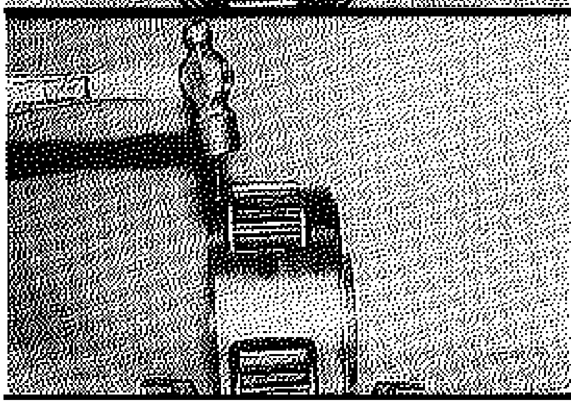
NOTE: Grease or petroleum jelly may be used to hold the washers together and in place on the planet shaft.



10. Now insert **planet shaft(2E)** through the opposite planet shaft hole on **carrier housing(2A).**



11. Using an alignment punch or similar tool, align the dowel pin holes on the carrier housing and planet shaft.

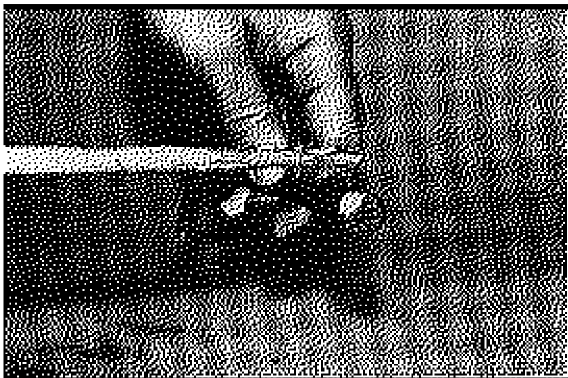


12. If you examine a **dowel pin(2G)** carefully, you will notice that one end is smaller than the other. Drive this end of **dowel pin(2G)** down into the aligned dowel pin holes. It should be driven to just below (1/10 in.) the surface of the carrier housing.

13. Repeat the procedure in steps 1-12 for installation of the two remaining second stage planet gears(2F).

14. At this point the second stage carrier sub-assembly is complete.

HUB-SHAFT SUB-ASSEMBLY

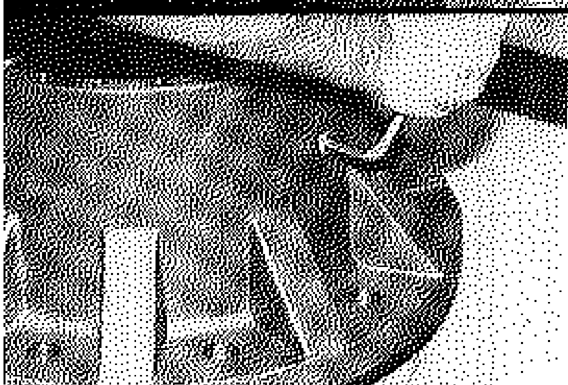


1. Apply a light coat of “Never-Seize” to the four hub **pipe plugs (1M), (1N), and (1P).**

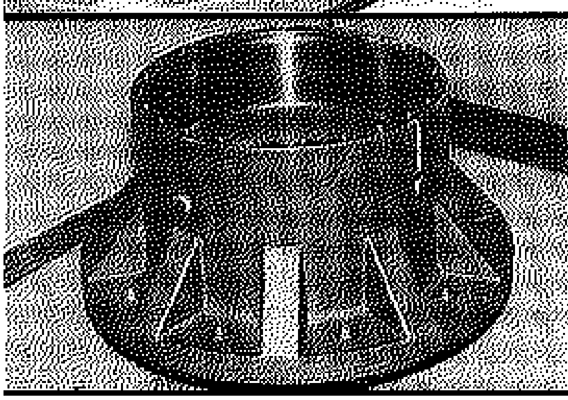
Note: **Pipe plug(1P)** is a magnetic plug.

2. With **hub(lG)** standing on its large diameter end, tighten **pipe plugs(1M)** into the two pipe plug holes nearest the small diameter end of **hub(1g).**

NOTE: Notice that **pipe plugs(lM)** are much smaller than **pipe plugs (1N)** and **(1P).**

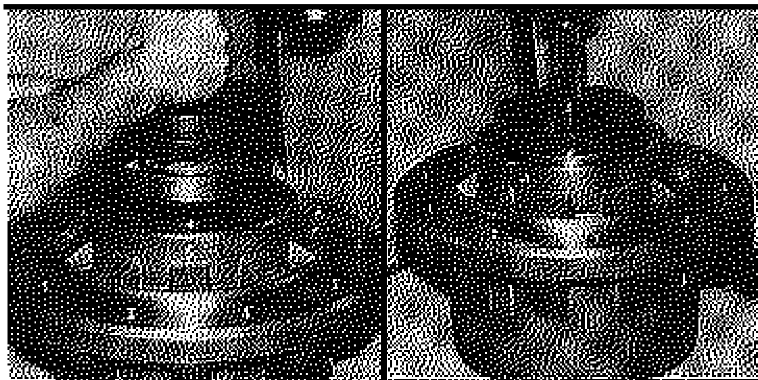


3. Turn **hub(1G)** over so that it rests on its small diameter end and the two pipe plug holes nearest the hub’s large diameter and are facing you. Tighten **magnetic pipe plug(1P)** into the right-hand pipe plug hole.



4. Mark the location of magnetic pipe **plug(1P)** so that it may be aligned with the pipe plug hole in **cover(6)** in a later step.

5. Install **pipe plug(1N)** into the left-hand pipe plug hole nearest the large diameter end of **hub (1G).**

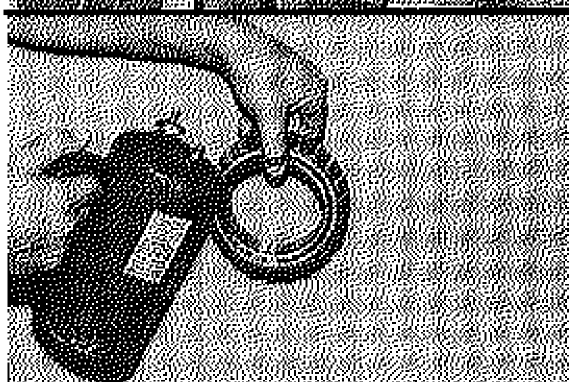


6. With **hub(1G)** still standing on its large diameter end, press **bearing cup(1C)** into the small diameter end of **hub(1G)** usina a bearing cup pressing fixture (tool no.T- 156792).

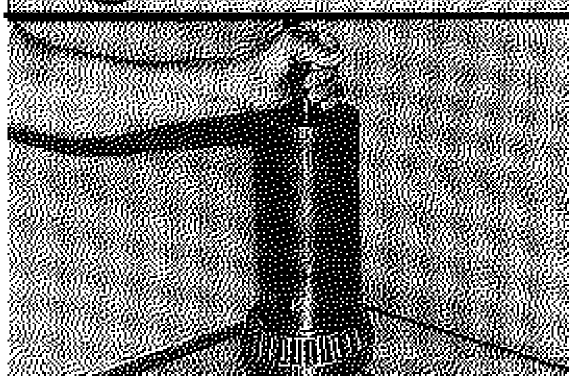
NOTE: Make sure that the cup sits square with the counterbore of the hub before pressing.

7. Turn **hub(1G)** over so that it rests on its small diameter end. Press **bearing cup(1E)** down into **hub(lG)** using a bearing cup pressing fixture (tool no. T-130717).

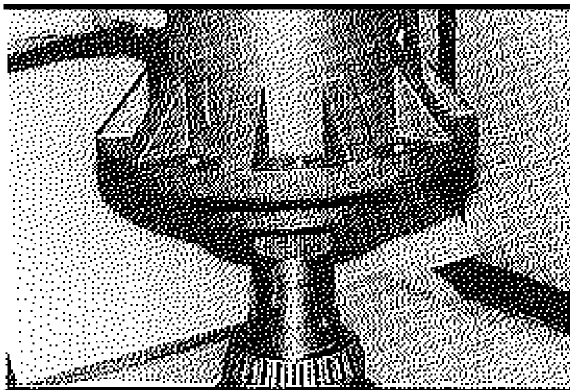
NOTE: Make sure that the cup sits square with the counterbore of the hub before pressing.



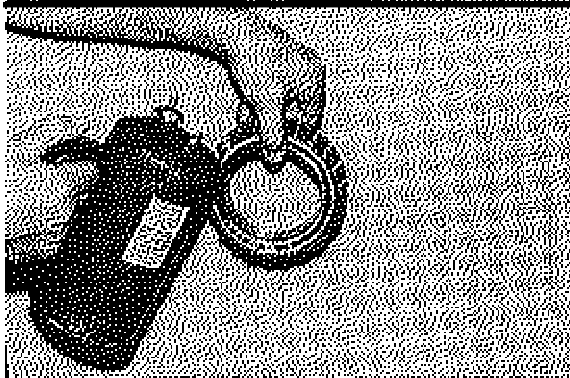
8. Spray the inside of **bearing cone(1D)** with oil.



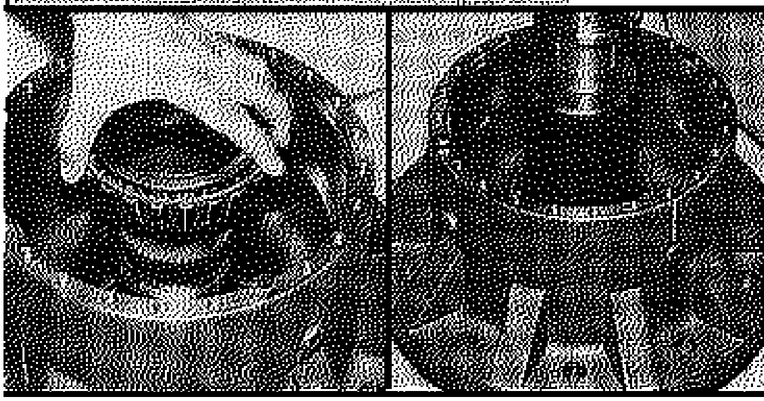
9. Press **bearing cone(1D)** onto **output shaft(1A)** using a bearing cone pressing fixture (tool no.T-158049).



10. With small diameter end down, lower **hub(1G)** onto **output shaft(1A).**

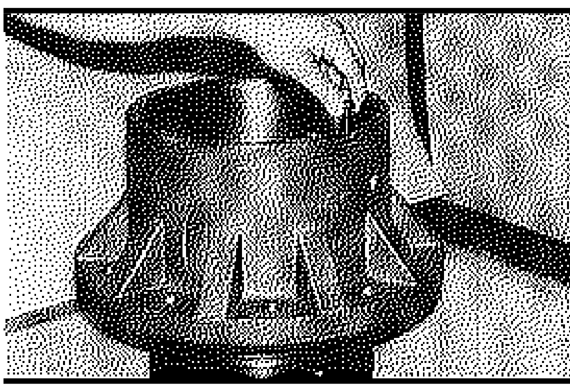


11. Spray the inside of **bearing cone(1F)** with oil.



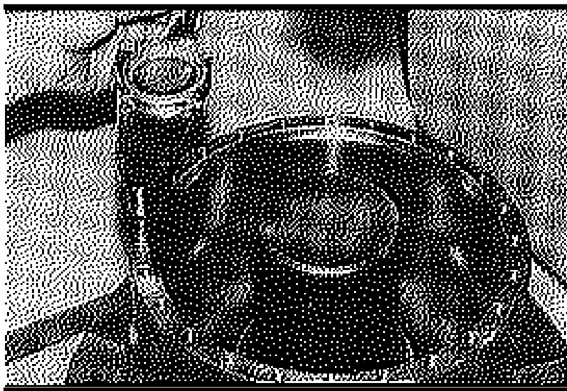
12. Press **bearing cone(1F)** onto **output shaft(1A)** using a bearing cone pressing fixture (tool no. T-146588). Reduce the pressure applied to the bearing cone and press the cone again. This time rotate the hub in both clockwise and counter-clockwise directions while pressing. Stop pressing when the hub starts to resist the rotation.

13. Now measure the initial rolling torque of **hub(1G).** To do this, follow steps a-d.



a) Tighten a bolt into one of the bolt holes on the hub. The bolt used should be one that fits the hole.

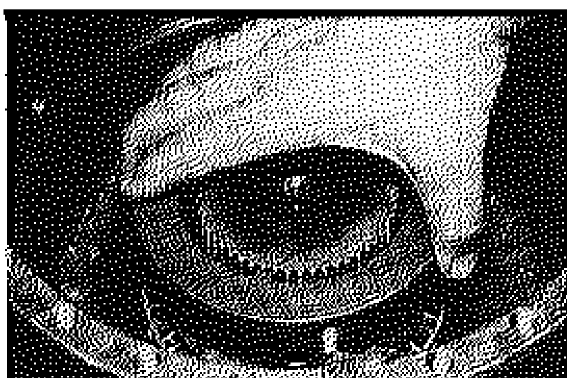
b) Place a torque wrench on the bolt so that the arm of the wrench lines up on a tangent to the circumference of the hub as shown in figure 1.



c) Keeping the wrench in this position at all times, use the arm of the wrench to guide the hub around in one rotation.

d) Read the gauge on the torque wrench. The initial rolling torque should be 25-30 in.-lbs. Measure the rolling torque several times to insure an accurate reading.

NOTE: If the initial rolling torque is less than 25 in.-lbs., apply more pressure to **bearing cone(1F).** If the initial rolling torque is higher than 30 in.-lbs., strike the top of **output shaft(1A)** with a soft face hammer to release the load on the shaft, then repeat steps 13b - 13d.



14. Place **tanged Fwasher(1H)** onto **output shaft(1A).**

THE CORRECT READING CAN ONLY BE MADE IF THE TORQUE WRENCH IS PULLED <u>SLOWLY</u> (APPROX. 3.5 R.P.M.) AND <u>SMOOTHLY</u> TOWARDS YOU.

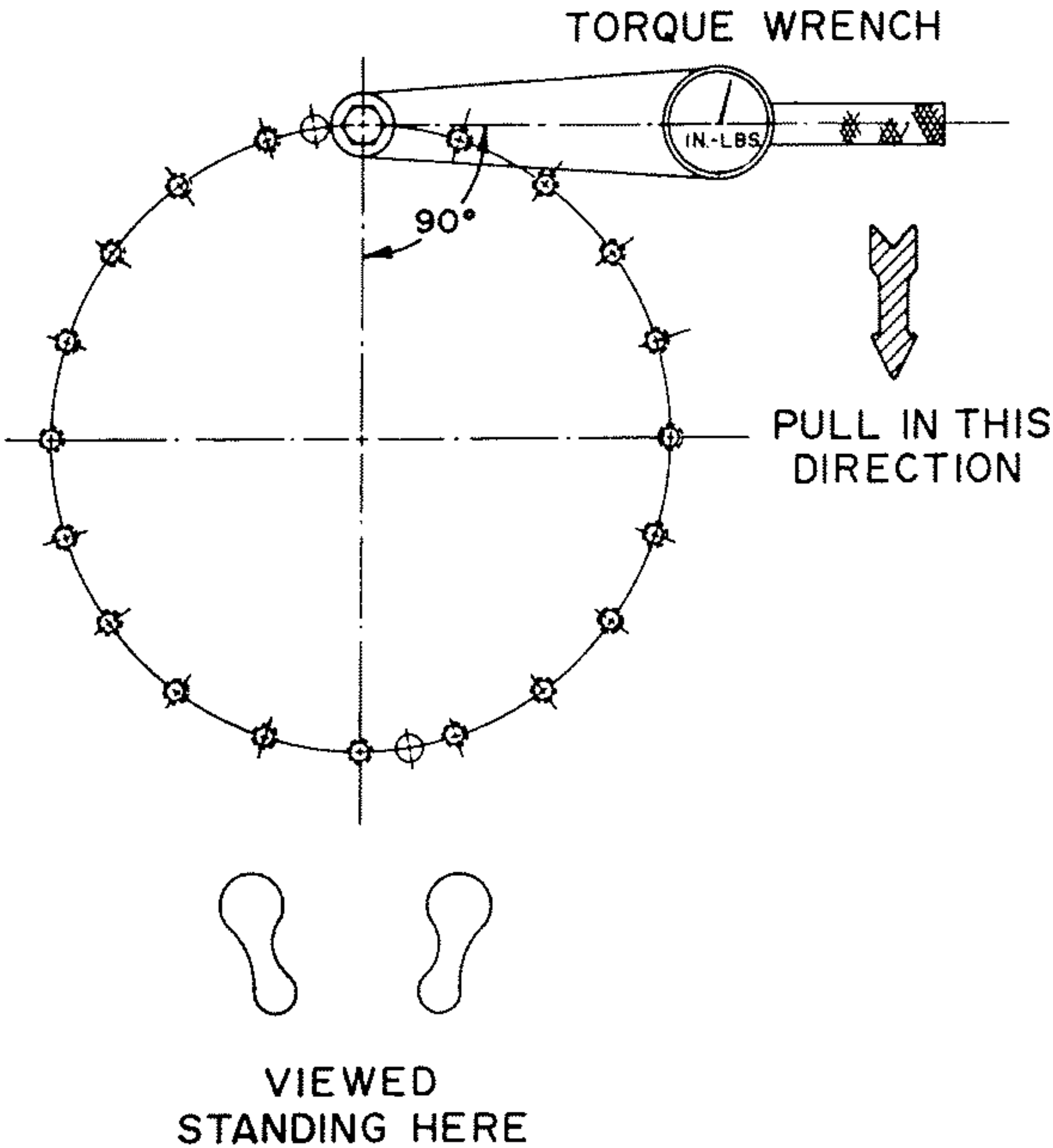
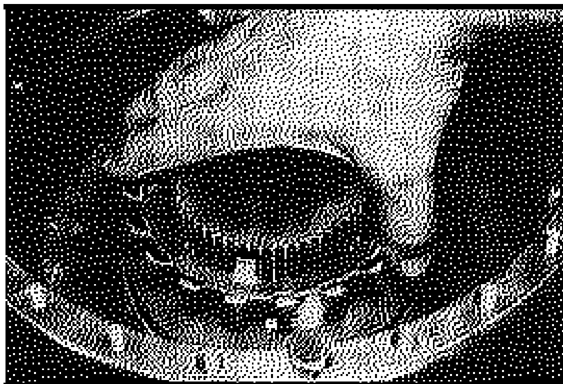
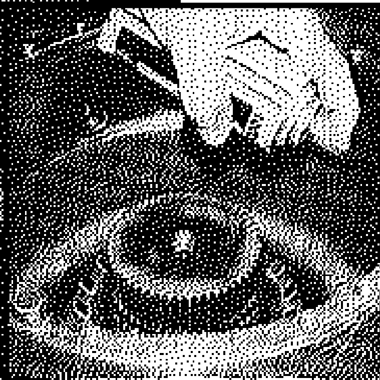


Figure 1.

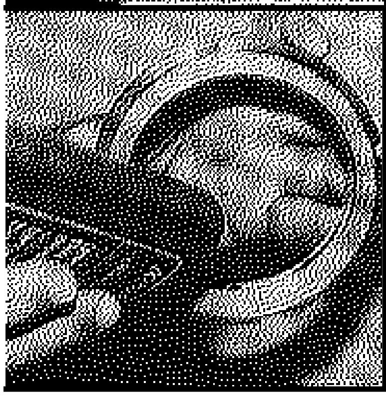


15. Place **lockwasher(1J)** onto **output shaft(1A).**

NOTE: Notice that **lockwasher(1J)** has tangs and **tanged washer(1H)** does not.



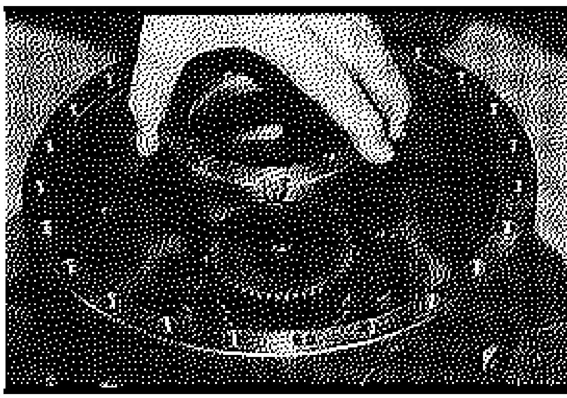
16. Spray the inside of **locknut(1K)** and the exposed sides of **output shaft(1A)** with Locquic Primer T. Allow two minutes drying time.



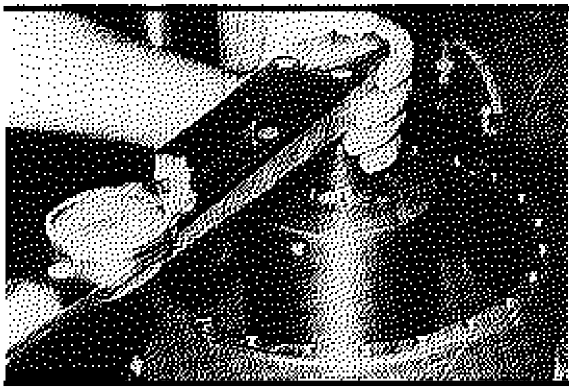
17. Apply Loctite 277 Adhesive/ Sealant to the second screwthread from the bottom of **locknut(1K).**

NOTE: The bottom of **locknut(1K)** has a chamfered or inward sloping edge.

NOTE: Loctite 277 is an anaerobic adhesive. Once it has been removed from air, it sets. Therefore, once the locknut has been placed on the output shaft, it must be torqued immediately or the adhesive will make it difficult to turn.

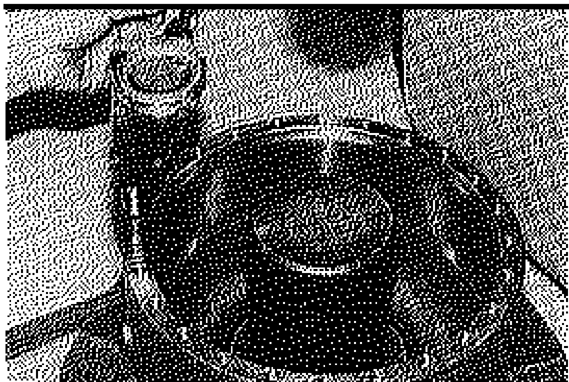


18. Place **locknut(1K)** onto **output shaft(1A)** and screw into place.



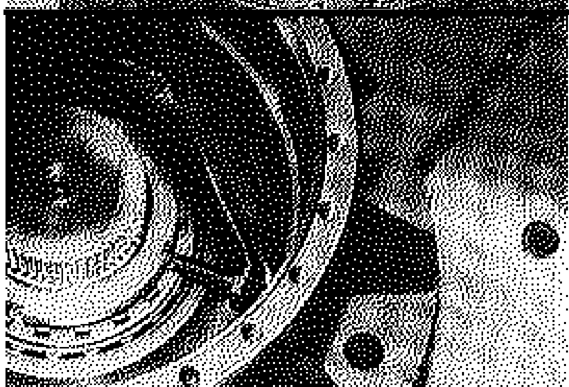
19. Using an AN-18 locknut wrench (tool no. T-156766) and a torque wrench, apply 225 ft.-lbs. of torque to **locknut(1K).**

NOTE: <u>One</u> tang on **lockwasher(1J)** must line up directly with one notch on **locknut(1K).** If one tang does not line up with a locknut notch, apply sufficient <u>increased</u> torque to the locknut until it does. <u>Never loosen the locknut</u>.

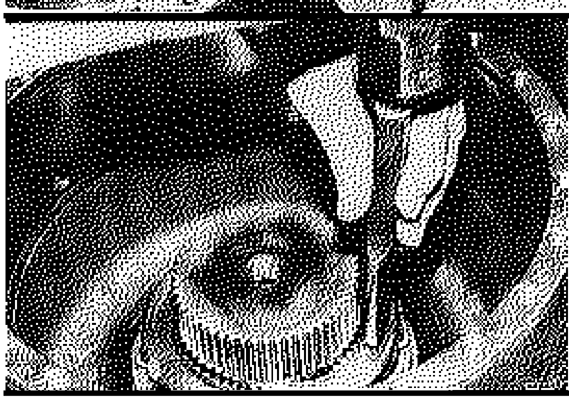


20. Measure the final rolling torque of **hub(1G)** using the same manner described in steps 13a - 13d. The final rolling torque should measure 35-60 in.-lbs.

NOTE: Remove the bolt from the hub.



21. Bend the aligned tang on **lockwasher(1J)** up into the notch on **locknut(1K).**

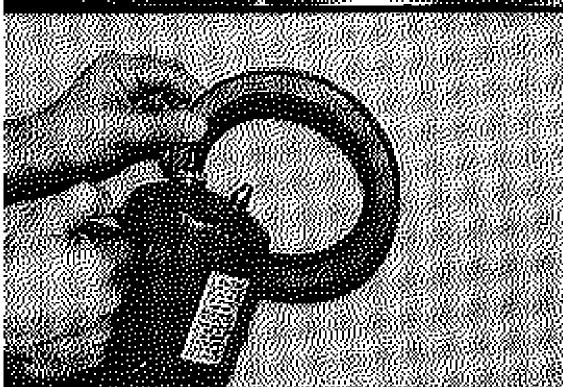


22. Using a center punch and hammer, stake **locknut(1K)** in four equally spaced positions around the circumference of the locknut and at a distance of 1/8 in. from the inside edge of the locknut.

23. At this point the hub-shaft subassembly is complete.

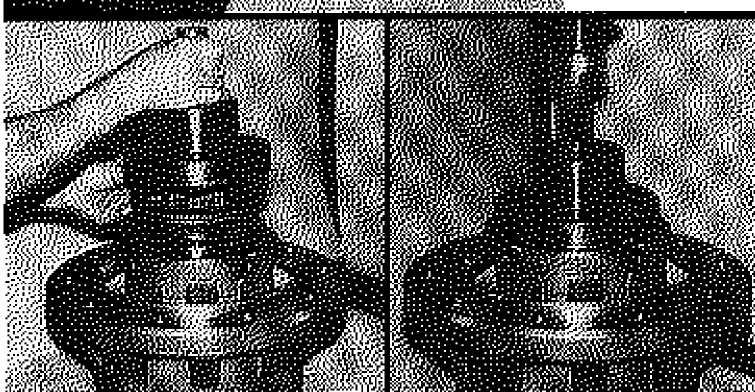
MAIN ASSEMBLY

1. Turn **hub(1G)** over so that it rests on its large diameter end. Spray oil on all exposed surfaces inside the hub while turning **output shaft(1A).**



2. Spray the inside of **seal(1B)** with oil.

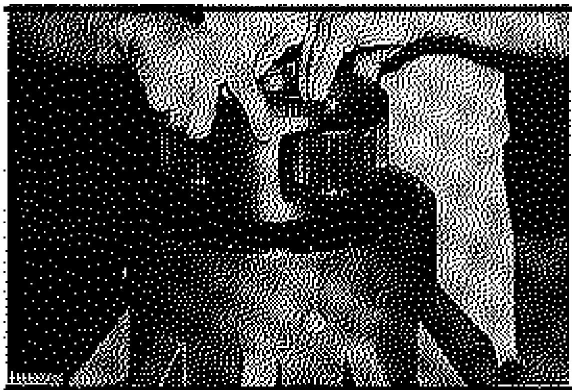
NOTE: The open face of the seal may have a waved surface. This is an intentional design used to keep dirt out.



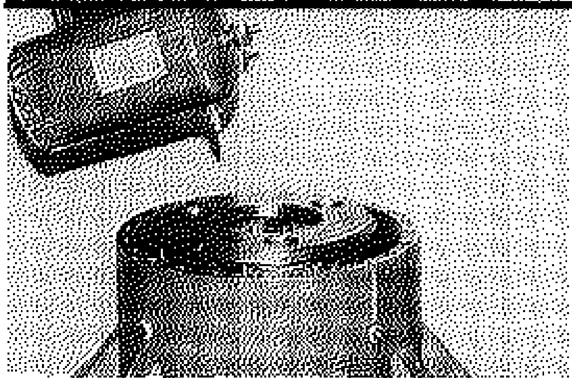
3. Press **seal(1B)** into the small diameter end of **hub (1G)** using a seal pressing fixture (tool no.T-156799).

4. Turn **hub(1G)** over once again so that it rests on its small diameter end. Using retaining ring pliers, insert **retaining ring(1L)** into the groove on **output shaft(1A).**

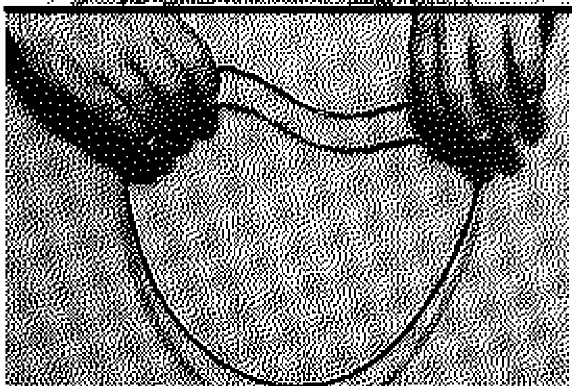
CAUTION: Saftey glasses should be worn during this procedure.



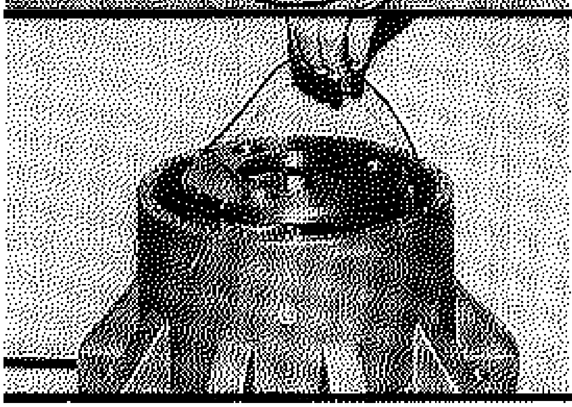
5. Place second **stage carrier assembly(2)**, with spline connections down, into **hub(1G)** so that the carrier's spline connections mesh with the spline connections on **output shaft (1A).**



6. Spray oil on all exposed surfaces inside **hub(1G).**



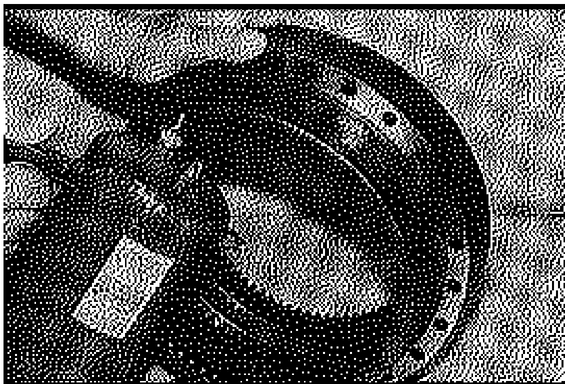
7. Grease **"O" ring(5).**



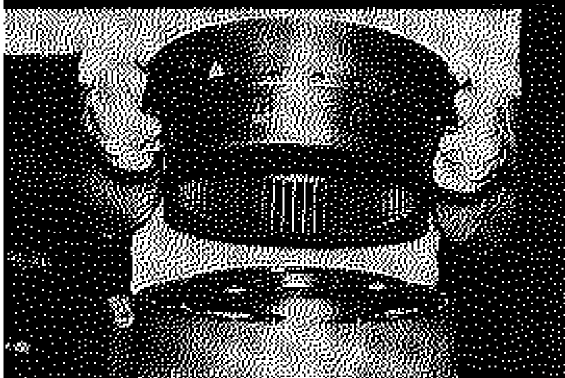
8. Place **"O" ring(5)** into the counterbore of **hub(1G).** Make sure that the counterbore is oil free before installing "O" ring.

CAUTION: Beware of sharp edges and burrs in the counterbore while installing the "O" ring.

NOTE: "O" rings may be stretched to fit the counterbore. If an "O" ring has been stretched too much, simply squeeze the "O" ring together bit by bit as you place it around the counterbore. It can be made to fit exactly.



9. Spary oil on the inside of **ring gear(4).**

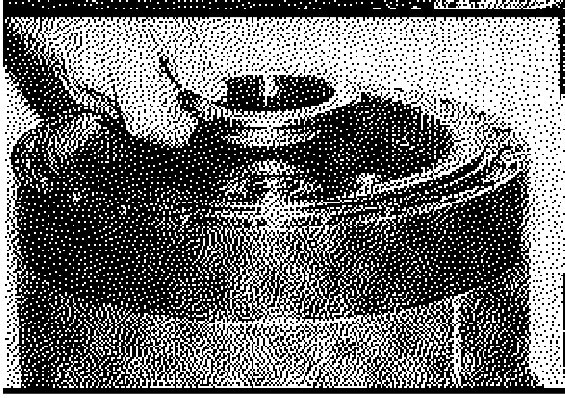


10. Place **ring gear(4)** with small diameter end down, into **hub(lG)** so that it fits over **second stage carrier assembly(2).**

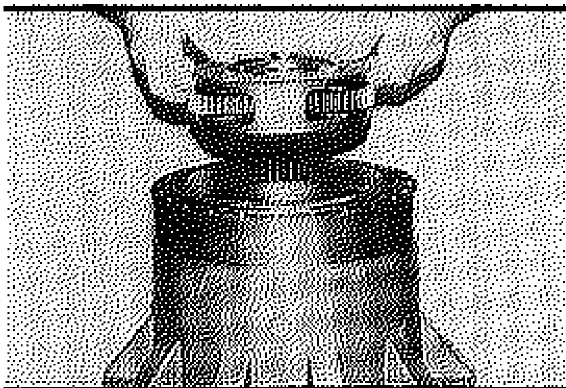
11. Place **second stage sun gear(11),** with large diameter end down, into mesh with the planet gears of the **second stage carrier assembly(2).**

l2. Place large **thrust washer(14), thrust bearing(13)**, and large **thrust washer(12)** in that order into the counterbore of **second stage carrier assembly(2).**

NOTE: Notice that **thrust washer(14)** is much thicker than **thrust washer(12).**

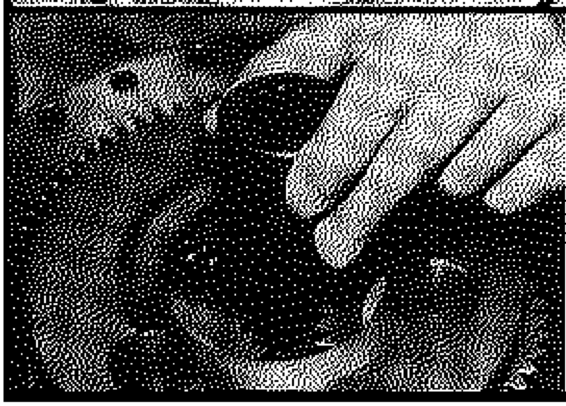


13. Place thrust bearing carrier (10), with small diameter end down, into the counterbore of **second stage carrier assembly(2).** It should fit over the thrust bearing set(12, 13, 14) described in step 12.



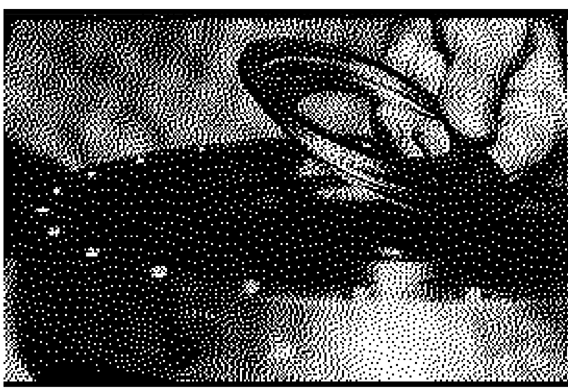
14. Place **first stage carrier assembly(3)**, with spline connections down, into mesh with the **second stage sun gear(ll)** and the **ring gear(4).**

15. Place small **thrust washer(9)** on top of **second stage sun gear(ll).**



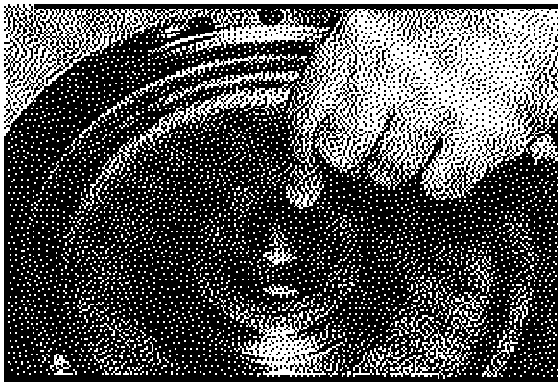
16. Place **input gear(8)**, with small diameter end down, into mesh with the planet gears of **first stage carrier assembly(3).** The input gear should be centered on the small **thrust washer(9).**

17. Set **cover(6)** down on its small diameter end.

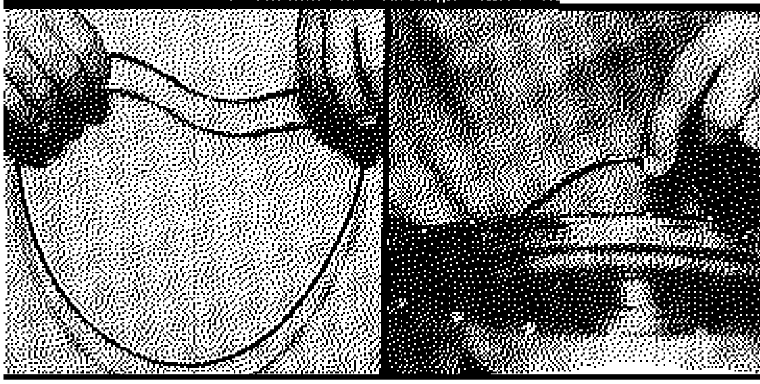


18. Grease one side of large **thrust washer(12), thrust bearing(13)**, and large **thrust washer(14)** and place them greased side down in that order over the raised inside circular edge of **cover(6).**

NOTE: Notice that **thrust washer(14)** is much thicker that **thrust washer (12).**



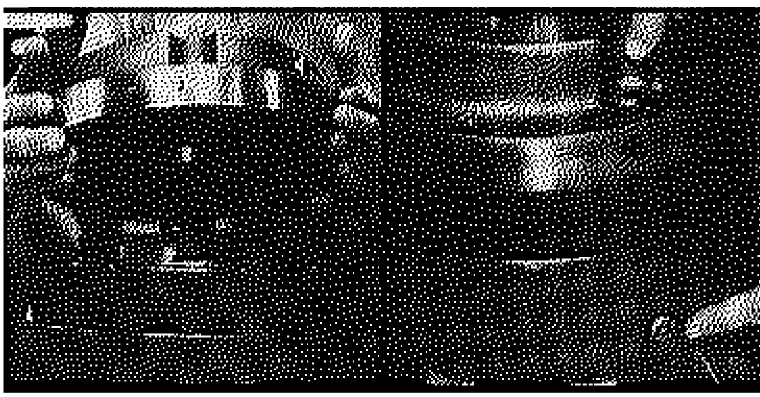
19. Grease small **thrust washer(7)** and place it in the counterbore of the center hole in **cover(6).**



20. Grease **“O” ring(5)** and place it around the counterbore in **cover(6).**

CAUTION: Beware of sharp edges and stalling the “O” ring.

NOTE: “O” rings may be stretched to fit the counterbore. If an “O” ring has been stretched too much, simply squeeze the “O” ring together bit by bit as you place it around the counterbore. It can be made to fit exactly.



21. Place **cover(6)**, with large diameter end down, on top of **ring gear(4)** so that the cover’s pipe plug hole aligns with the magnetic pipe plug hole in **hub(lG)** according to figure 2.

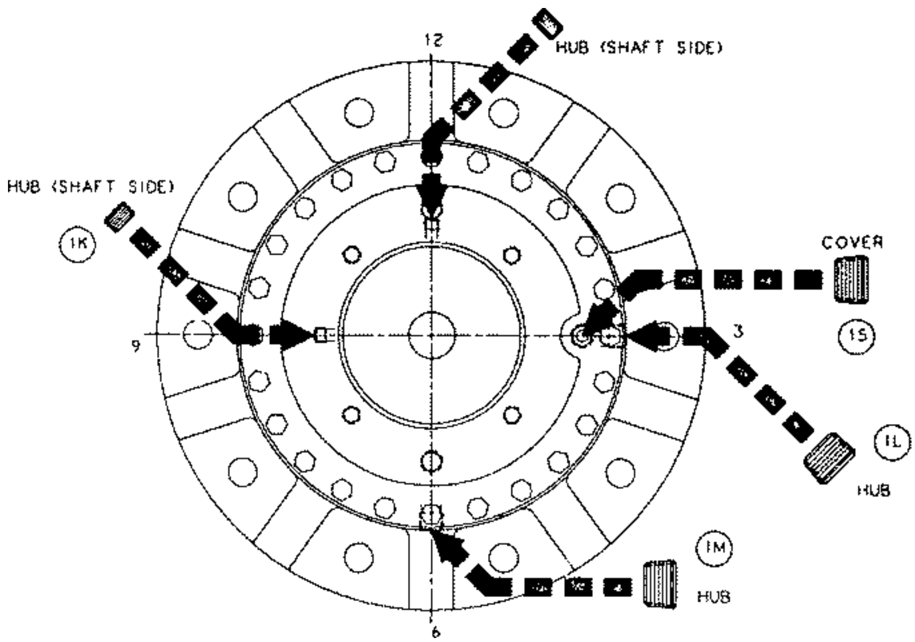
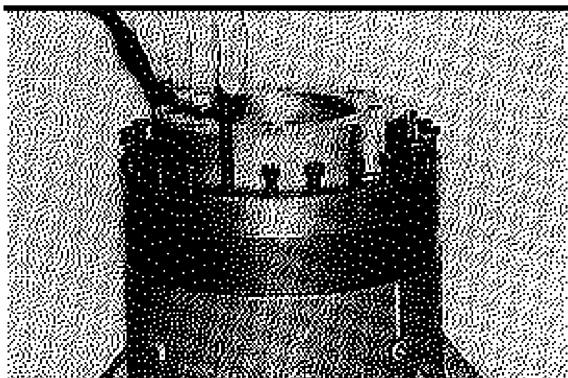
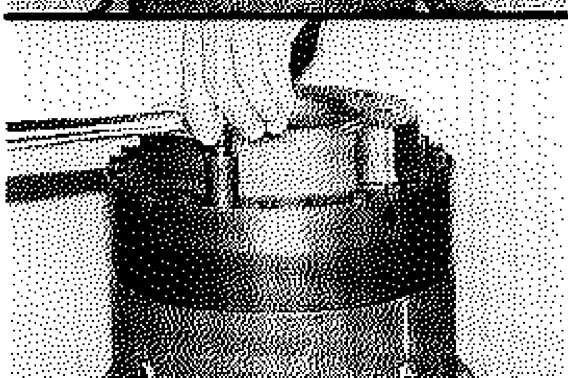


Figure 2.

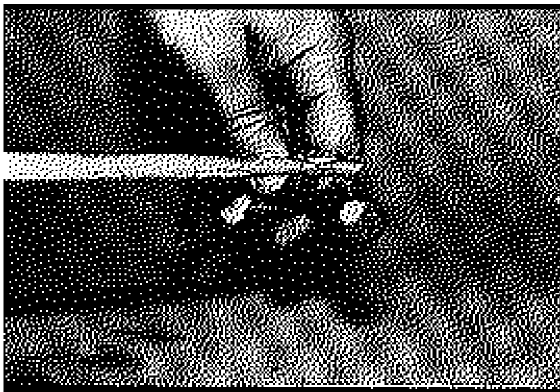
This figure shows the most common pipe plug timing for this series. Pipe plug timings may vary among units with different model numbers. Refer to an original assembly print for your particular unit to determine its correct pipe plug timing.



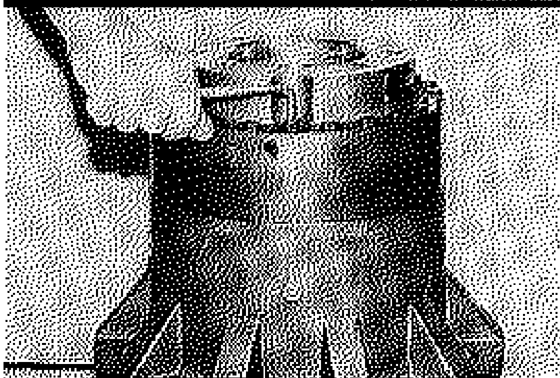
22. Place the 24 **grade 8 bolts(16)** into **cover(6)** and tighten.



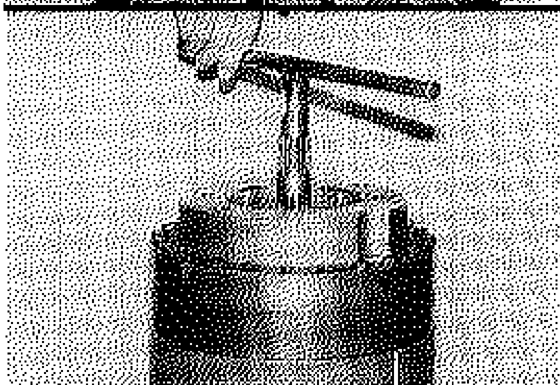
23. Using a torque wrench, apply 35-45 ft.-lbs of torque to each **grade 8 bolt (16).**



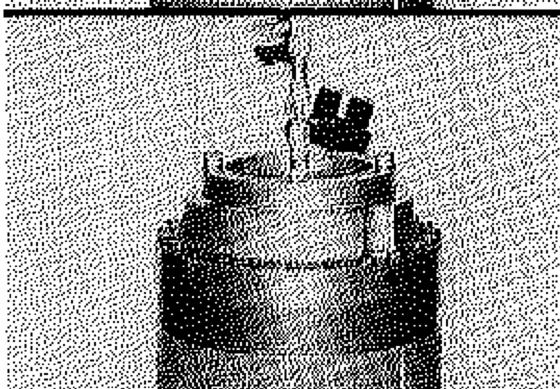
24. Apply a light coat of “Never-Seize” to **pipe plug(15).**



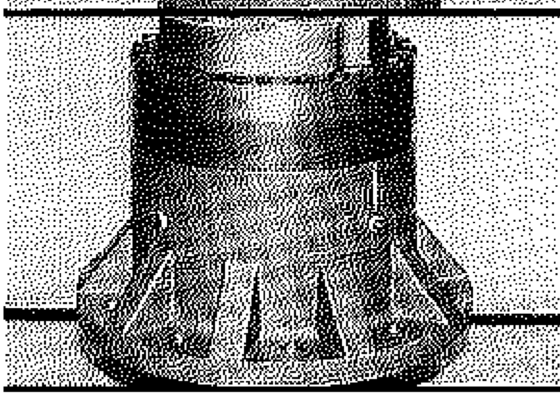
25. Tighthen **pipe plug(15)** into the pipe plug hole in **cover(6).**



26. Roll test the unit in both clockwise and counterclockwise directions. Perform the same number of turns in each direction as the ratio of the unit. The ratio number is the same as the last two digits in the model number found on the **ID** tag of the unit.



27. Leak test the unit at a pressure of 5 psi for 2-3 minutes.



28. At this point the main assembly complete.

TOOLING

The following specialized tools are used in the assembly of this unit. The tool diagrams included in this manual are intended for the customer who may wish to have a tool made. All tools must be made from mild steel. All dimensions are given in inches.

OPTIONAL: In order to improve tool life, tools may be carborized and hardened. If this is done, however, the tools must be ground on all surfaces labeled with a “G” on the tool diagram.

1. TOOL NO. T-130717
   BEARING CUP PRESSING FIXTURE for CUP(1E)

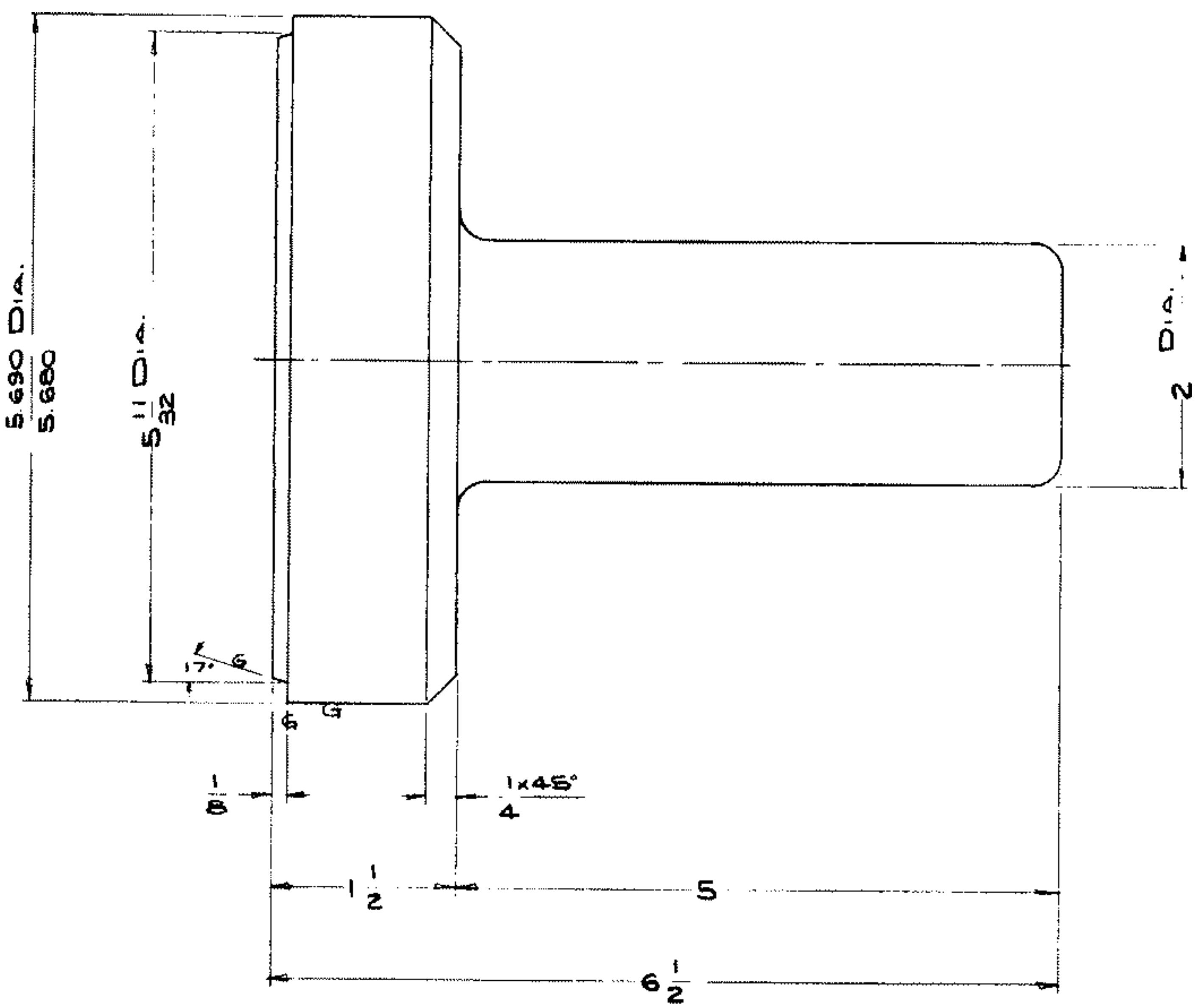
2. TOOL NO. T-156792
   BEARING CUP PRESSING FIXTURE for CUP(1C)

3. TOOL NO. T-158049
   BEARING CONE PRESSING FIXTURE for CONE(1D)

4. TOOL NO. T-146588
   BEARING CONE PRESSING FIXTURE for CONE(1F)

5. TOOL NO. T-156766
   AN-18 LOCKNUT WRENCH

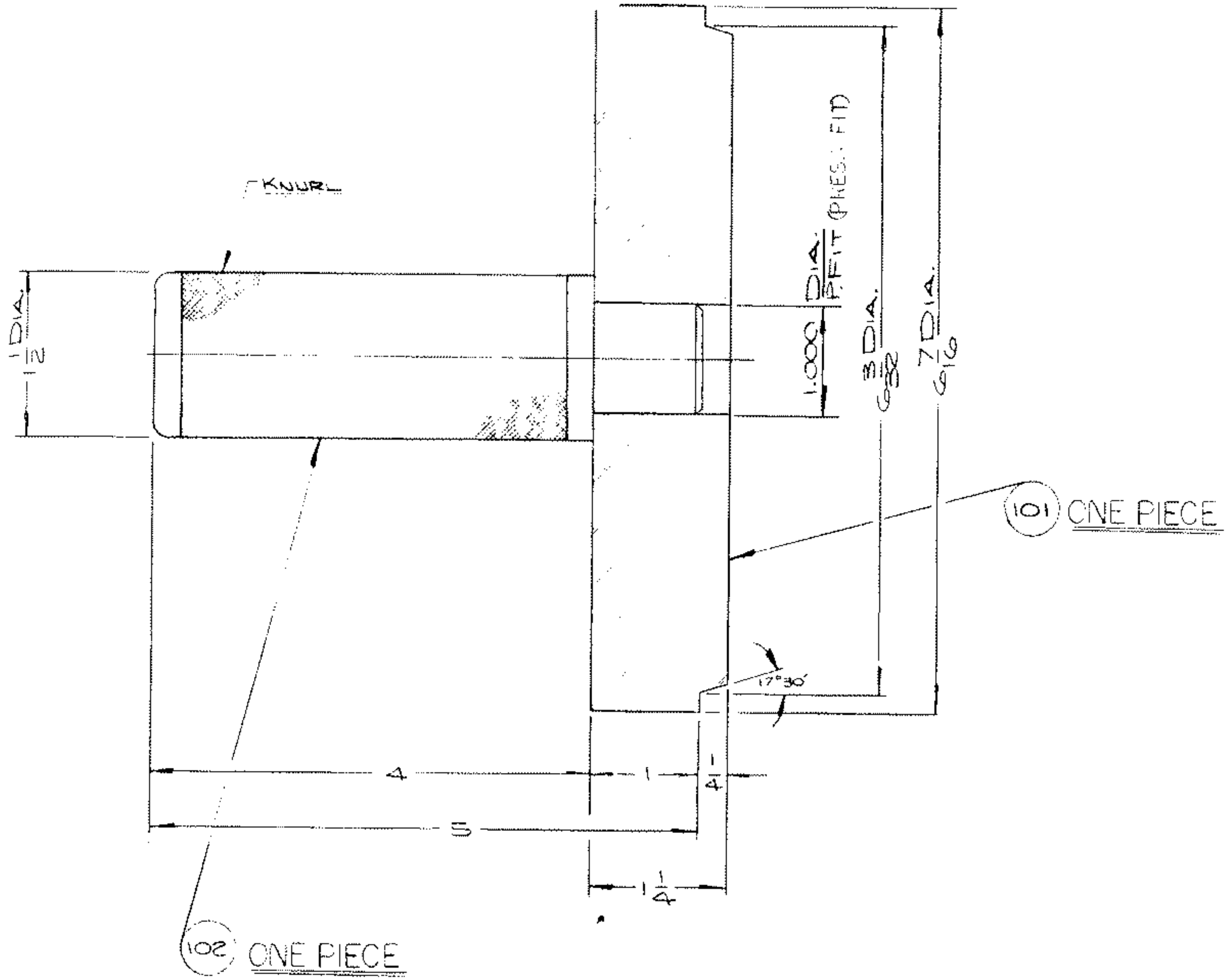
6. TOOL NO. T-156799
   SEAL PRESSING FIXTURE



T-130717

SCALE: 3/4 ONE PIECE

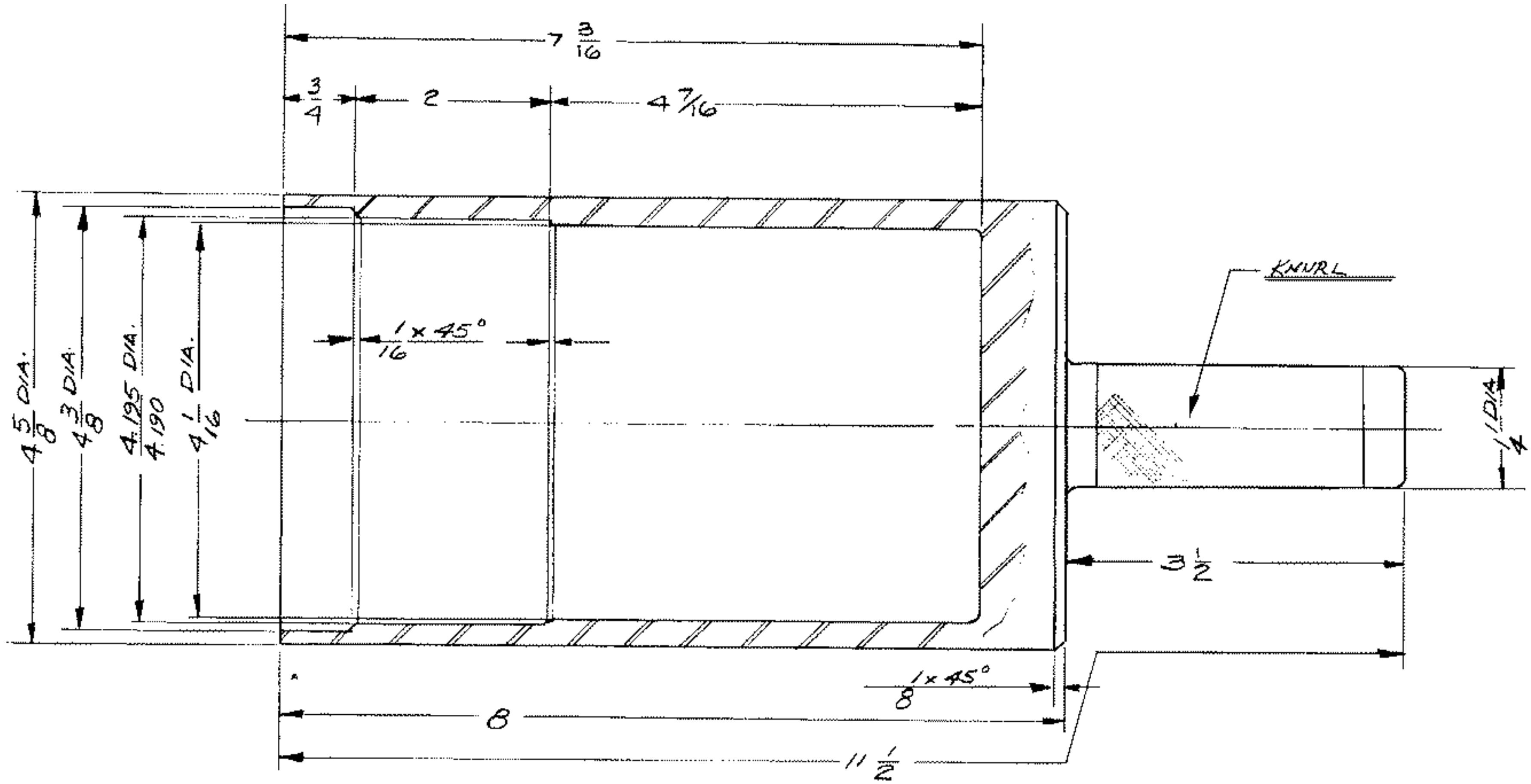
BEARING CUP PRESSING FIXTURE
for CUP(1E)



T-156792

SCALE: 3/4

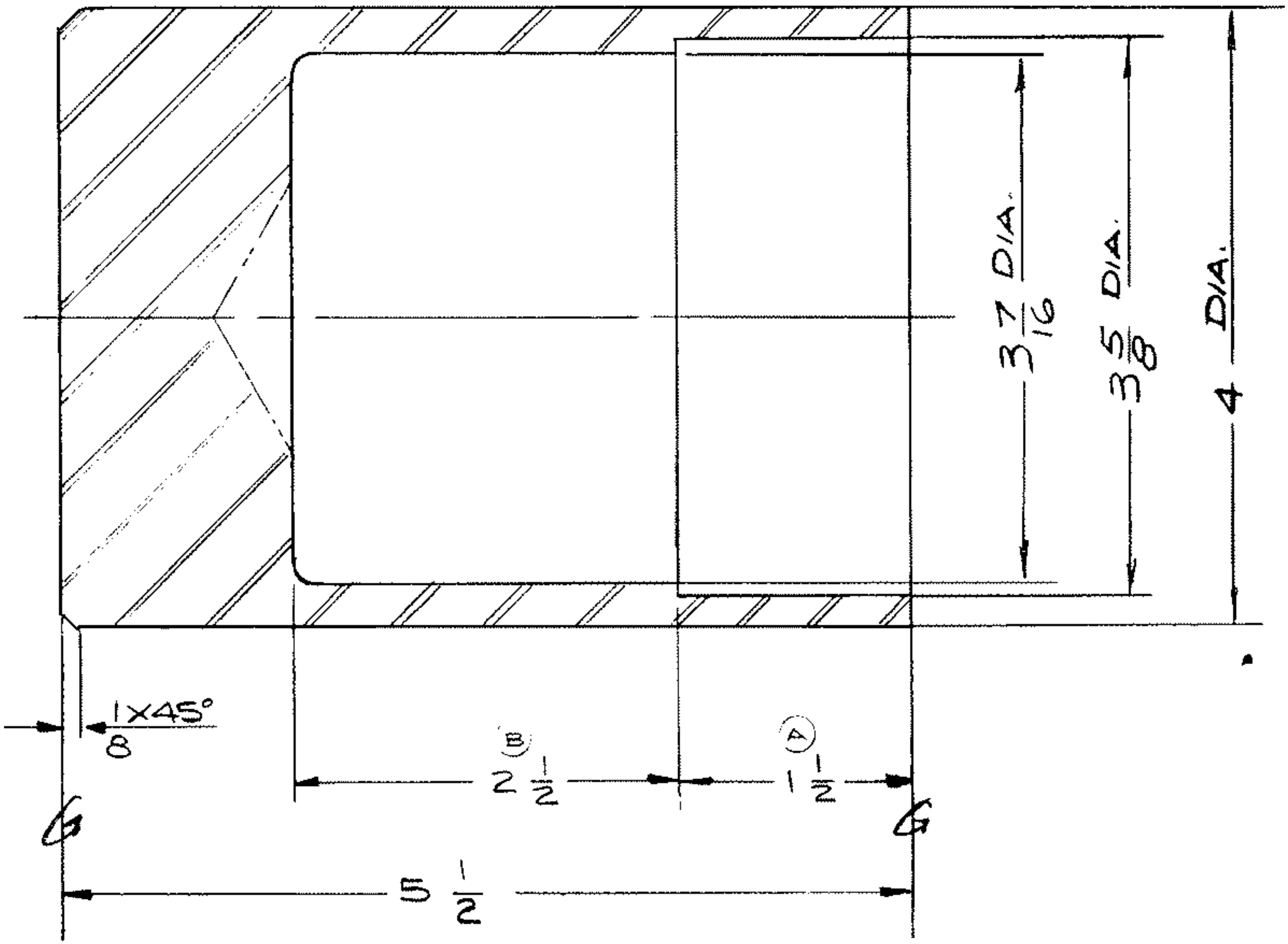
BEARING CUP PRESSING FIXTURE
for CUP(1C)



T-158049

BEARING CONE PRESSING FIXTURE
for CONE(1D)

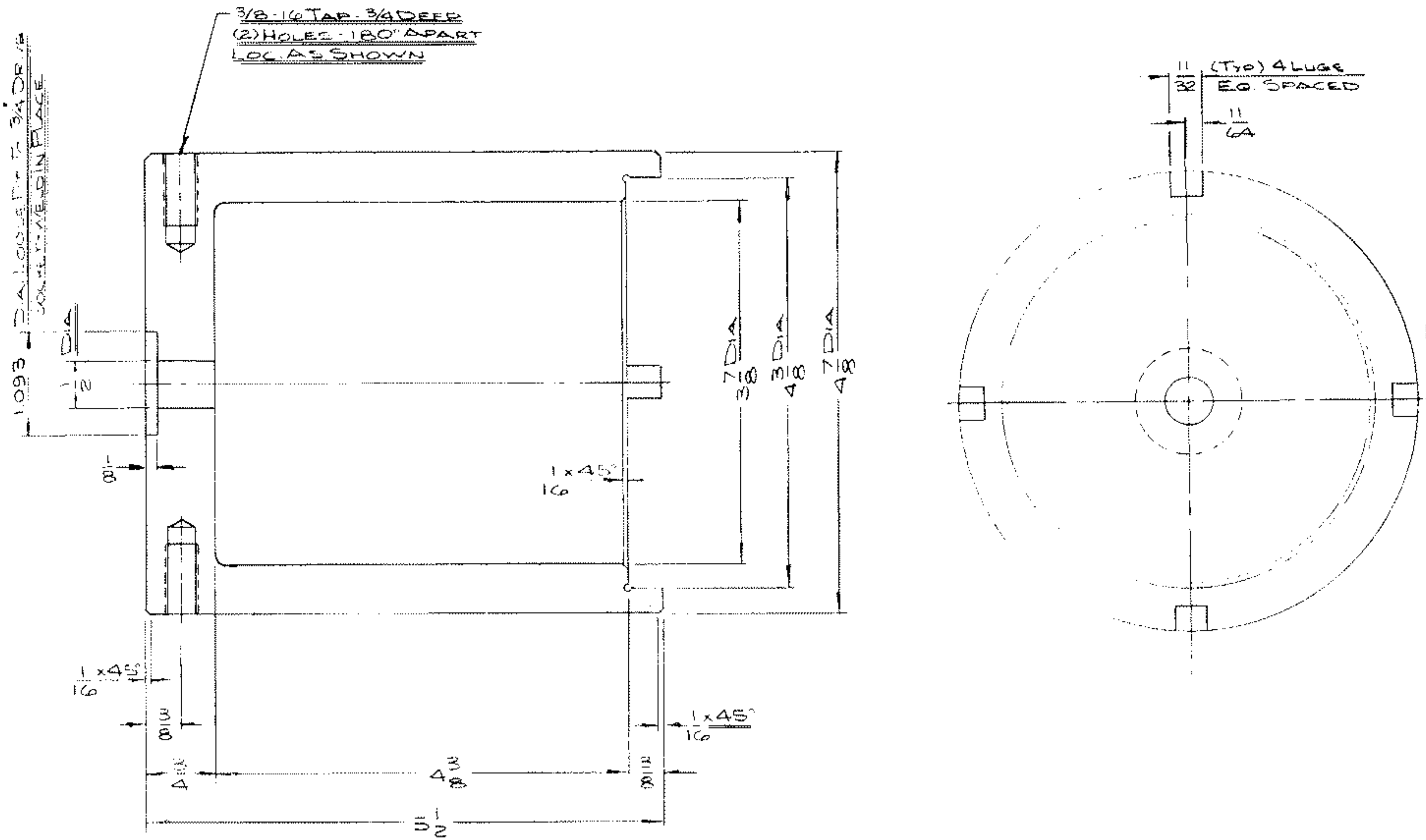
SCALE: 3/4 ONE PIECE



T-146588

SCALE: full ONE PIECE

BEARING CONE PRESSING FIXTURE
for CONE(1F)

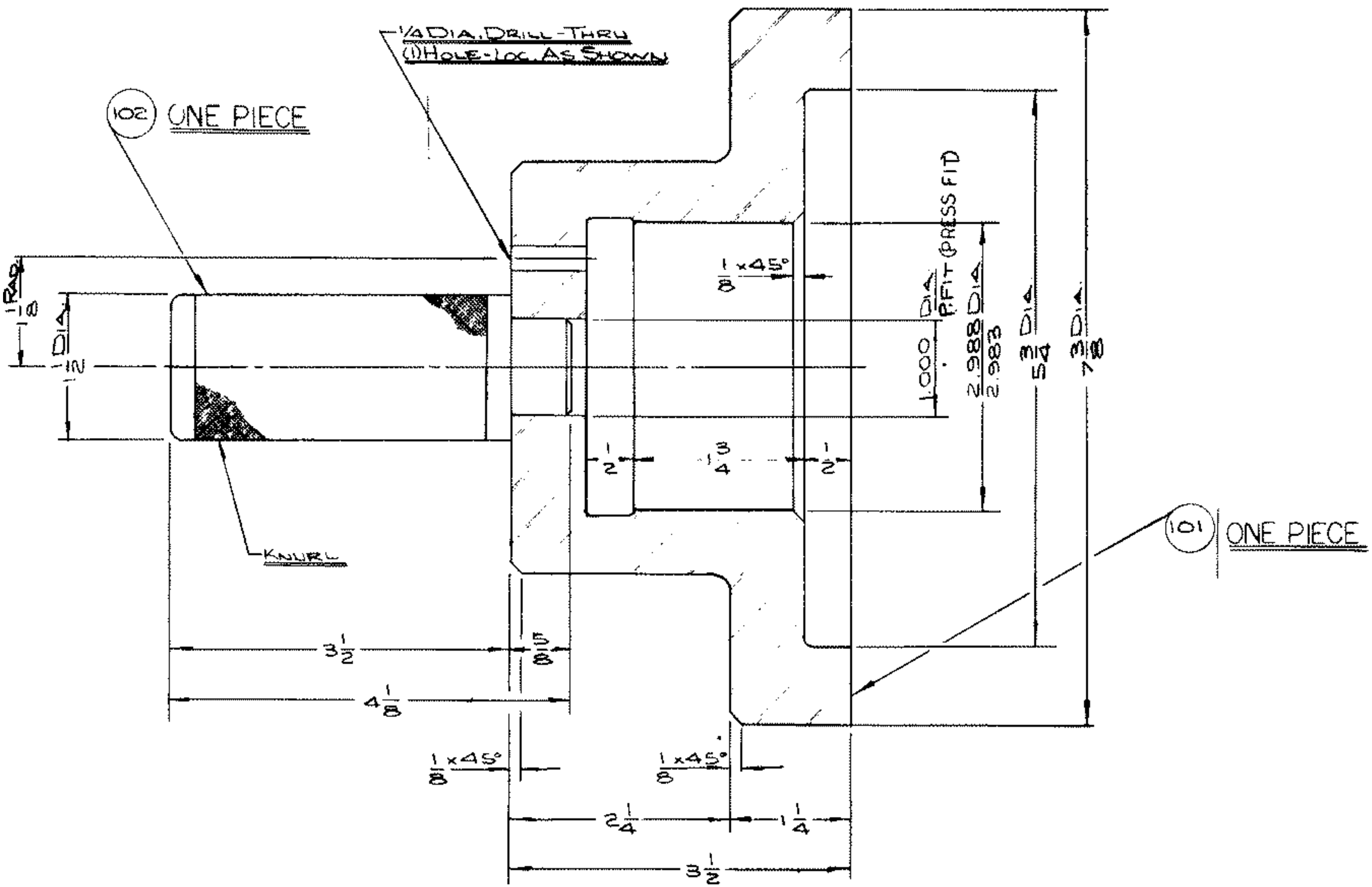


T-156766

AN-18 LOCKNUT WRENCH

SCALE: 2/3 ONE PIECE

USE 3/4 in. DRIVE SOCKET



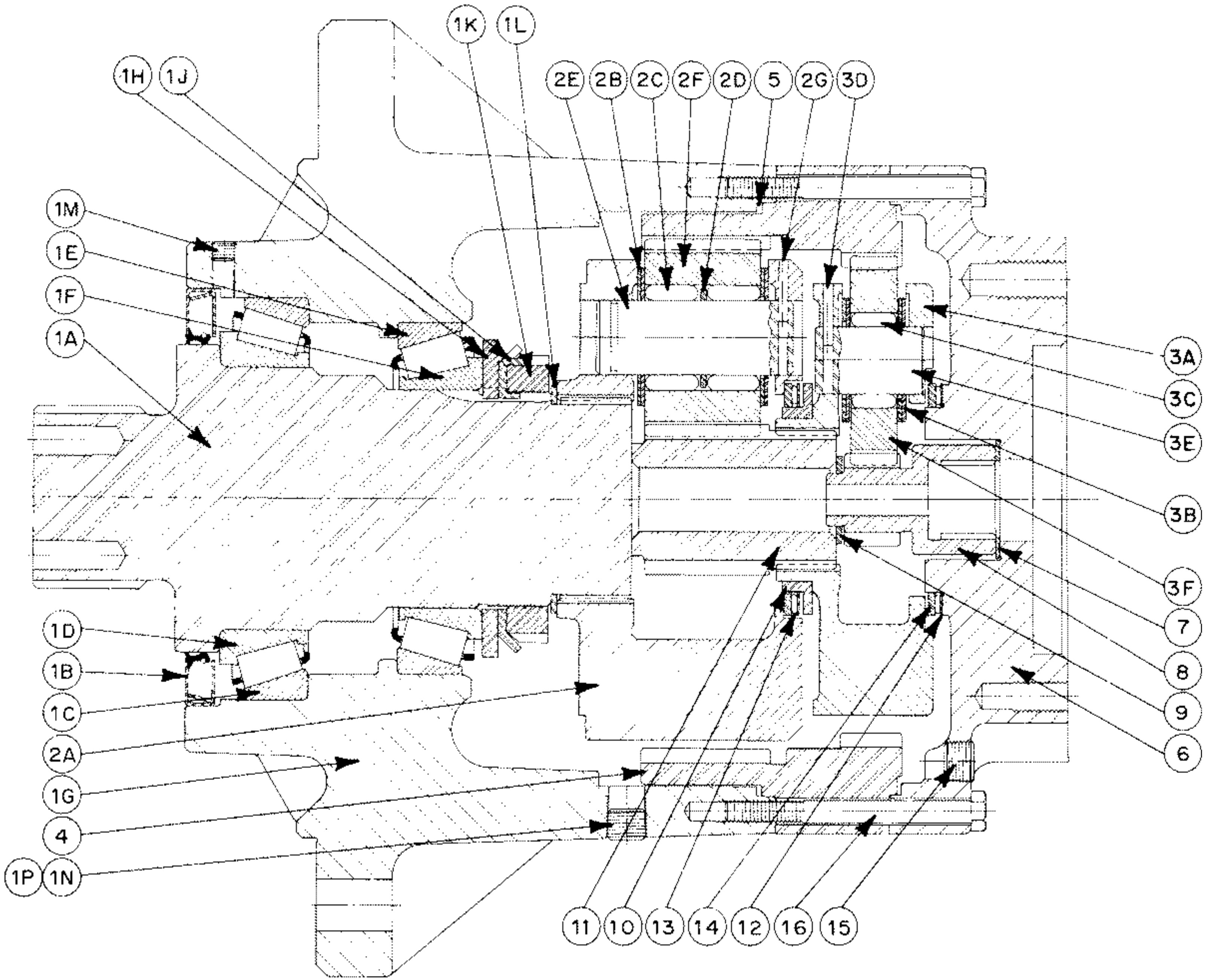
T-156799 **SCALE: 2/3**

SEAL PRESSING FIXTURE

PARTS LIST

ITEM	QUANTITY	DESCRIPTION
1	1	hub-spindle sub-assembly
1A	1	output shaft
1B	1	seal
1C	1	bearing cup
1D	1	bearing cone
1E	1	bearing cup
1F	1	bearing cone
1G	1	hub
1H	1	tanged washer
1J	1	lockwasher
1K	1	locknut
1L	1	retaining ring
1M	2	pipe plug
1N	1	pipe plug
1P	1	magnetic pipe plug
2	1	second stage carrier sub-assembly
2A	1	second stage carrier
2B	12	thrust washer
2C	108	needle roller
2D	3	spacer
2E	3	planet shaft
2F	3	planet gear
2G	3	dowel pin
3	1	first stage carrier sub-assembly
3A	1	1 first stage carrier
3B	12	thrust washer
3C	57	needle roller
3D	3	dowel pin
3E	3	planet shaft
3F	3	planet gear
4	1	ring gear
5	2	“O” ring
6	1	cover
7	1	thrust washer
8	1	input gear
9	1	thrust washer

ITEM	QUANTITY	DESCRIPTION
10	1	thrust bearing carrier
11	1	second stage sun gear
12	2	thrust washer
13	2	thrust bearing
14	2	thrust washer
15	1	pipe plug
16	24	bolt
17	4	drive screw
18	1	ID plate



CROSS-SECTIONAL VIEW of S6A

FAIRFIELD

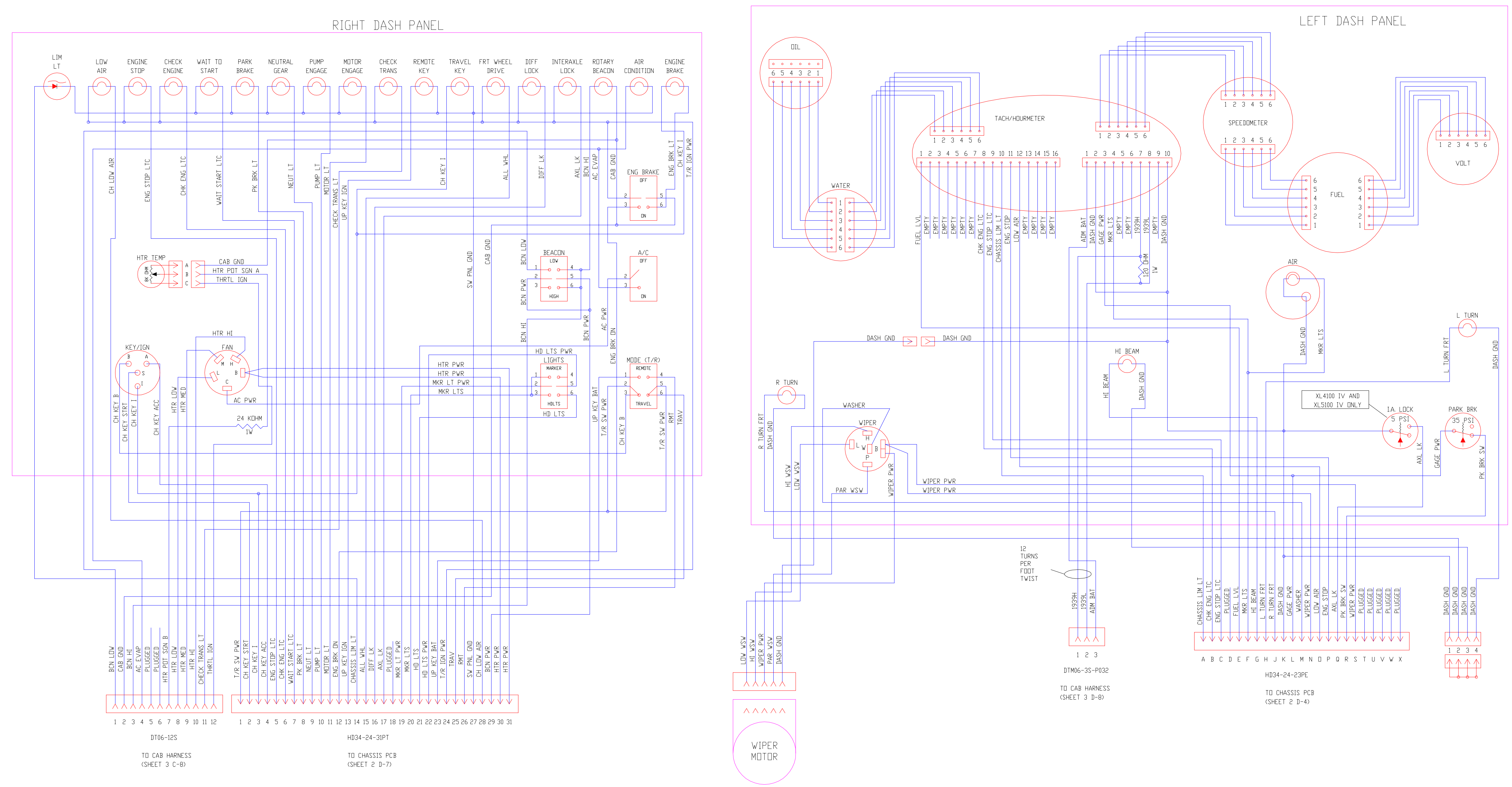
Motion Innovation Products and Systems

GEARED FOR EXCELLENCE

Fairfield

U.S. 52 South • P.O. Box 7940
Lafayette, IN 47903-7940 USA
765 • 772-4000
765 • 772-4001

Rev. 3/00



CHASSIS DASH PANELS

DRAWINGS CREATED IN Pro/ENGINEER.
UNLESS OTHERWISE SPECIFIED, ALL
DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD

REVISIONS

SPECIFICATIONS
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1

UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.
ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED
THIRD ANGLE PROJECTION

DRAWN BY:	CES
DATE:	30NOV15
CHK'D. BY:	RDM
DATE:	30NOV15
E.R. NO.	SO3429817
FINISH:	N/A
REF. DWG.	NONE
MACH. SURF. MAX	125

GRADALL

TITLE: ELECTRICAL SCHEMATIC, SERIES V ON-HIGHWAY

MATERIAL: N/A

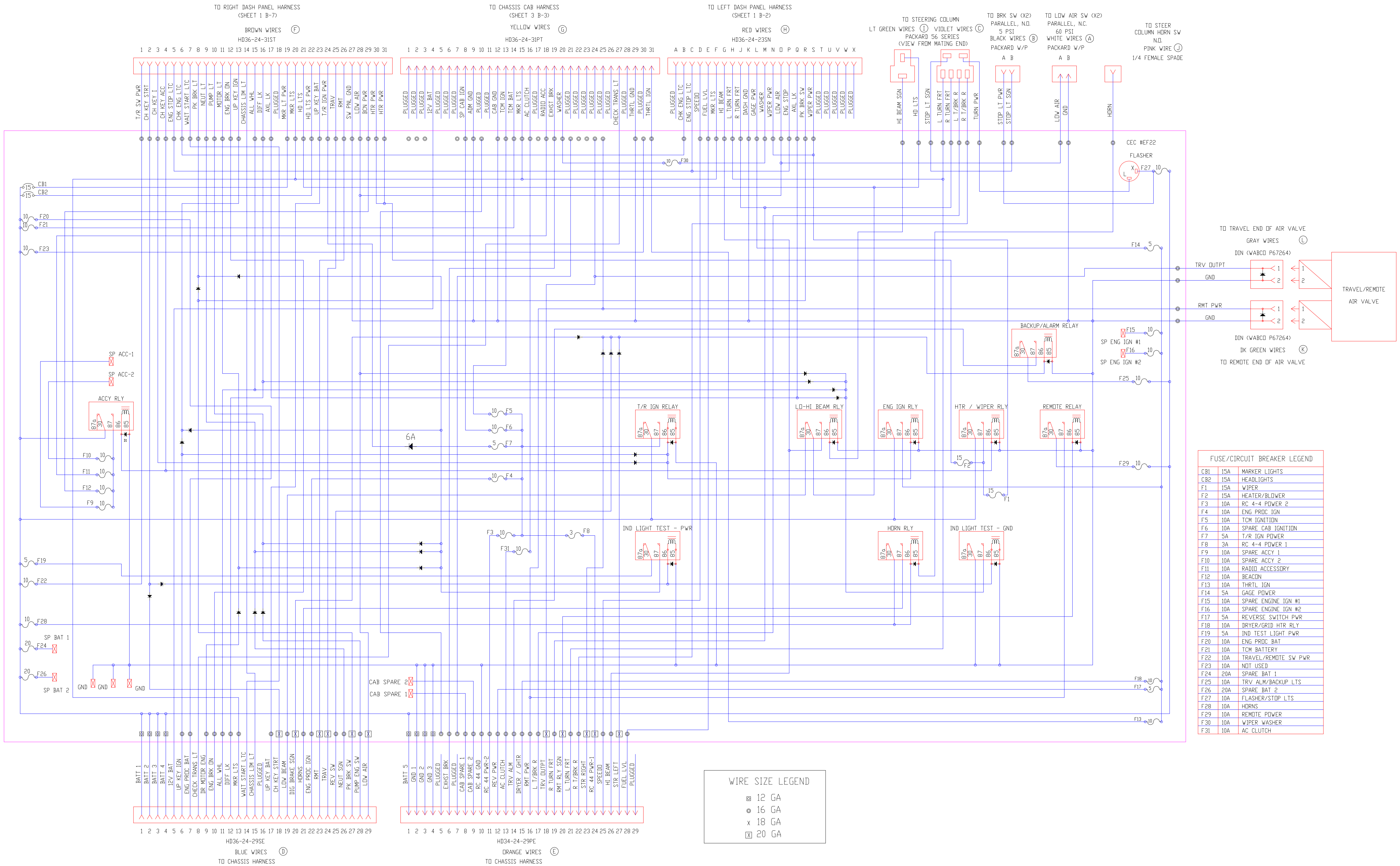
SIZE	CAGE CODE:	DWG NO.	REV
D		80709015	-

SCALE: NONE EST WT: N/A SHEET: 1 OF 12

NEXT ASSY 80700003

DO NOT SCALE DRAWING

DRAWING NUMBER 80709015



FUSE/CIRCUIT BREAKER LEGEND		
CB1	15A	MARKER LIGHTS
CB2	15A	HEADLIGHTS
F1	15A	WIPER
F2	15A	HEATER/BLOWER
F3	10A	RC 4-4 POWER 2
F4	10A	ENG PROC IGN
F5	10A	TCM IGNITION
F6	10A	SPARE CAB IGNITION
F7	5A	T/R IGN POWER
F8	3A	RC 4-4 POWER 1
F9	10A	SPARE ACCY 1
F10	10A	SPARE ACCY 2
F11	10A	RADIO ACCESSORY
F12	10A	BEACON
F13	10A	THRTL IGN
F14	5A	GAGE POWER
F15	10A	SPARE ENGINE IGN #1
F16	10A	SPARE ENGINE IGN #2
F17	5A	REVERSE SWITCH PWR
F18	10A	DRYER/GRID HTR RLY
F19	5A	IND TEST LIGHT PWR
F20	10A	ENG PROC BAT
F21	10A	TCM BATTERY
F22	10A	TRAVEL/REMOTE SW PWR
F23	10A	NOT USED
F24	20A	SPARE BAT 1
F25	10A	TRV ALM/BACKUP LTS
F26	20A	SPARE BAT 2
F27	10A	FLASHER/STOP LTS
F28	10A	HORNS
F29	10A	REMOTE POWER
F30	10A	WIPER WASHER
F31	10A	AC CLUTCH

WIRE SIZE LEGEND

- ⊠ 12 GA
- o 16 GA
- x 18 GA
- ☒ 20 GA

CHASSIS CIRCUIT BOARD

DRAWINGS CREATED IN Pro/ENGINEER.
UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD

REVISIONS

SPECIFICATIONS
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1

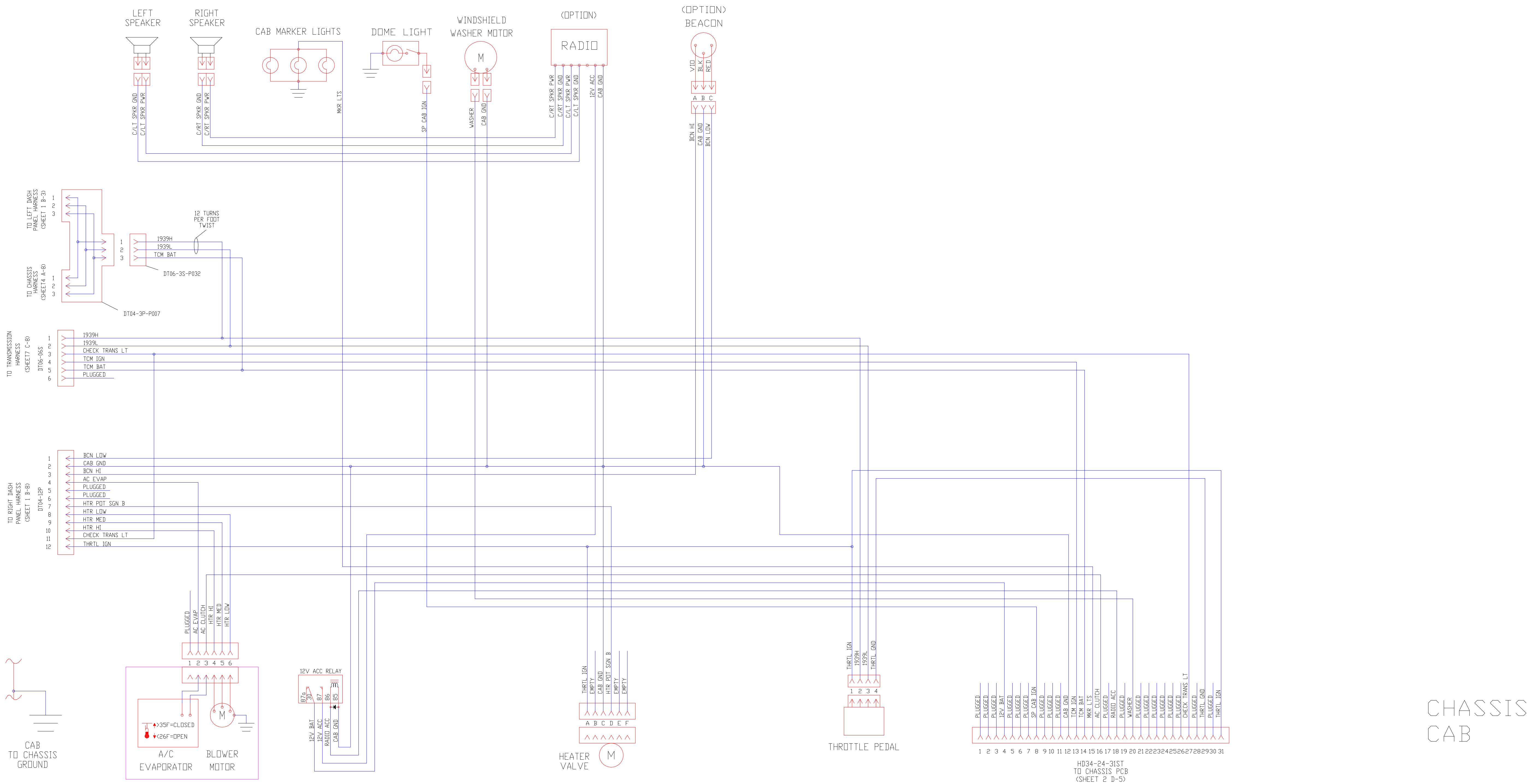
UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.
ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED
THIRD ANGLE PROJECTION

NEXT ASSY 80700003
DO NOT SCALE DRAWING

DRAWN BY: CES
DATE: 30NOV15
CHK'D. BY: RDM
DATE: 30NOV15
E.R. NO. SO3429817
FINISH: N/A
REF. DWG. NONE
MACH. SURF. 125 MAX

GRADALL
TITLE: ELECTRICAL SCHEMATIC, SERIES V ON-HIGHWAY
MATERIAL: N/A
SIZE D | CAGE CODE: | DWG NO. 80709015 | REV -
SCALE: NONE | EST WT: N/A | SHEET 2 OF 12

DRAWING NUMBER 80709015



DRAWINGS CREATED IN Pro/ENGINEER. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES.

THIS PRINT IS THE PROPERTY OF GRADALL AND CONTAINS PROPRIETARY AND CONFIDENTIAL INFORMATION OF GRADALL. IT MAY NOT BE COPIED OR DISCLOSED TO ANY THIRD PARTY WITHOUT GRADALL'S WRITTEN CONSENT AND IS PROVIDED FOR THE LIMITED PURPOSE OF REVIEW AND EVALUATION.

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD

REVISIONS

SPECIFICATIONS
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1

NEXT ASSY 80700003

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.
ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED
THIRD ANGLE PROJECTION

DRAWN BY: ADH
DATE: 30NOV15
CHK'D. BY: RDM
DATE: 30NOV15
E.R. NO. SO3429817
FINISH: N/A
REF. DWG. NONE
MACH. SURF. 125 MAX

GRADALL

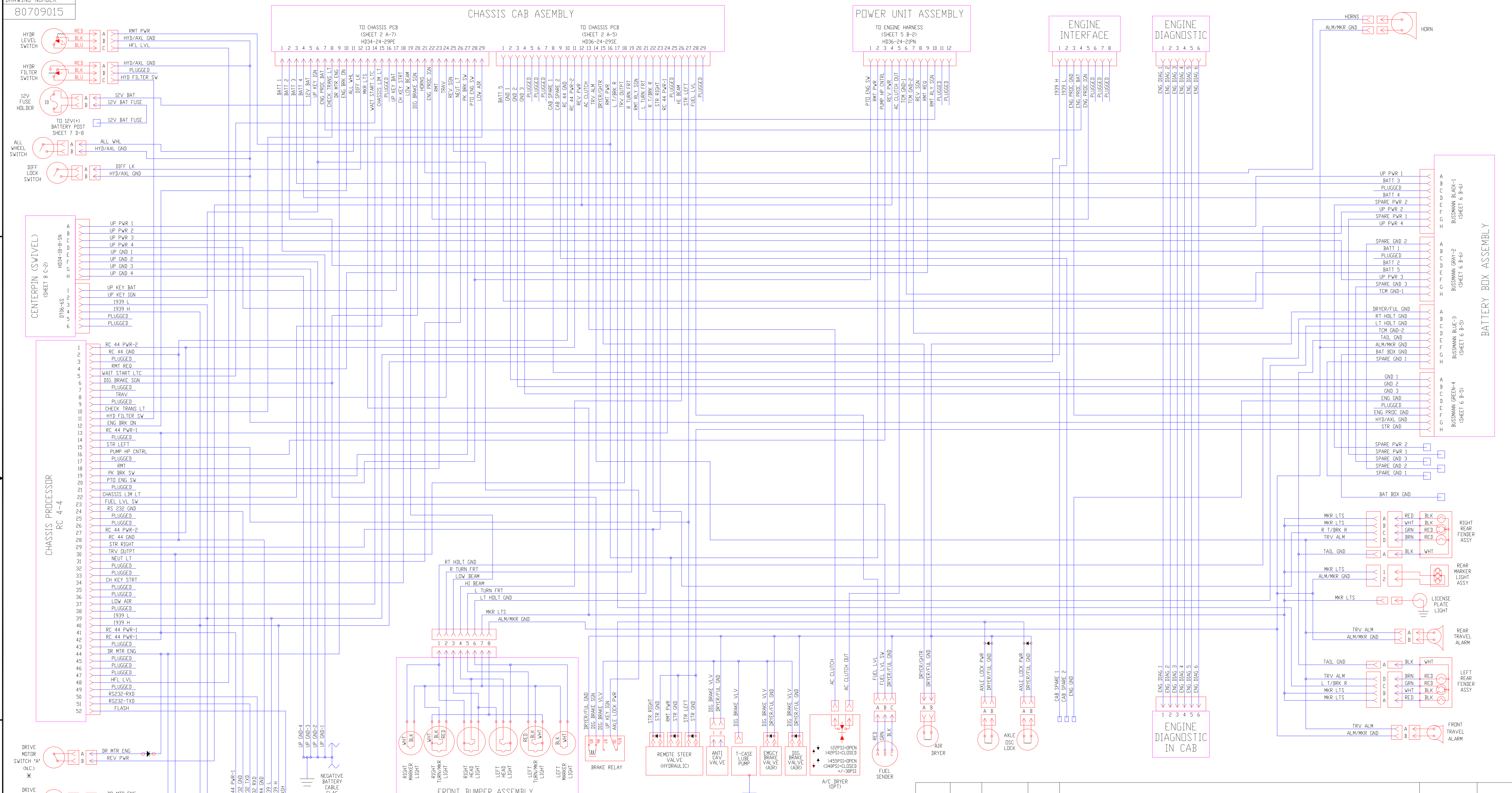
TITLE: ELECTRICAL SCHEMATIC SERIES V ON-HIGHWAY

MATERIAL: N/A

SIZE D | CAGE CODE: | DWG NO. 80709015 | REV -

SCALE: NONE | EST WT: N/A | SHEET:3 OF 12

DRAWING NUMBER 80709015



CHASSIS HARNESS

DRAWINGS CREATED IN Pro/ENGINEER.
UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES.

THIS PRINT IS THE PROPERTY OF GRADALL AND CONTAINS PROPRIETARY AND CONFIDENTIAL INFORMATION OF GRADALL. IT MAY NOT BE COPIED OR DISCLOSED TO ANY THIRD PARTY WITHOUT GRADALL'S WRITTEN CONSENT AND IS PROVIDED FOR THE LIMITED PURPOSE OF REVIEW AND EVALUATION.

* DRIVE MOTOR ENGAGEMENT KEY

	COLOR	POSTITION	TRAVEL MODE	REMOTE MODE
SWITCH-A	GOLD	9 O'CLOCK	SWITCH "OPEN"	SWITCH "CLOSED"
SWITCH-B	SILVER	5 O'CLOCK	SWITCH "OPEN"	SWITCH "NOT USED"

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD

REVISIONS

SPECIFICATIONS
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1

UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.
ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED
THIRD ANGLE PROJECTION

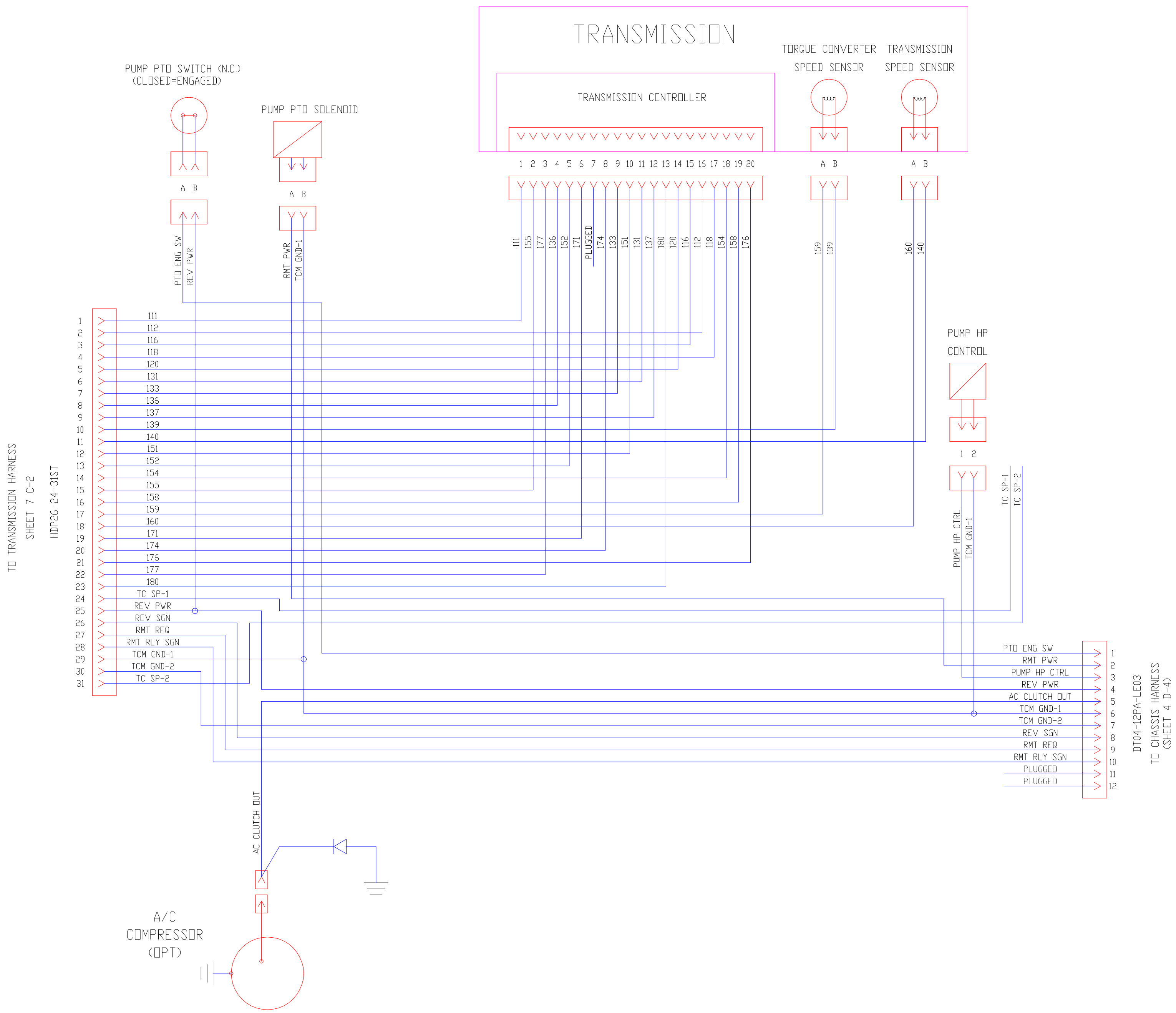
NEXT ASSY 80700003
DO NOT SCALE DRAWING

DRAWN BY: CES
DATE: 30NOV15
CHK'D. BY: RDM
DATE: 30NOV15
E.R. NO. SD3429817
FINISH: N/A
REF. DWG. NONE
MACH. SURF. 125 MAX

GRADALL

TITLE: ELECTRICAL SCHEMATIC, SERIES V ON-HIGHWAY
MATERIAL: N/A
SIZE D | CAGE CODE: | DWG NO. 80709015 | REV -
SCALE: NONE | EST WT: N/A | SHEET: 4 OF 12

DRAWING NUMBER 80709015



ENGINE CONTROLLER LEGEND

SEE SHEET 6 FOR ENGINE CONTROLLER SCHEMATICS

System Information, EMS

1 Start battery (24 V)
2 Main switch
3 Starter motor
4 Alternator
5 Relay module
6 Emergency stop
7 8-pin connector, engine
8 16-pin connector, EATS
9 Dosing valve, EATS injection
10 Connection, circuit breakers
11 Circuit breakers
12 NOX sensor
13 Pre-heater relay
14 14-pin connector, injectors
15 Connection, VGT
16 Connection, EGR
17 Switch, coolant level
18 Temperature, EGR
19 Coolant temperature sensor
20 Throttle sensor
21 Exhaust back pressure
22 Oil pressure sensor
23 Fuel pressure sensor
24 Sensor, oil level/temp
25 Sensor, boost pressure/temp
26 Sensor, differential pressure, EBR
27 Sensor, rail pressure
28 Sensor, air filter indicator (pressure)
29 Sensor, camshaft signal
30 Electric fan
31 Crankshaft signal sensor
32 MPROP
33 PRV
34 Sensor, turbocharger rpm

Cable colors

BL = Blue
LBL = Light blue
BN = Brown
LBN = Light brown
GN = Green
GR = Gray
OR = Orange
P = Pink
R = Red
SB = Black
VO = Violet
W = White
Y = Yellow

Wire cross-sectional area = 0.75 mm² unless otherwise stated.

POWER UNIT

DRAWINGS CREATED IN Pro/ENGINEER.
UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES.

REVISIONS

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD

SPECIFICATIONS
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1

NEXT ASSY 80700003

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.
ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED

THIRD ANGLE PROJECTION

DRAWN BY: CES
DATE: 30NOV15
CHK'D. BY: RDM
DATE: 30NOV15
E.R. NO. SO3429817
FINISH: N/A
REF. DWG. NONE
MACH. SURF. 125 MAX

GRADALL

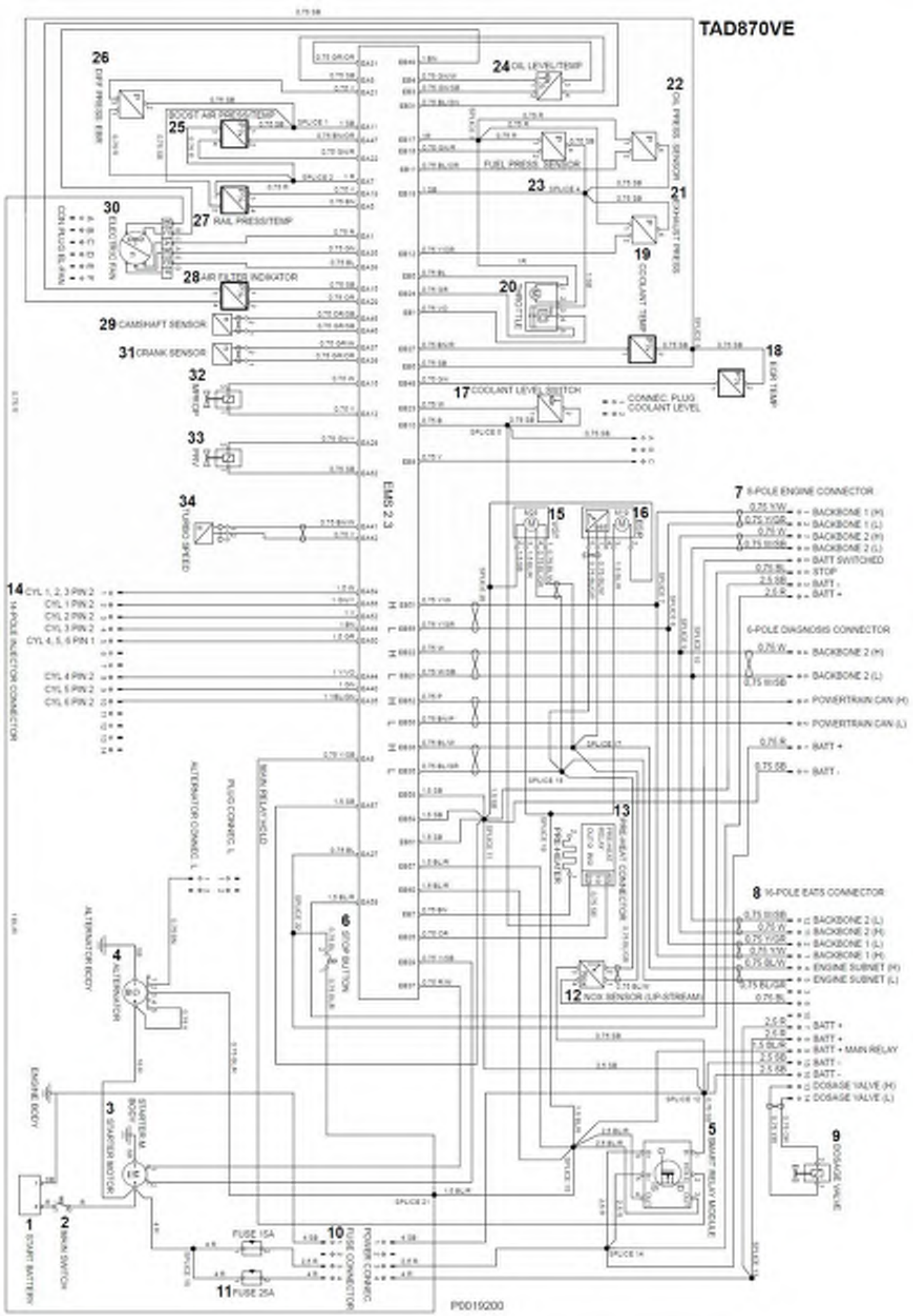
TITLE: ELECTRICAL SCHEMATIC, SERIES V ON-HIGHWAY

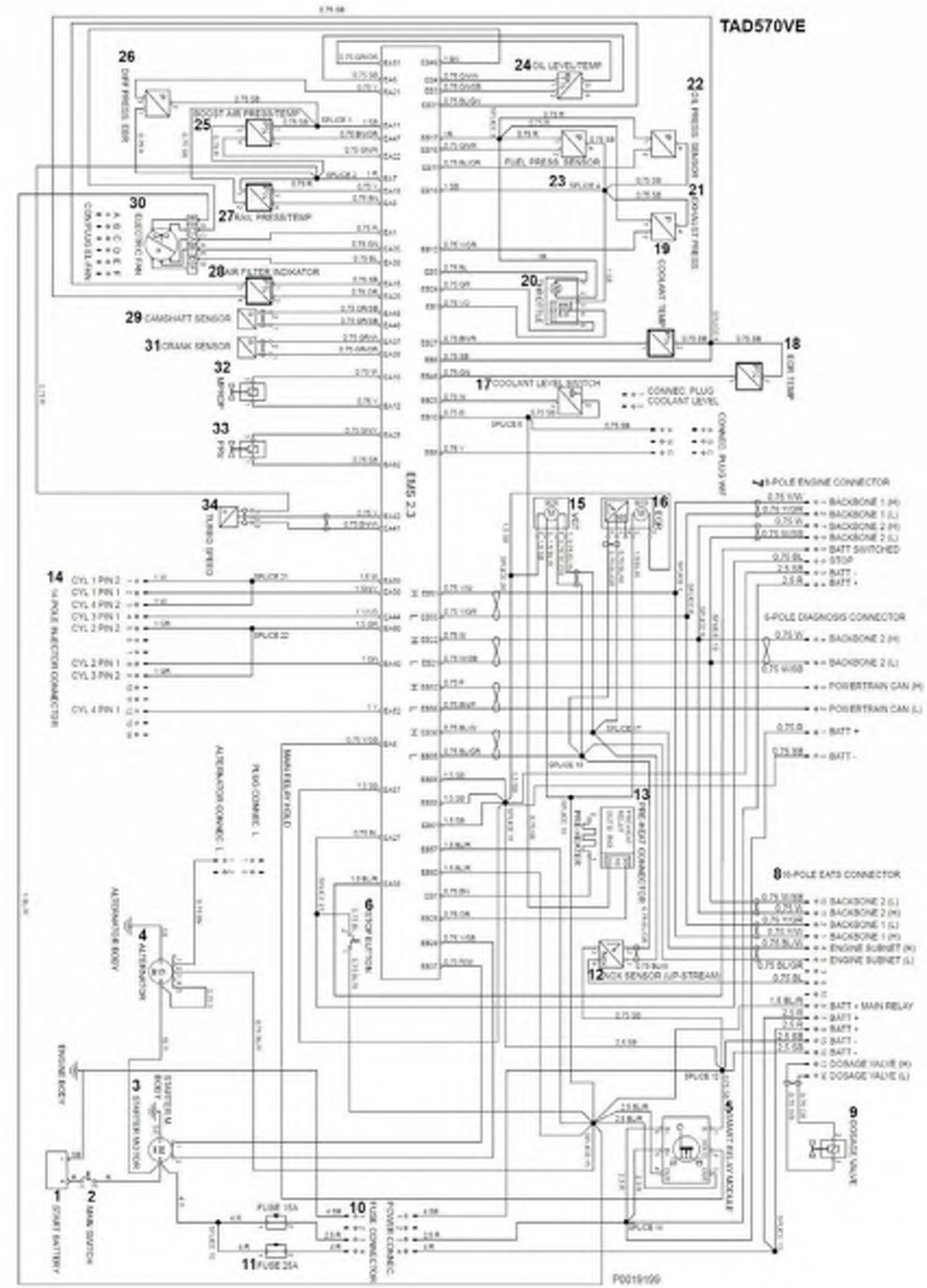
MATERIAL: N/A

SIZE: D | CAGE CODE: | DWG NO. 80709015 | REV -

SCALE: NONE | EST WT: N/A | SHEET 5 OF 12

DRAWING NUMBER 80709015





ENGINE ECU SCHEMATICS

TAD870VE :
6 CYLINDER ENGINES
248 HP
282 HP
315 HP

TAD870VE :
4 CYLINDER ENGINES
215 HP

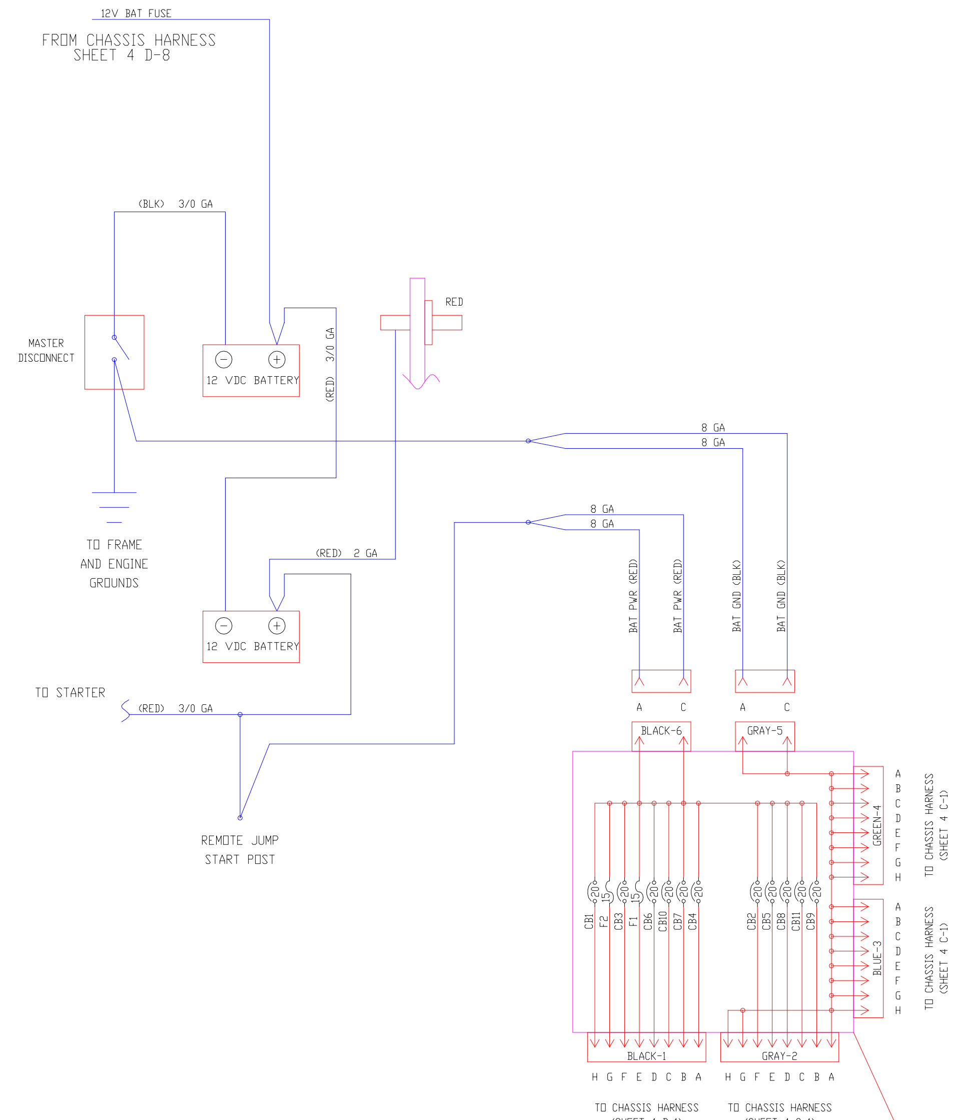
DRAWINGS CREATED IN Pro/ENGINEER.
UNLESS OTHERWISE SPECIFIED, ALL
DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD
				REVISIONS		

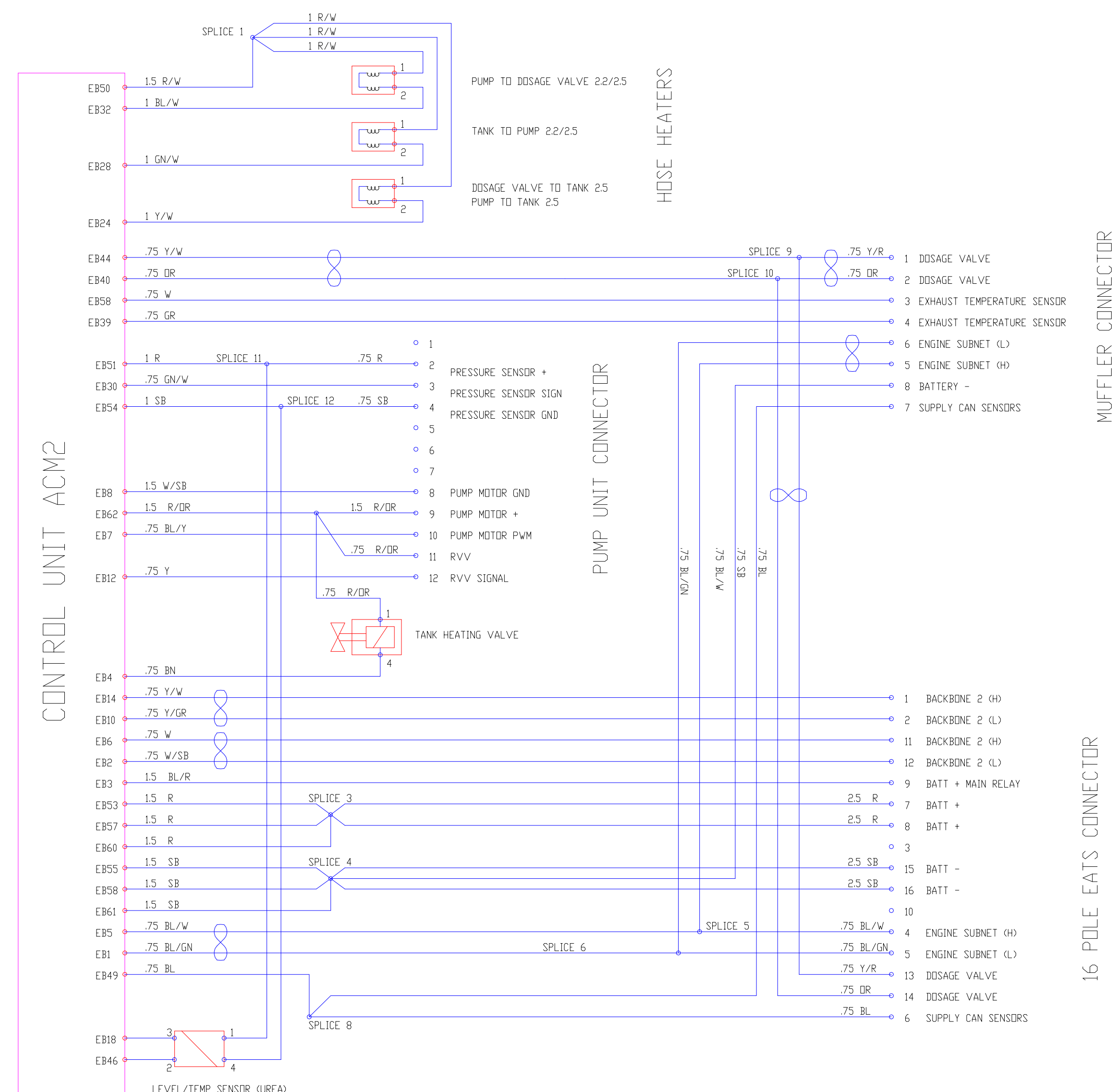
SPECIFICATIONS	UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.	DRAWN BY: CES	GRADALL
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994		DATE: 30NOV15	
ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1	ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED	CHK'D. BY: RDM	TITLE: ELECTRICAL SCHEMATIC, SERIES V ON-HIGHWAY
		DATE: 30NOV15	
		E.R. NO. S03429817	
	THIRD ANGLE PROJECTION	FINISH: N/A	MATERIAL: N/A
NEXT ASSY 80700003		REF. DWG. NONE	SIZE D / CAGE CODE: / DWG NO. 80709015 / REV -
DO NOT SCALE DRAWING		MACH. SURF. 125 MAX	SCALE: NONE / EST WT: N/A / SHEET 6 OF 12

DRAWING NUMBER 80709015 REV. -

DRAWING NUMBER
80709015



BUSSMANN VEC



BUSSMANN FUSE / CIRCUIT BREAKER LEGEND		
CB1	20A	UP PWR 4 (UPPER POWER 4)
CB2	20A	UP PWR 3 (UPPER POWER 3)
CB3	20A	UP PWR 2 (UPPER POWER 2)
CB4	20A	UP PWR 1 (UPPER POWER 1)
CB5	20A	BATT 5 (CHASSIS POWER 5)
CB6	20A	BATT 4 (CHASSIS POWER 4)
CB7	20A	BATT 3 (CHASSIS POWER 3)
CB8	20A	BATT 2 (CHASSIS POWER 2)
CB9	20A	BATT 1 (CHASSIS POWER 1)
CB10	20A	NOT USED
CB11	20A	NOT USED
F1	15A	SP PWR 2 (SPARE POWER 2)
F2	15A	SP PWR 1 (SPARE POWER 1)

ACM2 PUMP CONTROL UNIT LEGEND	
EB59 (SPLICE 1)	PUMP TO DOSAGE VALVE 2.2/2.5 TANK TO PUMP 2.2/2.5 DOSAGE VALVE TO TANK 2.5 / PUMP TO TANK 2.2
EB32	PUMP TO DOSAGE VALVE 2.2/2.5
EB28	TANK TO PUMP 2.2/2.5
EB24	DOSAGE VALVE TO TANK 2.5 / PUMP TO TANK 2.2
EB44 (SPLICE 9)	DOSAGE VALVE
EB40 (SPLICE 10)	DOSAGE VALVE
EB56	EXHAUST TEMPERATURE SENSOR
EB39	EXHAUST TEMPERATURE SENSOR
EB51 (SPLICE 11)	PRESSURE SENSOR + LEVEL/TEMPERATURE SENSOR (UREA)
EB30	PRESSURE SENSOR SIGNAL
EB54 (SPLICE 12)	PRESSURE SENSOR GND LEVEL/TEMPERATURE SENSOR (UREA)
EB8	PUMP MOTOR GND
EB62	PUMP MOTOR +
EB7 (SPLICE 2)	PUMP MOTOR PWM RVV TANK HEATING VALVE
EB12	RVV SIGNAL
EB4	TANK HEATING VALVE
EB14	BACKBONE 1 (H)
EB10	BACKBONE 1 (L)
EB6	BACKBONE 2 (H)
EB2	BACKBONE 2 (L)
EB3	BATTERY + MAIN RELAY
EB53 (SPLICE 3)	BATTERY +
EB57 (SPLICE 3)	BATTERY +
EB60 (SPLICE 3)	BATTERY +
EB55 (SPLICE 4)	BATTERY -
EB58 (SPLICE 4)	BATTERY -
EB61 (SPLICE 4)	BATTERY -
EB5 (SPLICE 5)	ENGINE SUBNET (H)
EB1 (SPLICE 6)	ENGINE SUBNET (L)
EB49 (SPLICE 8)	SUPPLY CAN SENSORS
EB18	LEVEL/TEMPERATURE SENSOR (UREA)
EB46	LEVEL/TEMPERATURE SENSOR (UREA)

BATTERY BOX SCR CIRCUIT

DRAWINGS CREATED IN Pro/ENGINEER. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD

REVISIONS

SPECIFICATIONS
DIMENSIONING AN TOLERANCING PER ASME Y14.5M-1994
ALL WELDING TO STRUCTURAL WELDCODE-STEEL ANSI/AWS D1.1

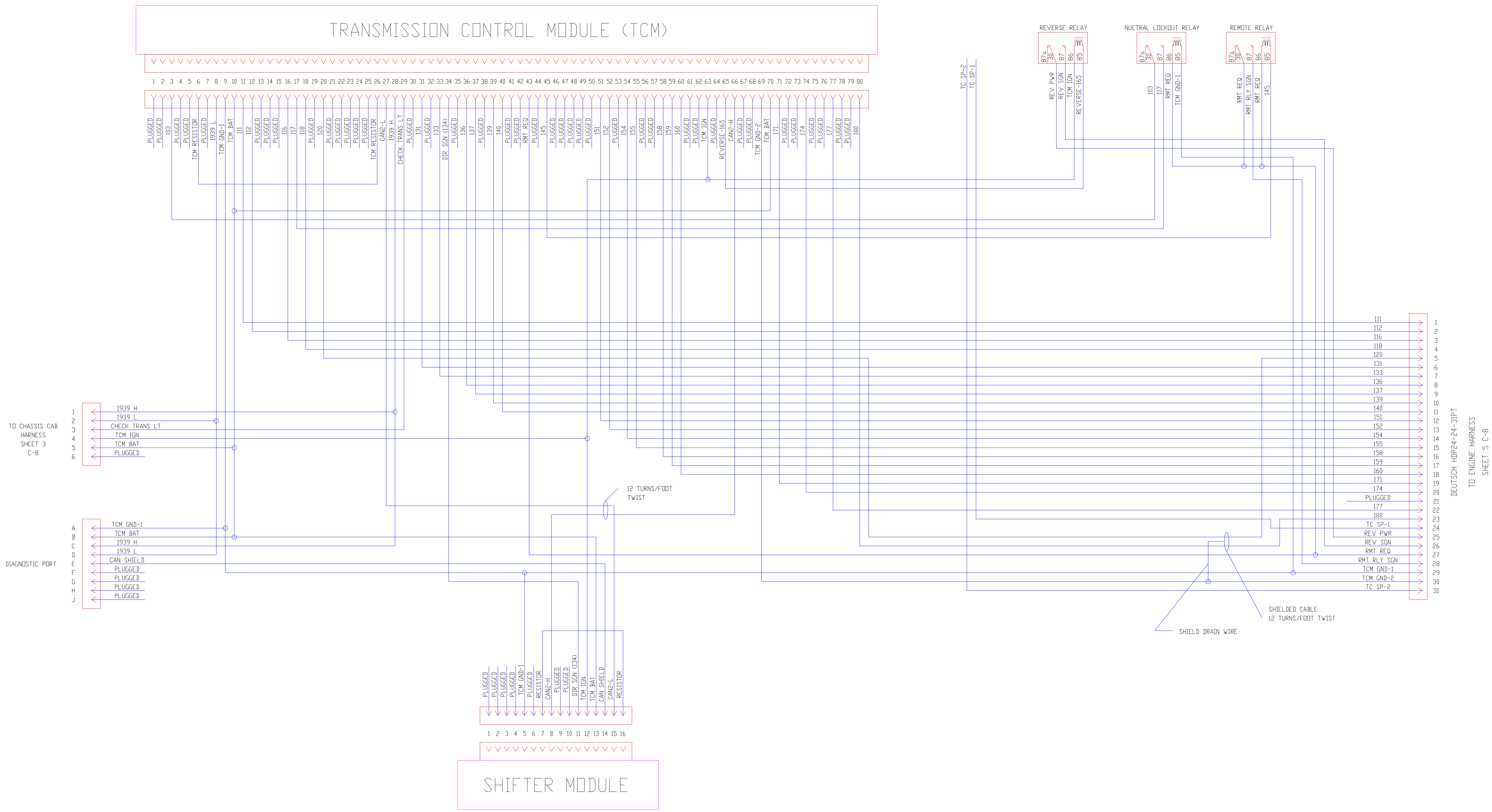
UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.
ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED
THIRD ANGLE PROJECTION

NEXT ASSY 80700003
DO NOT SCALE DRAWING

DRAWN BY: CES
DATE: 30NOV15
CHK'D. BY: RDM
DATE: 30NOV15
E.R. NO. S03429817
FINISH: N/A
REF. DWG. NONE
MACH. SURF. 125 MAX

GRADALL
TITLE: ELECTRICAL SCHEMATIC, SERIES V ON-HIGHWAY
MATERIAL: N/A
SIZE D | CAGE CODE: | DWG NO. 80709015 | REV -
SCALE: NONE | EST WT: N/A | SHEET: 7 OF 12

DRAWING NUMBER
80709015



TRANSMISSION CONTROL CIRCUIT

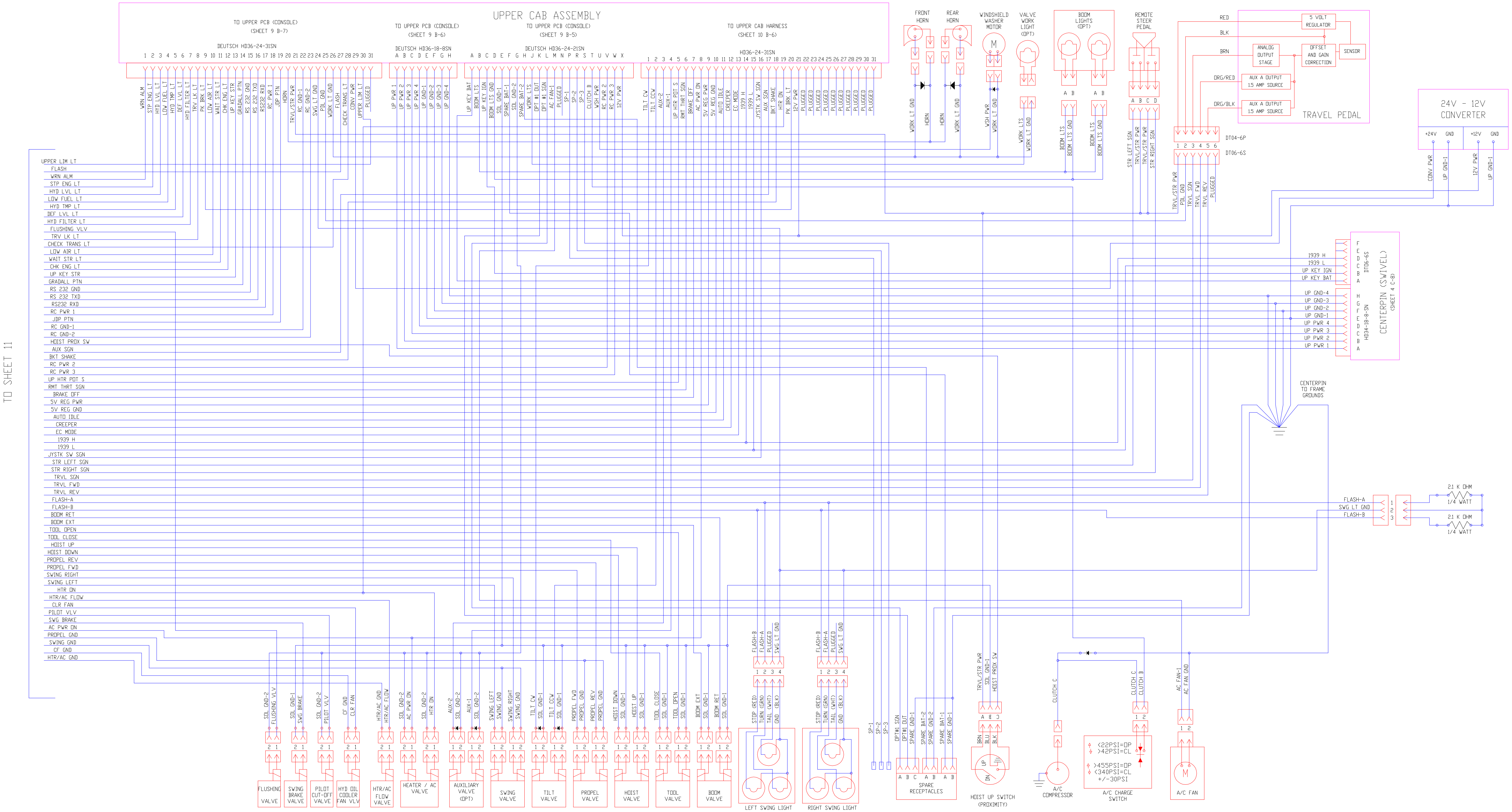
DRAWINGS CREATED IN Pro/ENGINEER. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD

REVISIONS

SPECIFICATIONS			
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994	UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.	DRAWN BY: CES	GRADALL
ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1	ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED	DATE: 30NOV15	TITLE: ELECTRICAL SCHEMATIC, SERIES V ON-HIGHWAY
		CHK'D. BY: RDM	
		DATE: 30NOV15	
		E.R. NO. S03429817	
NEXT ASSY 80700003	THIRD ANGLE PROJECTION	FINISH: N/A	MATERIAL: N/A
		REF. DWG. NONE	SIZE D; CAGE CODE:; DWG NO. 80709015; REV -
DO NOT SCALE DRAWING		MACH. SURF. 125 MAX	SCALE: NONE; EST WT: N/A; SHEET: 8 OF 12

DRAWING NUMBER 80709015



UPPER HARNESS

DRAWINGS CREATED IN Pro/ENGINEER. UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD

REVISIONS

SPECIFICATIONS

DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994

ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1

UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.

ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED

THIRD ANGLE PROJECTION

NEXT ASSY 80700003

DO NOT SCALE DRAWING

DRAWN BY:	CES
DATE:	30NOV15
CHK'D. BY:	RDM
DATE:	30NOV15
E.R. NO.	S03429817
FINISH:	N/A
REF. DWG.	NONE
MACH. SURF. MAX	125

GRADALL

TITLE: ELECTRICAL SCHEMATIC, SERIES V ON-HIGHWAY

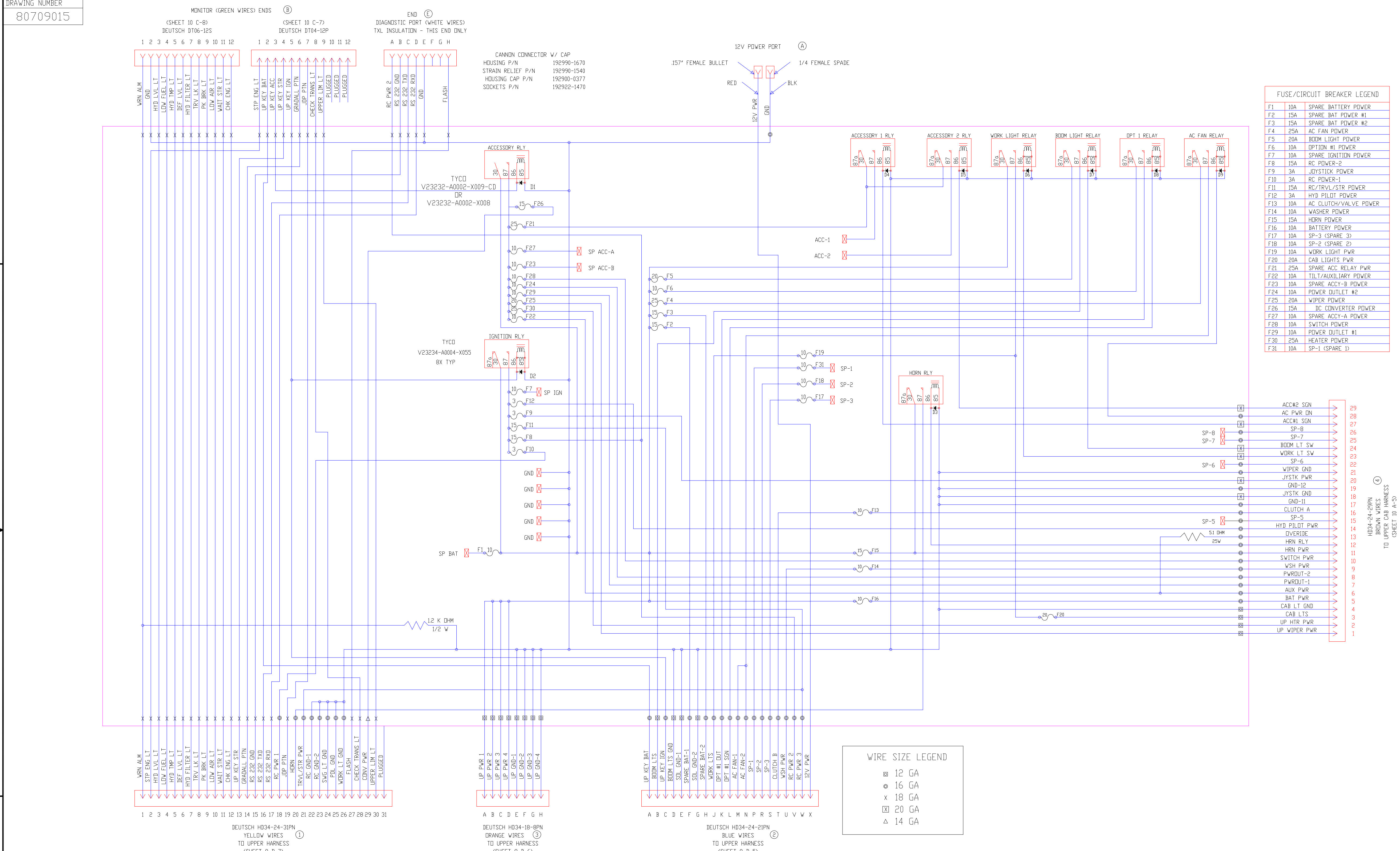
MATERIAL: N/A

SIZE: D | CAGE CODE: | DWG NO. 80709015 | REV -

SCALE: NONE | EST WT: N/A | SHEET: 9 OF 12

DRAWING NUMBER 80709015 REV. -

DRAWING NUMBER 80709015



FUSE/CIRCUIT BREAKER LEGEND		
F1	10A	SPARE BATTERY POWER
F2	15A	SPARE BAT POWER #1
F3	15A	SPARE BAT POWER #2
F4	25A	AC FAN POWER
F5	20A	BOOM LIGHT POWER
F6	10A	OPTION #1 POWER
F7	10A	SPARE IGNITION POWER
F8	15A	RC POWER-2
F9	3A	JOYSTICK POWER
F10	3A	RC POWER-1
F11	15A	RC/TRVL/STR POWER
F12	3A	HYD PILOT POWER
F13	10A	AC CLUTCH/VALVE POWER
F14	10A	WASHER POWER
F15	15A	HORN POWER
F16	10A	BATTERY POWER
F17	10A	SP-3 (SPARE 3)
F18	10A	SP-2 (SPARE 2)
F19	10A	WORK LIGHT PWR
F20	20A	CAB LIGHTS PWR
F21	25A	SPARE ACC RELAY PWR
F22	10A	TILT/AUXILIARY POWER
F23	10A	SPARE ACCY-B POWER
F24	10A	POWER OUTLET #2
F25	20A	WIPER POWER
F26	15A	DC CONVERTER POWER
F27	10A	SPARE ACCY-A POWER
F28	10A	SWITCH POWER
F29	10A	POWER OUTLET #1
F30	25A	HEATER POWER
F31	10A	SP-1 (SPARE 1)

WIRE SIZE LEGEND	
⊠	12 GA
o	16 GA
x	18 GA
☒	20 GA
△	14 GA

UPPER CIRCUIT BOARD

DRAWINGS CREATED IN Pro/ENGINEER.
UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD

REVISIONS

SPECIFICATIONS
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1

UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.
ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED
THIRD ANGLE PROJECTION

NEXT ASSY: 80700003
DO NOT SCALE DRAWING

DRAWN BY:	CES
DATE:	30NOV15
CHK'D. BY:	RDM
DATE:	30NOV15
E.R. NO.	SO3429817
FINISH:	N/A
REF. DWG.	NONE
MACH. SURF. MAX	125

GRADALL

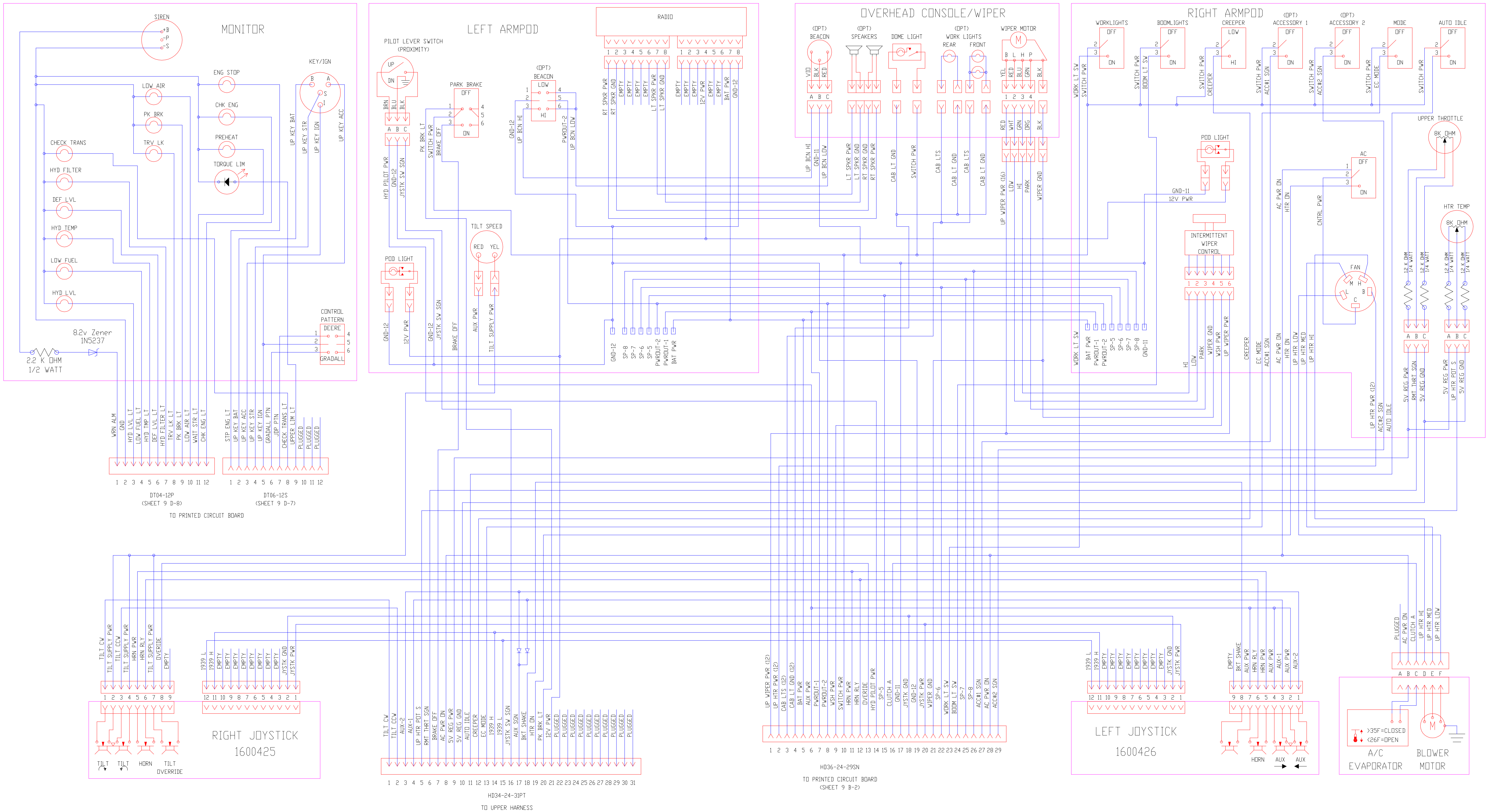
TITLE: ELECTRICAL SCHEMATIC, SERIES V ON-HIGHWAY

MATERIAL: N/A

SIZE	CAGE CODE:	DWG NO.	REV
D		80709015	-

SCALE: NONE | EST WT: N/A | SHEET: 10 OF 12

DRAWING NUMBER 80709015



UPPER CAB

DRAWINGS CREATED IN Pro/ENGINEER.
UNLESS OTHERWISE SPECIFIED, ALL
DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD

REVISIONS

SPECIFICATIONS
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1

UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.
ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED
THIRD ANGLE PROJECTION

NEXT ASSY 80700003

DO NOT SCALE DRAWING

DRAWN BY:	CES
DATE:	30NOV15
CHK'D. BY:	RDM
DATE:	30NOV15
E.R. NO.	S03429817
FINISH:	N/A
REF. DWG.	NONE
MACH. SURF. MAX	125

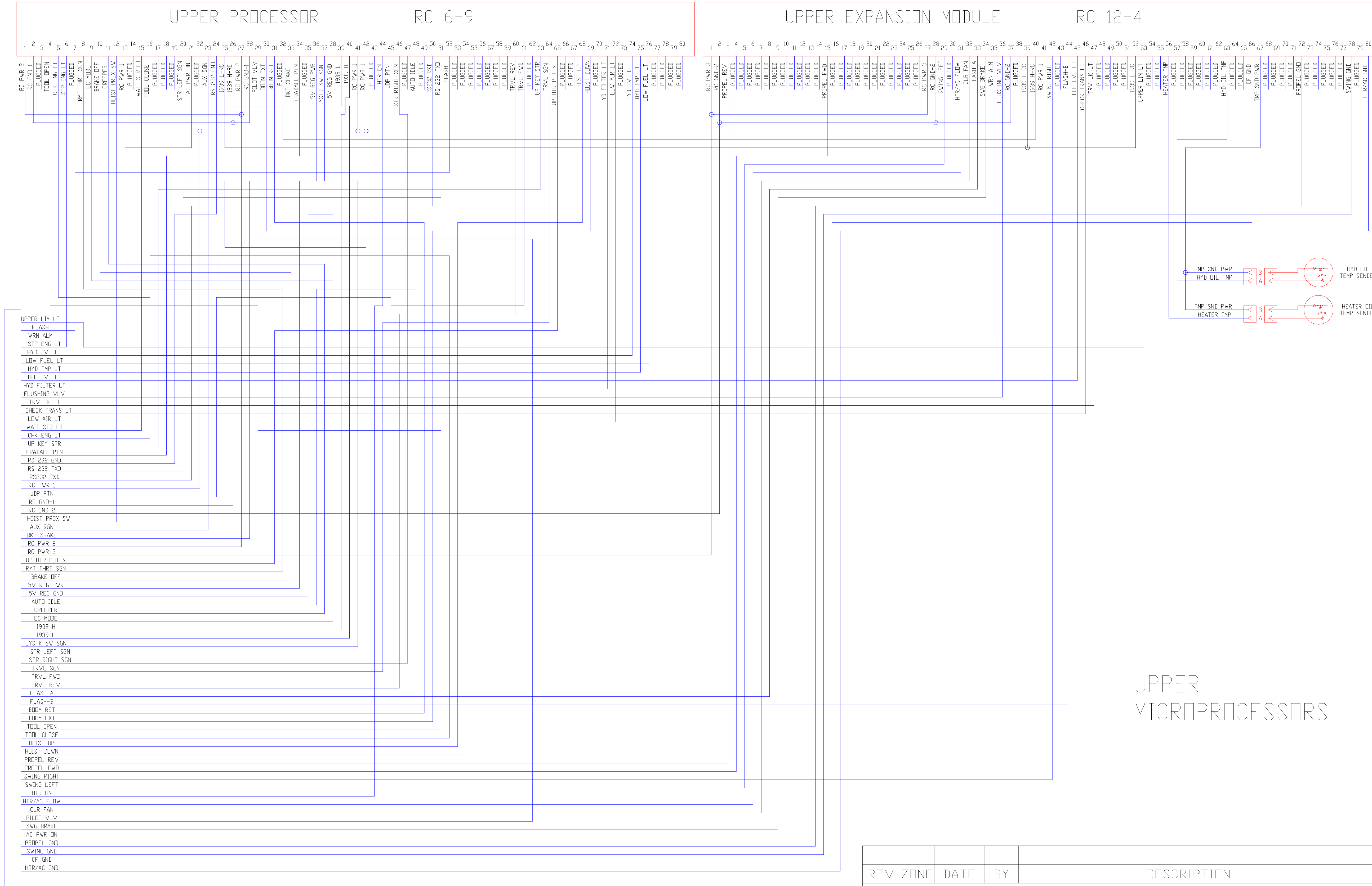
GRADALL

TITLE: ELECTRICAL SCHEMATIC, SERIES V ON-HIGHWAY

MATERIAL: N/A

SIZE D | CAGE CODE: | DWG NO. 80709015 | REV -

SCALE: NONE | EST WT: N/A | SHEET: 11 OF 12

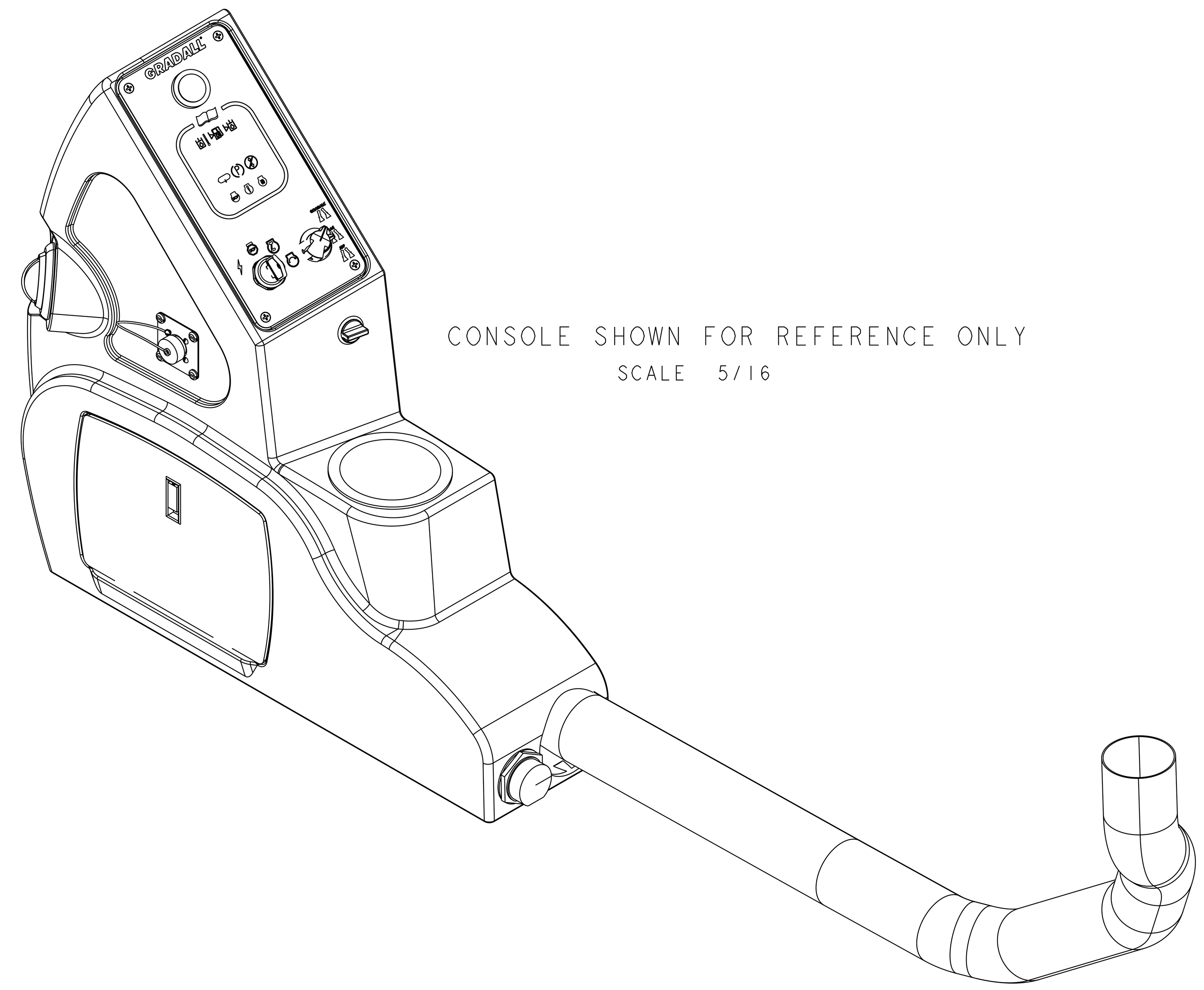


DRAWINGS CREATED IN Pro/ENGINEER.
UNLESS OTHERWISE SPECIFIED, ALL DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	DESCRIPTION	ER NO	CHKD

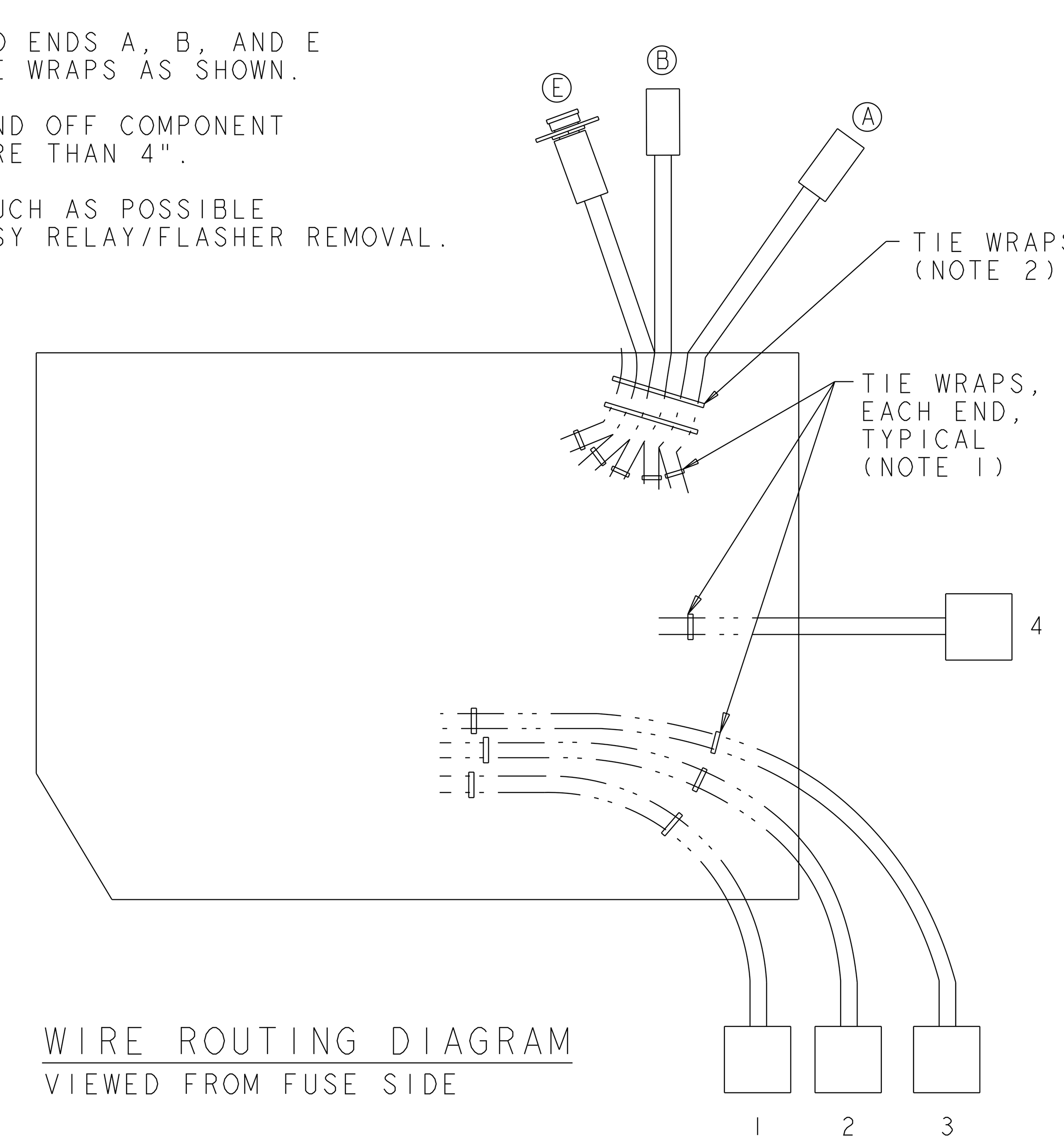
REVISIONS

SPECIFICATIONS	UNLESS OTHERWISE SPECIFIED ALL TOLERANCES ARE AS SHOWN.	DRAWN BY: CES	
DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994	ALL ANGLES ±1° UNLESS OTHERWISE SPECIFIED	DATE: 30NOV15	GRADALL
ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1		CHK'D. BY: RDM	TITLE: ELECTRICAL SCHEMATIC, SERIES V ON-HIGHWAY
	THIRD ANGLE PROJECTION	DATE: 30NOV15	MATERIAL: N/A
NEXT ASSY 80700003		E.R. NO. SO3429817	SIZE D, CAGE CODE:, DWG NO. 80709015, REV -
DO NOT SCALE DRAWING		FINISH: N/A	SCALE: NONE, EST WT: N/A
		REF. DWG. NONE	
		MACH. SURF. 125 MAX	

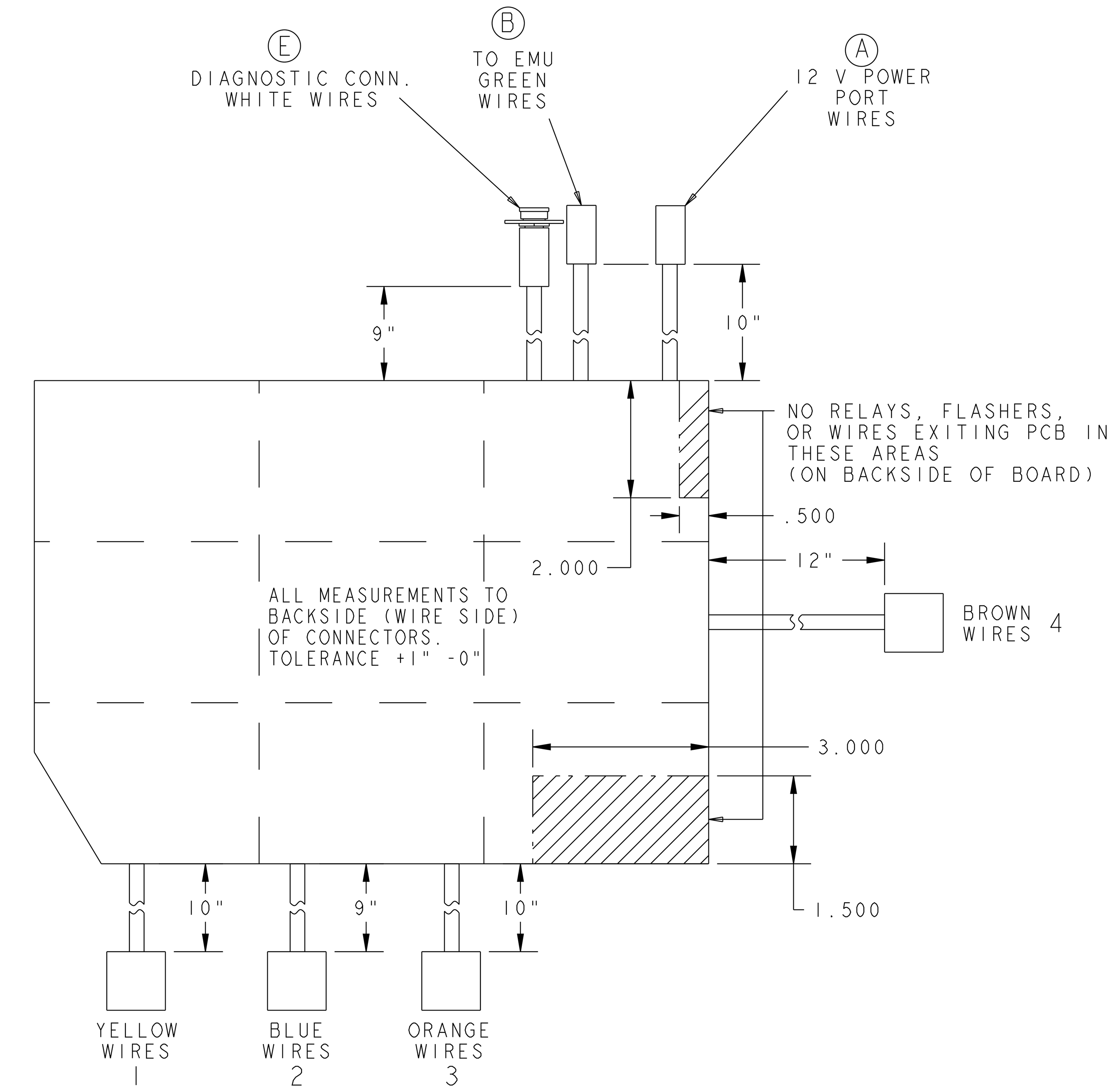


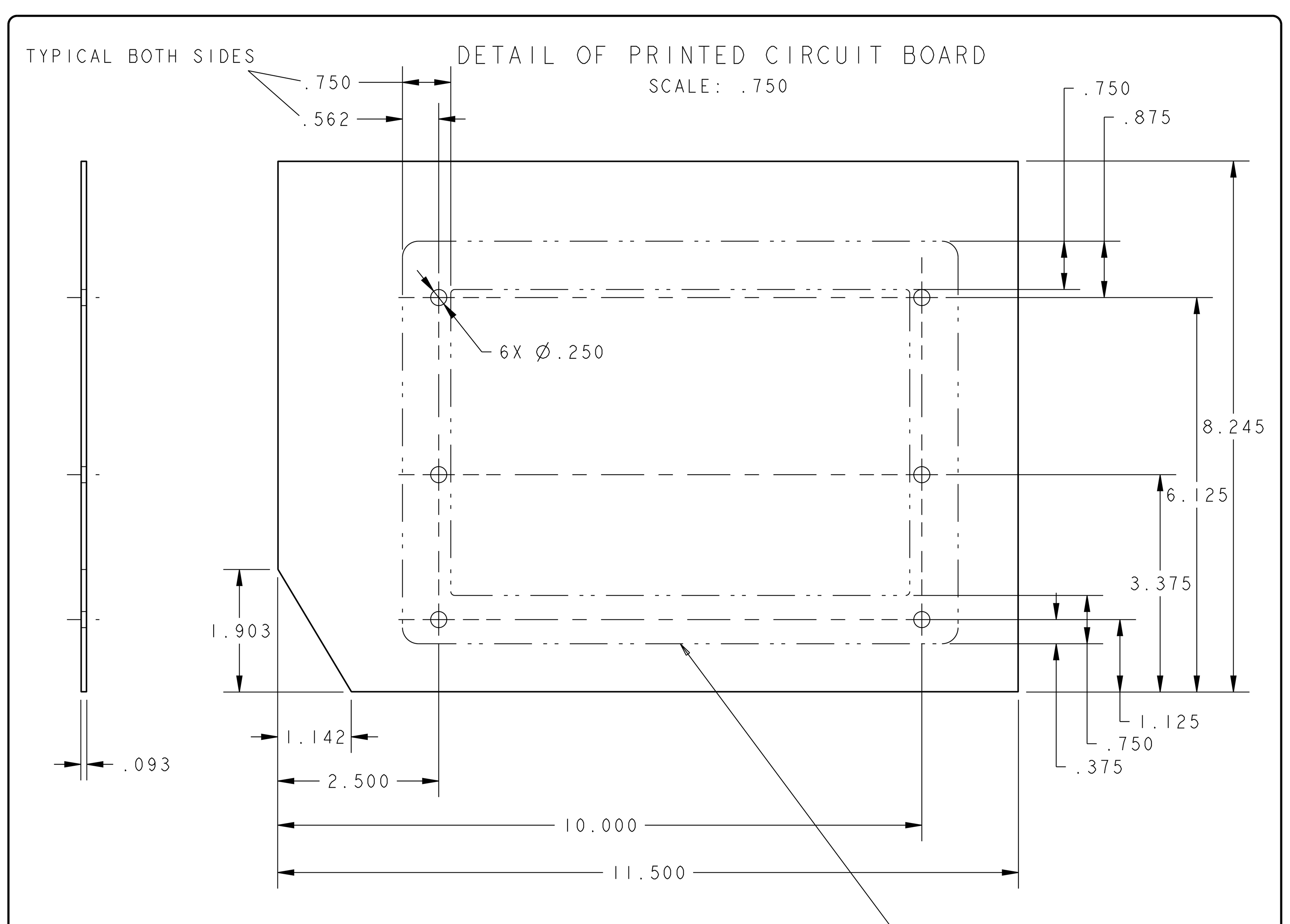
NOTES

1. TIE WRAP WIRES TO EACH END TO MAKE BUNDLES.
2. SECURE BUNDLES TO ENDS A, B, AND E TOGETHER WITH TIE WRAPS AS SHOWN.
3. WIRES NOT TO STAND OFF COMPONENT SIDE OF BOARD MORE THAN 4".
4. ROUTE WIRES AS MUCH AS POSSIBLE TO FACILITATE EASY RELAY/FLASHER REMOVAL.

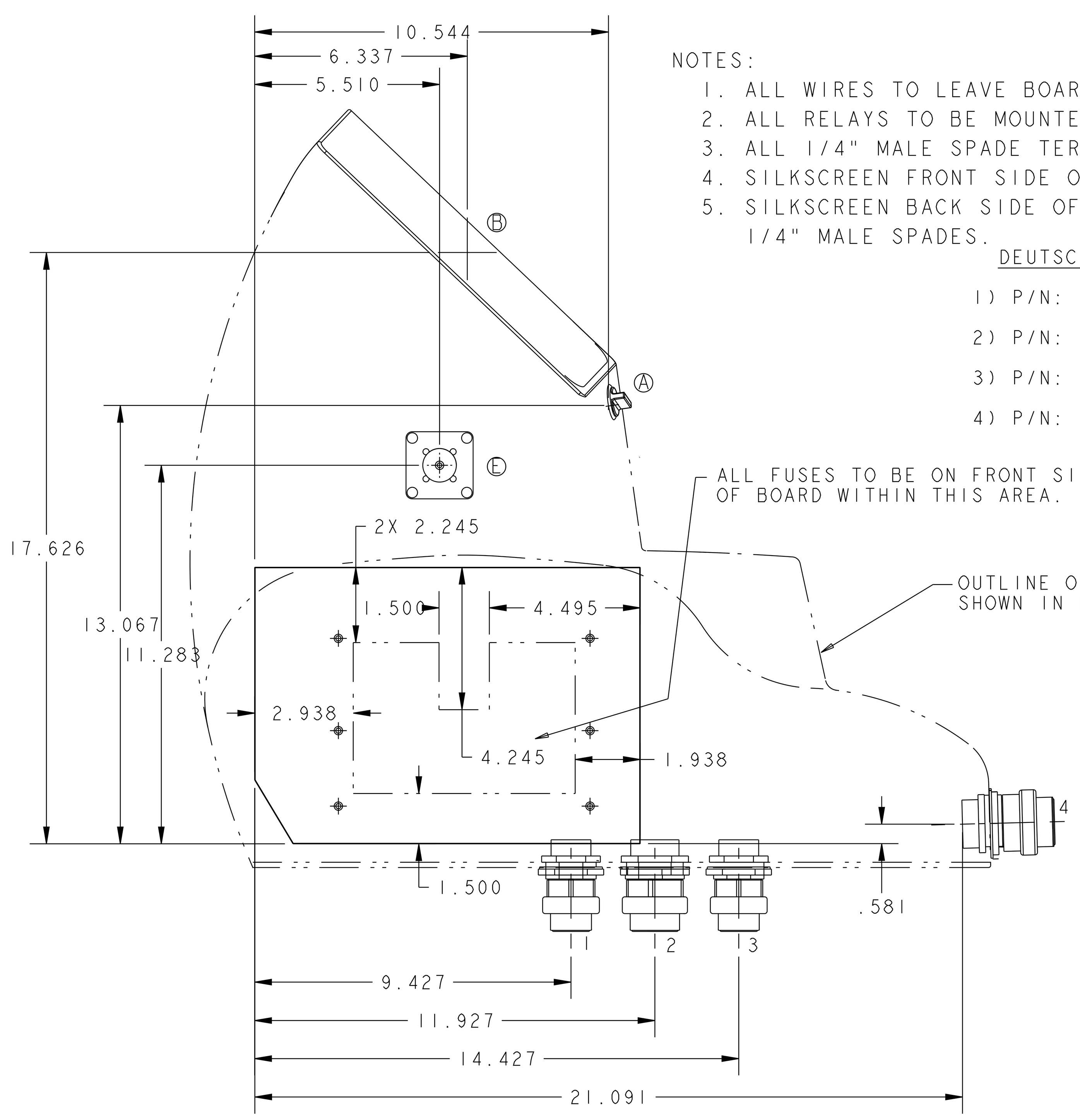


WIRE ROUTING DIAGRAM
VIEWED FROM FUSE SIDE





CONSOLE FLANGE CONTACT AREA. ALL PROTRUDING COMPONENTS AND TERMINAL ENDS ARE TO BE TRIMMED AS CLOSE AS POSSIBLE TO CIRCUIT BOARD IN THIS AREA (FUSE SIDE)



NOTES:
1. ALL WIRES TO LEAVE BOARD ON BACK SIDE.
2. ALL RELAYS TO BE MOUNTED TO BACK SIDE OF BOARD.
3. ALL 1/4" MALE SPADE TERMINALS TO BE ON BACK SIDE OF BOARD.
4. SILKSCREEN FRONT SIDE OF BOARD TO LABEL FUSE NUMBER AND SIZE.
5. SILKSCREEN BACK SIDE OF BOARD TO IDENTIFY ALL RELAYS AND 1/4" MALE SPADES.

	DEUTSCH HD 30 SERIES	PANEL NUT	LOCKWASHER
1)	P/N: HD 34-24-31-PN	112263-90	112264
2)	P/N: HD 34-24-21-PN	112263-90	112264
3)	P/N: HD 34-18-8-PN	114020-90	114021
4)	P/N: HD 34-24-29-PN	112263-90	112264

UNLESS OTHERWISE NOTED:
1) THIS IS A PRO ENGINEER / INTRALINK CONTROLLED DOCUMENT.
2) ALL DIMENSIONS ARE IN INCHES.

REVISIONS

REV	ZONE	DATE	BY	ER NO.	DESCRIPTION	CHKD
B		02SEP14	GTB	EC140295	REV LEVEL UPDATE, SEE SHEET 2	RDM
A		26Feb11	GTB	SO1818056	REV LEVEL UPDATE, SEE SHEET 2	CES

SPECIFICATIONS
1) DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2) ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1
3) ALL DIMENSIONAL TOLERANCES ARE ± .060
4) MACHINE TOLERANCE TO BE ± .015
5) ALL ANGLES ± 1°
6) MACH. SURF. 125 MAX

NEXT ASSY 80765052

DRAWN BY:	RAC
DATE:	14-Jul-10
CHK'D BY:	RDM
DATE:	14-Jul-10
ER NO.:	SO1818056
CAGE CODE:	
SIMILAR TO:	0610178
FINISH COAT REQ:	N

GRADALL

TITLE: PCB, 24V REMOTE UPPER

MATL: .

SIZE E | DWG NO. 80763082 | REV B

SCALE: 1/2 | EST WT: 1.5# | SHEET: 1 OF 2

DRAWING NUMBER 80763082

NOTES:

1. "⊠" SYMBOL DEFINES 1/4" MALE SPADE TERMINAL STANDING OFF PRINTED CIRCUIT BOARD.
2. "◎" SYMBOL DEFINES 16 GUAGE WIRE LEAVING PRINTED CIRCUIT BOARD.
3. "▣" SYMBOL DEFINES 12 GUAGE WIRE LEAVING PRINTED CIRCUIT BOARD.
4. "△" SYMBOL DEFINES 14 GUAGE WIRE LEAVING PRINTED CIRCUIT BOARD.
5. "K|" SYMBOL DEFINES DIODES TO BE IN 4004 OR EQUIVALENT EXCEPT NOTED EXCEPTION.
6. ALL WIRES TO BE SAE J1128 TYPE SXL (EXCEPT THOSE AT END E WHICH ARE TO BE TYPE TXL, AND THOSE AT END B WHICH ARE TO BE TYPE GXL) AND SOLDERED TO PRINTED CIRCUIT BOARD VIA FEEDTHROUGH HOLES.
7. TRACES CARRYING CURRENT ONTO THE BOARD FOR DISTRIBUTION SHALL BE SIZED AT A MINIMUM TO HANDLE THE LESSER OF:
   80 AMPS CONTINUOUS
   OR 80% OF THE SUM OF ALL FUSE VALUES FOR WHICH THAT TRACE SUPPLIES - CONTINUOUSLY RATED
   WITH A MAXIMUM TEMPERATURE RISE OF 20° C.
   BATTERY CIRCUITS FEEDING THE BOARD ARE UP PWR 1, UP PWR 2, UP PWR 3, UP PWR 4.
8. TRACES CARRYING CURRENT TO INDIVIDUAL CIRCUITS OFF-BOARD SHALL BE SIZED AT A MINIMUM TO HANDLE 1.5 TIMES THE VALUE OF THE FUSE ASSOCIATED WITH THAT CIRCUIT OR A MINIMUM OF 20 AMPS (WHICHEVER IS LARGER), CONTINUOUSLY RATED, WITH A MAXIMUM TEMPERATURE RISE OF 20° C
9. TRACES CARRYING CURRENT TO (AND FROM) COMPONENTS ON THE BOARD (SUCH AS RELAYS) SHALL BE SIZED AT A MINIMUM TO HANDLE 1.5 TIMES THE MAXIMUM RATED CONTINUOUS CURRENT ASSOCIATED WITH THAT COMPONENT WITH A MAXIMUM TEMPERATURE RISE OF 20° C.
10. TRACES TO OFF-BOARD CONNECTORS WHOSE CURRENT CARRYING CAPACITY CANNOT READILY BE DETERMINED SHALL BE SIZED (AT A MINIMUM) AS FOLLOWS:

OFF-BOARD WIRE SIZE (AWG)	CONTINUOUS CURRENT
20	15
18	20
16	25
14	30
12	40
10	50
8	70

WITH A MAXIMUM TEMPERATURE RISE OF 20° C

11. GROUND TRACES TO BE AS LARGE AS PRACTICAL, BUT AT A MINIMUM, SHALL BE CAPABLE OF THE FOLLOWING WITH A MAXIMUM TEMPERATURE RISE OF 20$ C.
   - GROUND TRACES LINKING ON-BOARD COMPONENTS SHALL BE SIZED BY CALCULATING ALL COMPONENT CURRENTS CONTRIBUTING TO THAT TRACE AND USING A MULTIPLIER OF 1.5 TO DETERMINE MAXIMUM CURRENT REQUIREMENTS.
   - GROUND TRACES LINKING OFF-BOARD CIRCUITS SHALL USE THE FOLLOWING GUIDELINES:

OFF-BOARD WIRE SIZE (AWG)	CONTINUOUS CURRENT
20	10
18	15
16	20
14	25
12	35
10	45
8	65

   WHERE GROUND TRACES BECOME ADDITIVE, THE MAXIMUM CONTINUOUS GROUND CURRENT SHALL BE 70 AMPS.

   IF REQUIRED, THESE VALUES MAY BE REVIEWED ON A CIRCUIT BY CIRCUIT BASIS BY THE GRADALL COMPANY TO REDUCE THE TRACE SIZES REQUIRED FOR CIRCUITS WHERE BOARD SPACE BECOMES AN ISSUE.

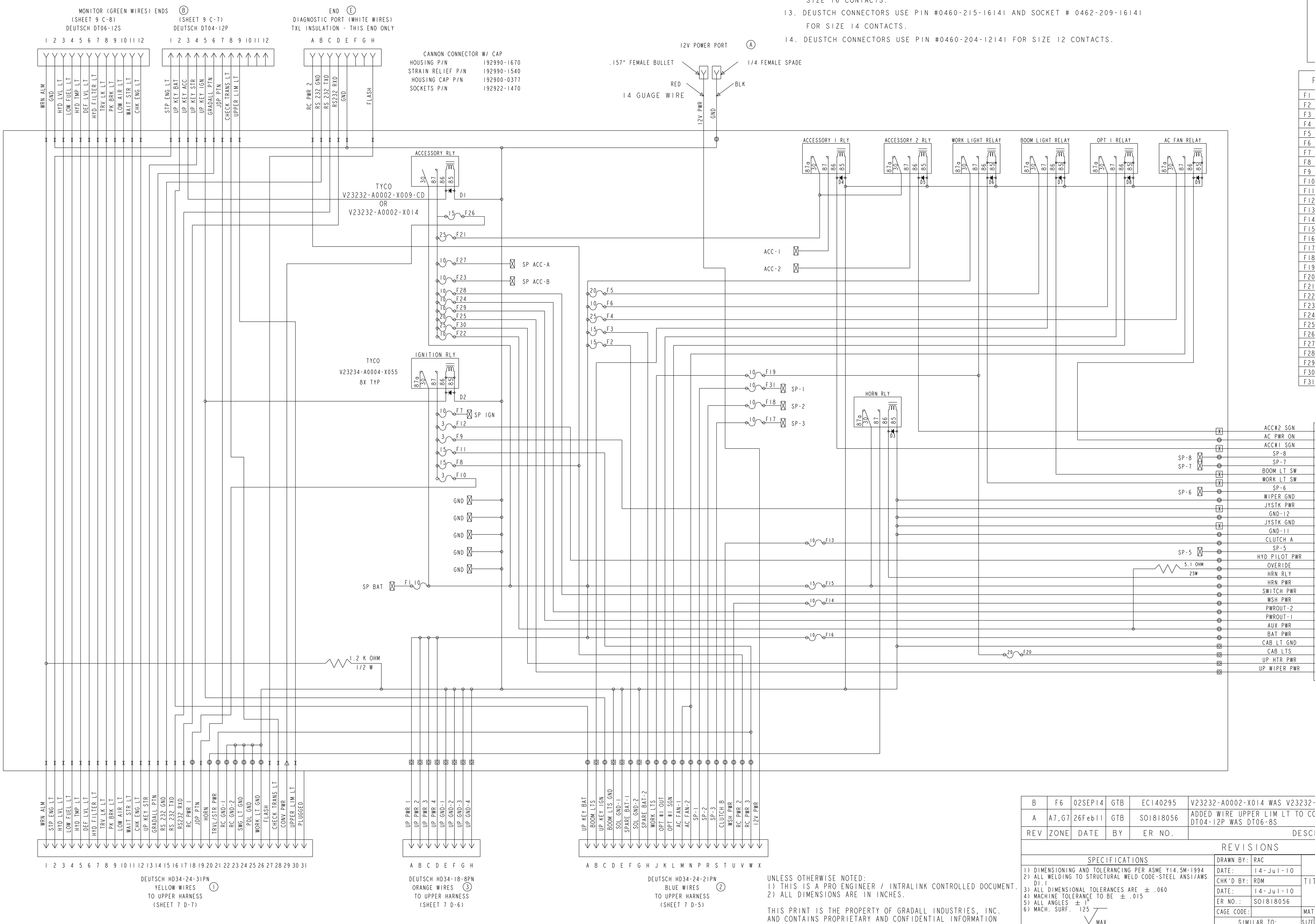
12. DEUTSCH CONNECTORS USE PIN #0460-202-16141 AND SOCKET# 0462-201-16141 FOR SIZE 16 CONTACTS.
13. DEUTSCH CONNECTORS USE PIN #0460-215-16141 AND SOCKET # 0462-209-16141 FOR SIZE 14 CONTACTS.
14. DEUSTCH CONNECTORS USE PIN #0460-204-12141 FOR SIZE 12 CONTACTS.
15. DEUSTCH CONNECTORS USE PIN #0460-202-20141 FOR SIZE 20 CONTACTS.
16. RELAY, FUSE, RESISTOR, AND SPADE DESIGNATIONS AS WELL AS ASSEMBLY PART NUMBER AND REVISION LEVEL TO BE SILKSCREENED ON THE APPROPRIATE SIDES OF THE CIRCUIT BOARD.
17. CONNECTOR ENDS OF ALL WIRES TO BE VISIBLY HOT STAMPED WITH WIRE DESIGNATIONS.

WIRE SIZE LEGEND

- ⊠ 12 GA
- ◎ 16 GA
- x 18 GA
- ⊠ 20 GA
- △ 14 GA

FUSE/CIRCUIT BREAKER LEGEND

F1	10A	SPARE BATTERY POWER
F2	15A	SPARE BAT POWER #1
F3	15A	SPARE BAT POWER #2
F4	25A	AC FAN POWER
F5	20A	BOOM LIGHT POWER
F6	10A	OPTION #1 POWER
F7	10A	SPARE IGNITION POWER
F8	15A	RC POWER
F9	3A	JOYSTICK POWER
F10	3A	RC POWER
F11	15A	RC/TRVL/STR POWER
F12	3A	HYD PILOT POWER
F13	10A	AC CLUTCH/VALVE POWER
F14	10A	WASHER POWER
F15	15A	HORN POWER
F16	10A	BATTERY POWER
F17	10A	SP-3 (SPARE 3)
F18	10A	SP-2 (SPARE 2)
F19	10A	WORK LIGHT PWR
F20	20A	CAB LIGHTS PWR
F21	25A	SPARE ACC RELAY PWR
F22	10A	TILT/AUXILIARY POWER
F23	10A	SPARE ACCY-B POWER
F24	10A	POWER OUTLET #2
F25	20A	WIPER POWER
F26	15A	DC CONVERTER POWER
F27	10A	SPARE ACCY-A POWER
F28	10A	SWITCH POWER
F29	10A	POWER OUTLET #1
F30	25A	HEATER POWER
F31	10A	SP-1 (SPARE 1)



REV	ZONE	DATE	BY	ER NO.	DESCRIPTION	CHKD
B	F6	02SEP14	GTB	EC140295	V23232-A0002-X014 WAS V23232-A0002-X008	RDM
A	A7,G7	26Feb11	GTB	SO1818056	ADDED WIRE UPPER LIM LT TO CONNECTOR 1 POSITION -30, DEUTCH DT04-12P WAS DT06-8S	CES

REVISIONS

UNLESS OTHERWISE NOTED:
1) THIS IS A PRO ENGINEER / INTRALINK CONTROLLED DOCUMENT.
2) ALL DIMENSIONS ARE IN INCHES.

SPECIFICATIONS
1) DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2) ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1
3) ALL DIMENSIONAL TOLERANCES ARE ± .060
4) MACHINE TOLERANCE TO BE ± .015
5) ALL ANGLES ± 1°
6) MACH. SURF. 125 MAX

NEXT ASSY 80765052

DRAWN BY:	RAC
DATE:	14-Jul-10
CHK'D BY:	RDM
DATE:	14-Jul-10
ER NO.:	SO1818056
CAGE CODE:	
SIMILAR TO:	0610178
FINISH COAT REQ:	N

GRADALL

TITLE: PCB, 24V REMOTE UPPER

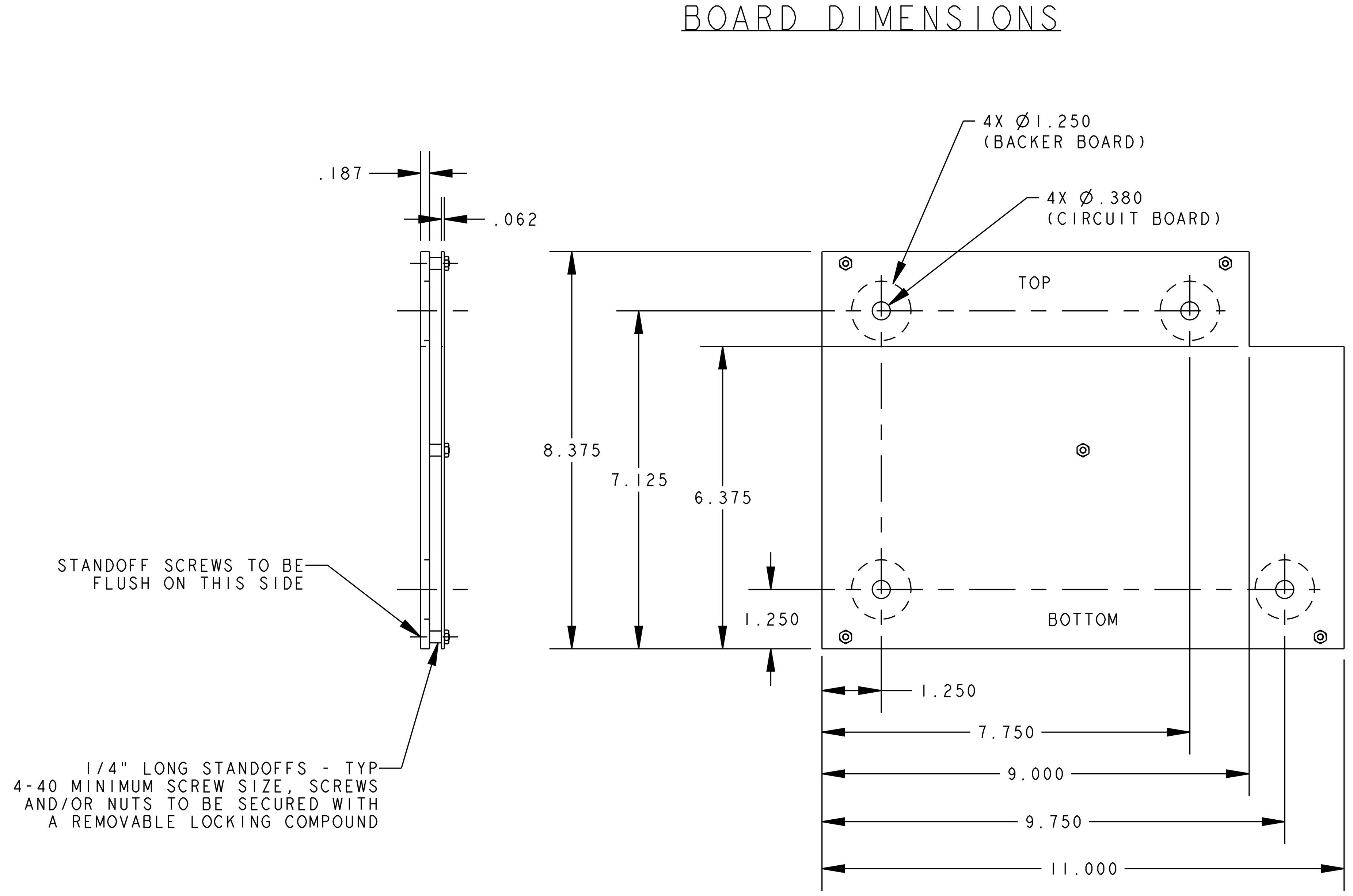
MATL: .

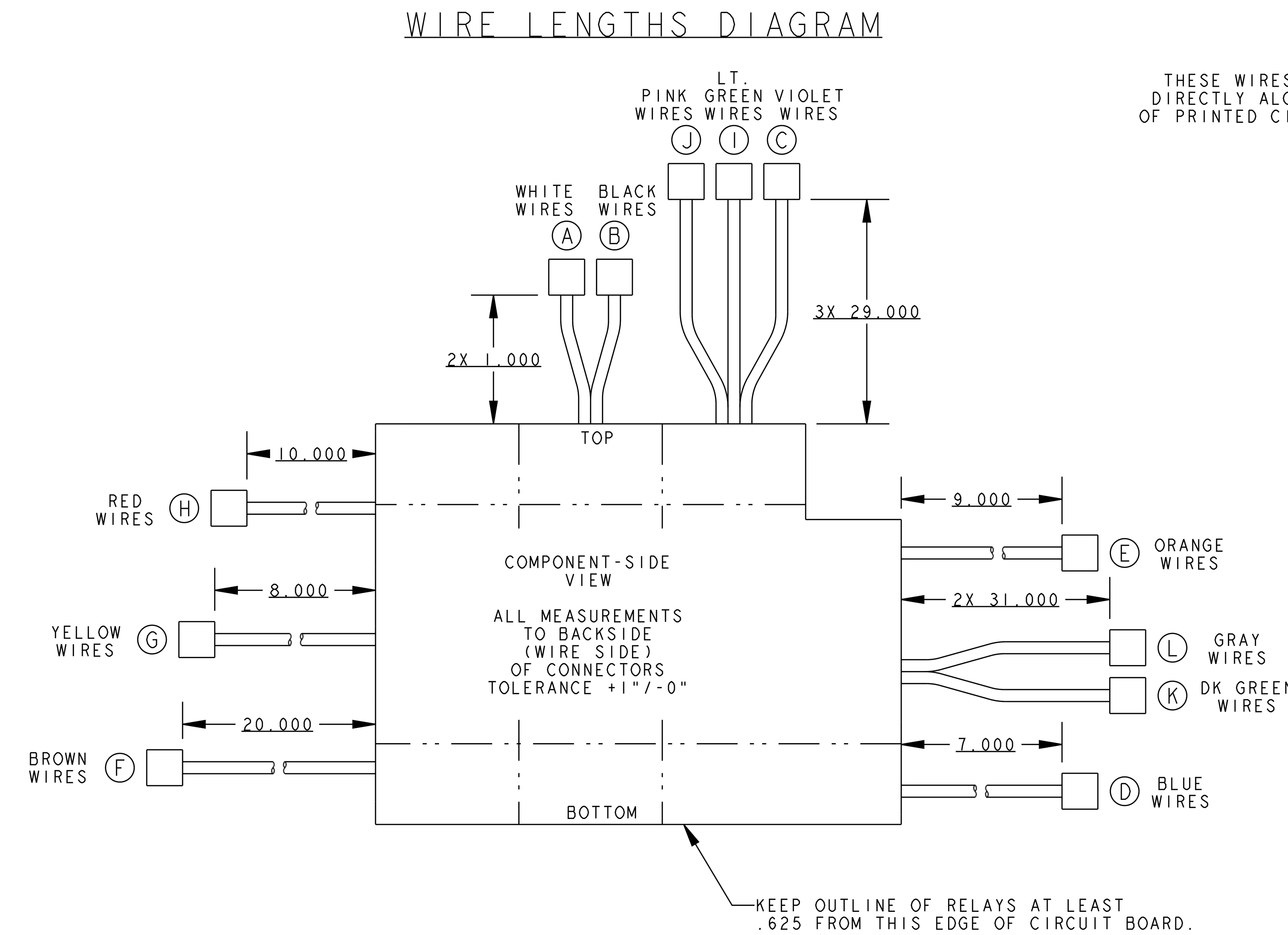
SIZE E | DWG NO. 80763082 | REV B

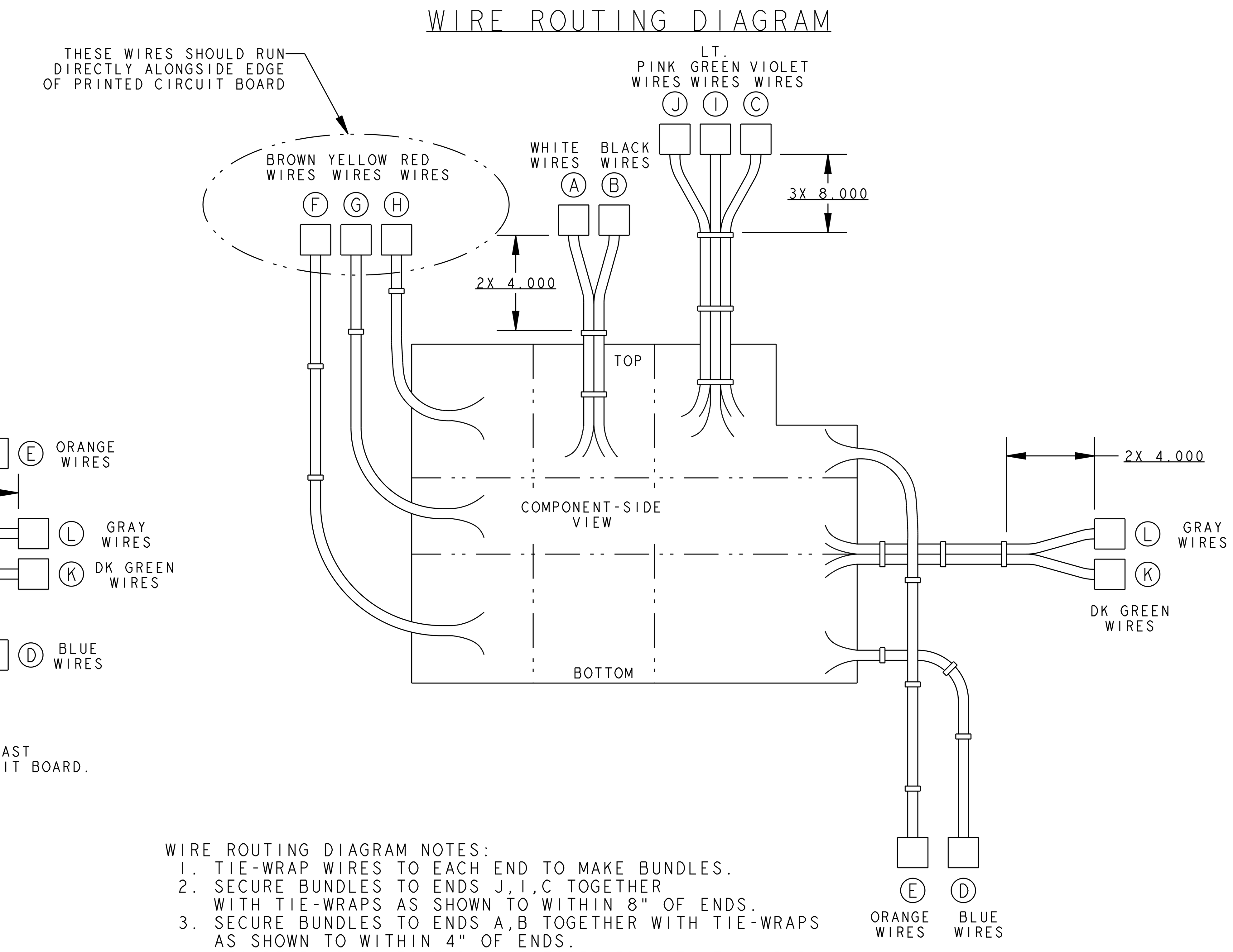
SCALE: 1/2 | EST WT: 1.5# | SHEET: 2 OF 2

DRAWING NUMBER 80783402 REV. A

DRAWING NUMBER
80783402







WIRE ROUTING DIAGRAM NOTES:
1. TIE-WRAP WIRES TO EACH END TO MAKE BUNDLES.
2. SECURE BUNDLES TO ENDS J,I,C TOGETHER WITH TIE-WRAPS AS SHOWN TO WITHIN 8" OF ENDS.
3. SECURE BUNDLES TO ENDS A,B TOGETHER WITH TIE-WRAPS AS SHOWN TO WITHIN 4" OF ENDS.
4. SECURE BUNDLES TO ENDS K,L TOGETHER WITH TIE-WRAPS AS SHOWN TO WITHIN 4" OF ENDS.
5. WIRES NOT TO STAND OFF BOARD MORE THAN 4".
6. ROUTE WIRES AS MUCH AS POSSIBLE TO FACILITATE EASY FUSE, FLASHER AND RELAY REMOVAL.

GENERAL NOTES:
1. "⊵" SYMBOL DEFINES 1/4" MALE SPADE TERMINAL STANDING OFF PRINTED CIRCUIT BOARD.
2. "▭" SYMBOL DEFINES 1/4" FEMALE SPADE TERMINAL STANDING OFF PRINTED CIRCUIT BOARD.
3. "⊵" SYMBOL DEFINES 20 GAUGE WIRE LEAVING PRINTED CIRCUIT BOARD.
4. "⊙" SYMBOL DEFINES 16 GAUGE WIRE LEAVING PRINTED CIRCUIT BOARD.
5. "⊚" SYMBOL DEFINES 12 GAUGE WIRE LEAVING PRINTED CIRCUIT BOARD.
6. WIRE DESIGNATIONS TO BE VISIBLY HOT-STAMPED ON CONNECTOR WIRE ENDS (CLEAR HEAT SHRINK SLEEVES NOT REQ,D.).
7. 20 GAUGE WIRE TO BE TYPE SXL, 7/28 STRANDING, SOLDERED TO PRINTED CIRCUIT BOARD VIA FEED-THROUGH HOLES.
8. 16 GAUGE WIRE TO BE TYPE SXL, 19/29 STRANDING, SOLDERED TO PRINTED CIRCUIT BOARD VIA FEED-THROUGH HOLES.
9. 12 GAUGE WIRE TO BE TYPE SXL, 19/25 STRANDING, SOLDERED TO PRINTED CIRCUIT BOARD VIA FEED-THROUGH HOLES.
10. DIODES WITH NO DESIGNATED TO HAVE A PEAK REPETITIVE REVERSE VOLTAGE (V_{RRM}) OF 400V AND AN AVERAGE FORWARD OUTPUT CURRENT (I_{FAV}) OF 1.0 A
11. DIODES DESIGNATED AS "6A" TO HAVE A PEAK REPETITIVE REVERSE VOLTAGE (V_{RRM}) OF 400V AND AN AVERAGE FORWARD OUTPUT CURRENT (I_{FAV}) OF 6.0 A
12. FUSES TO BE FAST ACTING ATC BLADE TYPE.
13. CIRCUIT BREAKERS TO BE ATC BLADE TYPE, AUTOMATIC RESET.
14. TRACES CARRYING CURRENT ONTO THE BOARD FOR DISTRIBUTION SHALL BE SIZED AT A MINIMUM TO HANDLE THE LESSER OF:
    - 100 AMPS CONTINUOUS.
    - OR 80% OF THE SUM OF ALL FUSE/CIRCUIT BREAKER VALUES FOR WHICH THAT TRACE SUPPLIES - CONTINUOUSLY RATED.
    MAXIMUM TEMPERATURE RISE TO BE 20°C.
    BATTERY CIRCUITS FEEDING THE BOARD ARE BATT 1, BATT 2, BATT 3, BATT 4, AND BATT 5.
15. TRACES CARRYING CURRENT TO INDIVIDUAL CIRCUITS OFF-BOARD SHALL BE SIZED AT A MINIMUM TO HANDLE 1.5 TIMES THE VALUE OF THE FUSE ASSOCIATED WITH THAT CIRCUIT OR A MINIMUM OF 20 AMPS (WHICHEVER IS LARGER), CONTINUOUSLY RATED, WITH A MAXIMUM TEMPERATURE RISE OF 20°C.
16. TRACES CARRYING CURRENT TO (AND FROM) COMPONENTS ON THE BOARD (SUCH AS RELAYS) SHALL BE SIZED AT A MINIMUM TO HANDLE 1.5 TIMES THE MAXIMUM RATED CONTINUOUS CURRENT ASSOCIATED WITH THAT COMPONENT WITH A MAXIMUM TEMPERATURE RISE OF 20°C.
17. TRACES TO OFF-BOARD CONNECTORS WHOSE CURRENT CARRYING CAPACITY CANNOT READILY BE DETERMINED SHALL BE SIZED (AT A MINIMUM) AS FOLLOWS:

OFF-BOARD WIRE SIZE (AWG)	CONTINUOUS CURRENT (A)
20	15
18	20
16	25
14	30
12	40
10	50
8	70

MAXIMUM TEMPERATURE RISE TO BE 20°C.

18. GROUND TRACES TO BE AS LARGE AS PRACTICAL, BUT AT A MINIMUM, SHALL BE CAPABLE OF THE FOLLOWING:
    - GROUND TRACES LINKING ON-BOARD COMPONENTS SHALL BE SIZED BY CALCULATING ALL COMPONENT CURRENTS CONTRIBUTING TO THAT TRACE AND USING A MULTIPLIER OF 1.5 TO DETERMINE MAXIMUM CONTINUOUS CURRENT REQUIREMENTS.
    - GROUND TRACES LINKING OFF-BOARD CIRCUITS SHALL USE THE FOLLOWING GUIDELINES:

OFF-BOARD WIRE SIZE (AWG)	CONTINUOUS CURRENT (A)
20	15
18	20
16	20
14	25
12	35
10	45
8	65

WHERE GROUND TRACES BECOME ADDITIVE, THE MAXIMUM CONTINUOUS GROUND CURRENT SHALL BE 80 AMPS.
MAXIMUM TEMPERATURE RISE TO BE 20°C.
IF REQUIRED, THESE VALUES MAY BE REVIEWED ON A CIRCUIT BY CIRCUIT BASIS BY THE GRADALL COMPANY TO REDUCE THE TRACE SIZES REQUIRED FOR CIRCUITS WHERE BOARD SPACE BECOMES AN ISSUE.

19. RELAY, FUSE, CIRCUIT BREAKER, RESISTOR, AND SPADE DESIGNATIONS AS WELL AS ASSEMBLY PART NUMBER AND REVISION LEVEL TO BE SILKSCREENED ON THE COMPONENT SIDE OF THE BOARD.
20. ALL COMPONENTS TO BE MOUNTED TO THE FRONT SIDE OF THE BOARD (OPPOSITE THE BACKER BOARD).
21. ALL WIRE TAKE-OFFS TO LEAVE THE BOARD ON THE COMPONENT SIDE.
22. SEAL WIRE ENTRY AT DIN-TYPE CONNECTORS AT K AND L WITH SILICONE ADHESIVE.
23. WIRE TAKE-OFF LOCATIONS ON THE CIRCUIT BOARD FOR DEUTSCH CONNECTORS SHALL BE GROUPED SO THAT ALL TAKE-OFFS FOR EACH DEUTSCH CONNECTOR ARE IN CLOSE PROXIMITY TO EACH OTHER FOR ORDERLY WIRE BUNDLES.
24. ALL UNDERLINED DIMENSIONS ARE OUT OF SCALE.
25. BOTH SIDES OF CIRCUIT BOARD TO BE CONFORMAL COATED (LESS MOUNTING LOCATIONS).
26. DIELECTRIC GREASE TO BE APPLIED TO ALL RELAY SOCKETS (ALL 5 TERMINALS), FUSE TERMINALS (2 PER FUSE) AND MALE SPADES.
27. MINI-RELAYS TO BE TYCO P/N V23234-A0004-X055 RATED FOR 24V D.C. SYSTEM.

UNLESS OTHERWISE NOTED:
1) THIS IS A PRO ENGINEER / WINDCHILL CONTROLLED DOCUMENT.
2) ALL DIMENSIONS ARE IN INCHES.

REVISIONS

REV	ZONE	DATE	BY	ER NO.	DESCRIPTION	CHKD
A		23FEB16	JPG	EC160084	SEE SHEET 2	RDM

SPECIFICATIONS
1) DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2) ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1
3) ALL DIMENSIONAL TOLERANCES ARE ± .060
4) MACHINE TOLERANCE TO BE ± .015
5) ALL ANGLES ± 1°
6) MACH. SURF. 125 MAX

DRAWN BY:	SEG
DATE:	20-Nov-15
CHK'D BY:	SNM
DATE:	20-Nov-15
ER NO.:	S03429817
CAGE CODE:	
SIMILAR TO:	80783104
FINISH COAT REQ:	N
NEXT ASSY	80785123

GRADALL

TITLE: PCB, 24V CHASSIS CAB, SV
MATL: PURCHASE COMPLETE
SIZE D | DWG NO. 80783402 | REV A
SCALE: 11/32 | EST WT: 12.6# | SHEET: 1 OF 2

DRAWING NUMBER 80783402

FUSE/CIRCUIT BREAKER LEGEND		
CB1	15A	MARKER LIGHTS
CB2	15A	HEADLIGHTS
F1	15A	WIPER
F2	15A	HEATER/BLOWER
F3	10A	RC 4-4 POWER 2
F4	10A	ENG PROC IGN
F5	10A	TCM IGNITION
F6	10A	SPARE CAB IGNITION
F7	5A	T/R IGN POWER
F8	3A	RC 4-4 POWER 1
F9	10A	SPARE ACCY 1
F10	10A	SPARE ACCY 2
F11	10A	RADIO ACCESSORY
F12	10A	BEACON
F13	10A	THRTL IGN
F14	5A	GAGE POWER
F15	10A	SPARE ENGINE IGN #1
F16	10A	SPARE ENGINE IGN #2
F17	5A	REVERSE SWITCH PWR
F18	10A	DRYER/GRID HTR RLY
F19	5A	IND TEST LIGHT PWR
F20	10A	ENG PROC BAT
F21	10A	TCM BATTERY
F22	10A	TRAVEL/REMOTE SW PWR
F23	10A	NOT USED
F24	20A	SPARE BAT 1
F25	10A	TRV ALM/BACKUP LTS
F26	20A	SPARE BAT 2
F27	10A	FLASHER/STOP LTS
F28	10A	HORNS
F29	10A	REMOTE POWER
F30	10A	WIPER WASHER
F31	10A	AC CLUTCH

WIRE SIZE LEGEND

- ⊠ 12 GA
- o 16 GA
- x 18 GA
- ⊠ 20 GA

UNLESS OTHERWISE NOTED:
1) THIS IS A PRO ENGINEER / WINDCHILL CONTROLLED DOCUMENT.
2) ALL DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	ER NO.	DESCRIPTION	CHKD
A	D5,C7	23FEB16	JPG	EC160084	POSITION "A" ON CONNECTOR "H" WAS CHASSIS LIM LT WIRE. NOW PLUGGED.	RDM

REVISIONS

SPECIFICATIONS
1) DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2) ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1
3) ALL DIMENSIONAL TOLERANCES ARE ± .060
4) MACHINE TOLERANCE TO BE ± .015
5) ALL ANGLES ± 1°
6) MACH. SURF. 125 √ MAX

NEXT ASSY 80785123

DRAWN BY:	SEG
DATE:	20-Nov-15
CHK'D BY:	SNM
DATE:	20-Nov-15
ER NO.:	S03429817
CAGE CODE:	
SIMILAR TO:	80783104
FINISH COAT REQ:	N

GRADALL

TITLE: PCB, 24V CHASSIS CAB, SV

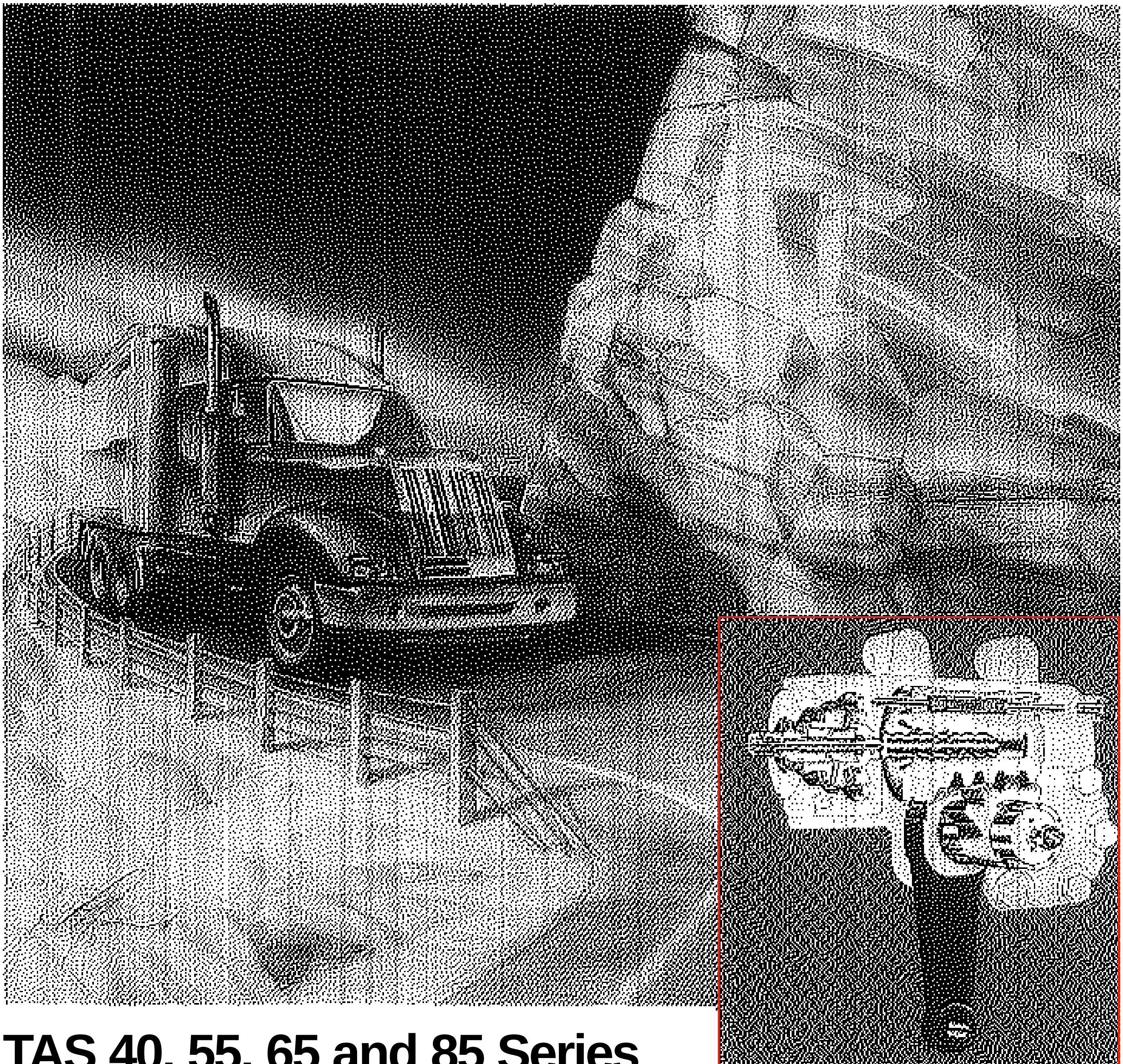
MATL: PURCHASE COMPLETE

SIZE D | DWG NO. 80783402 | REV A

SCALE: 11/32 | EST WT: 12.6# | SHEET: 2 OF 2

TRW Automotive
Steering & Suspension Systems

TAS Steering Gear Service Manual



TAS 40, 55, 65 and 85 Series
Standard Bore/Step Bore

Design Features

1. **Rotary Valve -** This device provides responsive steering control.

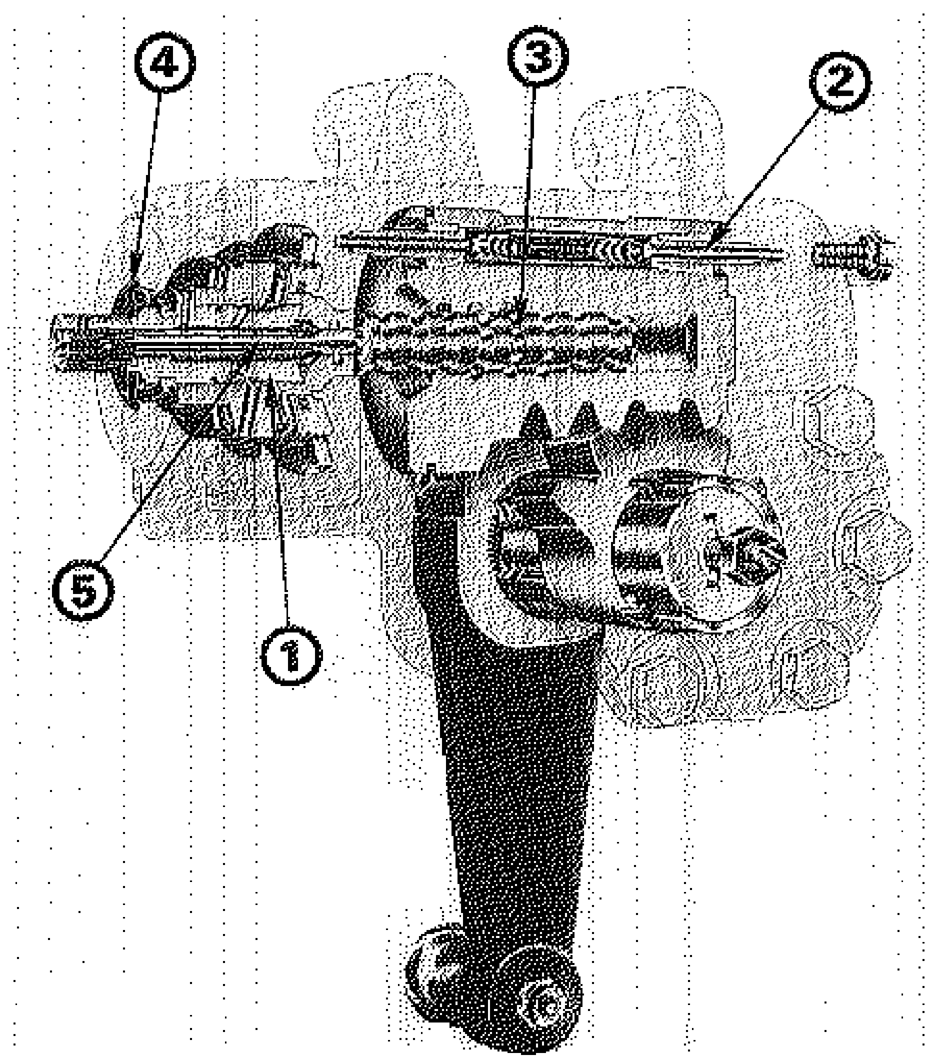
2. **Poppets (optional**)- These unloading valves are automatically set to furnish power steering pump protection and reduce pressure to unload steering linkage at vehicle axle stop settings.

3. **Recirculating Balls** - Combine high mechanical efficiency with smooth operation.

4. **Dirt & Water Seals** - Lip-type seals on both input and output shafts.

5. **Torsion Bar** - Provides positive valve centering with definitive “feel of the road”.

- Relief valves furnish pump protection by limiting maximum pressure (optional).
- Balanced area cylinder so back pressures cannot affect steering stability.
- High temperature seals were developed to withstand temperatures of 250°F.
- Manual steering capability provides for steering control in the event of hydraulic failure.
- Auxiliary porting available for auxiliary cylinder control.
- Seal protectors provide protection from harsh environment conditions.



Hazard Warning Definitions

⚠ WARNING	**A Warning describes hazards or unsafe practices which could result in severe personal injury or death.**
⚠ CAUTION	**A caution describes hazards or unsafe practices which could result in personal injury or product or property damage.**
NOTE	A note gives key information to make following a procedure easier or quicker.

Disclaimer

This Service Manual has been prepared by TRW Commercial Steering Division for reference and use by mechanics who have been trained to repair and service steering components and systems on heavy commercial vehicles. TRW Commercial Steering Division has exercised reasonable care and diligence to present accurate, clear and complete information and instructions regarding the TRW Commercial Steering TAS Series Integral Power Steering Gears. Since this is a general Service Manual, the photographs and illustrations may not look exactly like the steering gear being serviced. The procedures, therefore, must be carefully read and understood before servicing.

If inspection or testing reveals evidence of abnormal wear or damage to the TAS steering gear or if you encounter circumstances not covered in the Manual, **Stop - Consult the vehicle manufacturer's Service Manual and warranty. Do not try to repair or service a TAS steering gear which has been damaged or includes any part that shows excessive wear unless the damaged and worn parts are replaced with original TRW replacement and service parts and the unit is restored to TRW's specifications for the TAS steering gear.**

It is the responsibility of the mechanic performing the maintenance, repairs or service on a particular TAS steering gear to (a) inspect the steering gear for abnormal wear and damage, (b) choose a repair procedure which will not endanger his/her safety, the safety of others, the vehicle, or the safe operation of the vehicle, and (c) fully inspect and test the TAS steering gear and the vehicle steering system to ensure that the repair or service of the steering gear has been properly performed and that the steering gear and system will function properly.

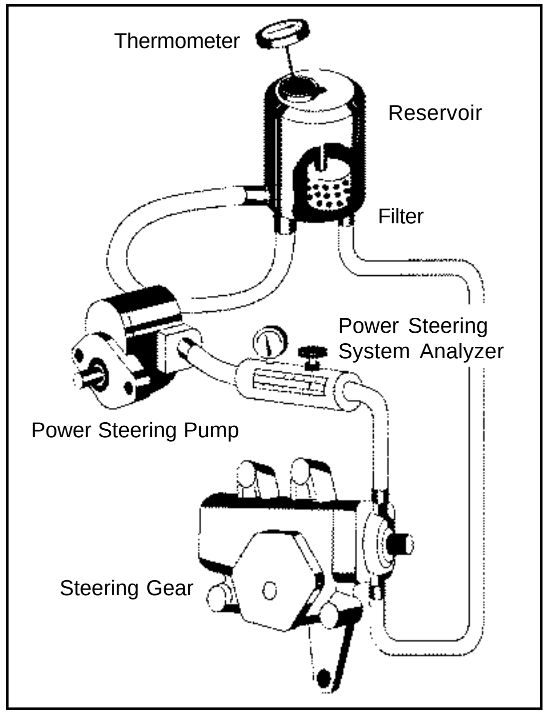
Patents

TRW Commercial Steering Division TAS power steering gears are covered by several United States and foreign patents, either issued or pending.

Chart Your Way to Easy Steering Directory

Chart Your Way to Easy Steering is a separate publication (actually a Manual, Flow Charts and two Videotapes) that facilitates troubleshooting steering system complaints. If while using this tool, your system has failed one or more tests, you probably have been directed to this Service Manual for repairs. The following directory will help you locate the specific repairs you will need to make to proceed with the Chart Your Way to Easy Steering process.

Use Example: The driver of the vehicle you are working on complains of “Steering Wheel Kick”. You have first determined (using Chart Your Way to Easy Steering) that there is no air in the system. The book then directs you to perform test #18 to check for lash in the system. While performing this test you detected lash or lost motion from the input shaft to the output shaft. Since this looseness is inside the steering gear you would refer to this Service Manual and locate the test number of the failed test, test #18. The problem listed below is “Input shaft - Output shaft lash”, and the solution is to make a sector shaft adjustment. You would then proceed to section 3 of this Service Manual and perform the Sector Shaft Adjustment procedure.



Failed Test	Problem	Solution	Section
Test 8	Excessive Internal Leakage	Replace damaged parts / reseal	4
Test 9	Excessive Internal Leakage	Replace damaged parts / reseal	4
Test 11	Intermittent loss of power assist	Reseal	4
Test 12	Air in hydraulic system	Bleed system	3
Test 17	Poppets improperly set	Reset poppets	3
Test 18	Input shaft - Output shaft lash	Adjust sector shaft	3
Test 19	Steering gear misadjusted	Adjust sector shaft first	3
		if required, replace worm assembly	4
Test 28	Gear control valve imbalanced	Replace worm-valve assy / reseal	4
External Leakage	Porosity in housing, side cover or valve assy	Replace porous parts / reseal	4
	Input shaft seal	Replace seal	3
	Output shaft seal	Reseal	4
	Side cover seal, vent plug, bolts, gaskets	Replace parts / reseal	4
	Valve housing sealing area	Remove nicks or replace / reseal	4
	Poppet screw or sealing nut	Replace with poppet adjusting screw kit / Reset poppets	3

Introduction

This new TAS Service Manual replaces all previous editions of TRW's TAS40, 55, 65 and TAS85 Service Manuals.

Changes in the layout of this Service Manual reflect TRW's commitment to provide easily usable material and highly recognizable hazard notices. Some of the major changes are:

- Revised caution and warning definitions that conform to international standards.
- Revised torque, force, pressure and flow notations that conform to international standards.
- Service Manual divided into sections for easier reference.
- Directory for Chart Your Way to Easy Steering users to speed service of correctly diagnosed problems.
- Uninterrupted resealing instructions. Reference to damage section allows you to repair or replace damaged parts and return to the resealing procedures easily.
- Binding process that better allows the Service Manual to lay flat.

The three-column format used in the Service Manual will also help make it easy for you to service a steering gear. Column I illustrates the procedure with photographs, column 2 gives a brief key as well as tools to be used for each procedure, and column 3 explains in detail the procedure you should follow. **Pay special attention to the notes, cautions and warnings.**

Item numbers on the exploded view correspond with item numbers used throughout the Service Manual.

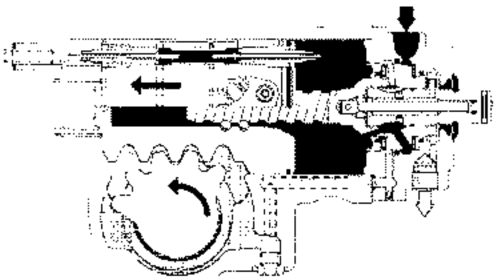
As you gain experience in servicing TAS steering gears, you may find that some information in this Service Manual could be clearer and more complete. If so, let us know about it. Don't try to second-guess the Service Manual; if you do not understand a procedure, or are stuck, contact our Field Service Department at 765.423.5377. Servicing TAS series steering gears should be safe and productive.

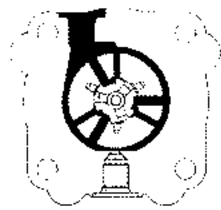
A special thanks to our customers who took the time to review this document prior to printing. It's a better publication because of your effort.

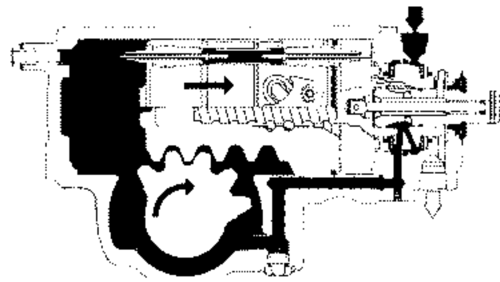
Oil Flow Illustration

Left Hand Lead

Right Hand Lead

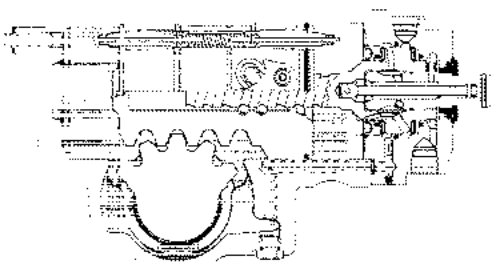


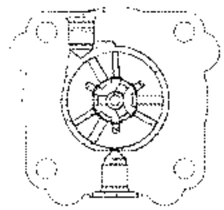


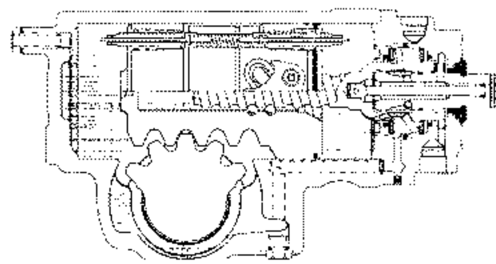


Right Hand Turn

Steering Wheel Input:
Clockwise Rotation

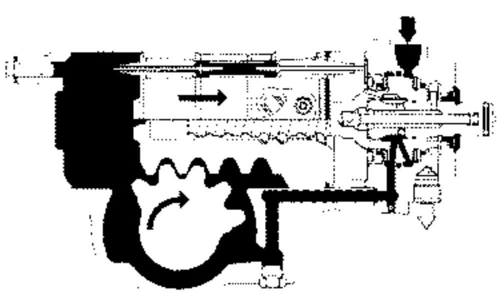


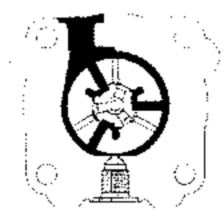


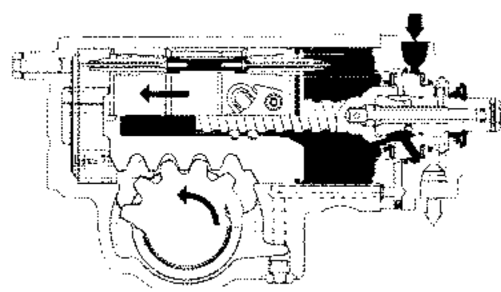


Straightline Running

No Steering Action







Left Hand Turn

Steering Wheel Input:
Counter-Clockwise Rotation

Supply Pressure

Return Pressure

General Design

Integral Power Steering

TAS power steering gears are the latest design in the TRVV Commercial Steering Division family of integral hydraulic power steering gears. Integral hydraulic power steering means that the gear contains a manual steering mechanism, a hydraulic control valve, and a hydraulic power cylinder, all in a single, compact package.

Rotary Control Valve

The rotary control valve combines simplicity of construction with desirable performance characteristics. The speed at which the driver can turn the steering wheel with power assist is dependent upon the pump flow (measured in gallons per minute or liters per minute) directed to a cylinder cavity. The control valve controls flow through the steering gear.

The pressure (measured in pounds per square inch, or bar) required for the gear to steer the vehicle is created by the power steering pump to overcome resistance at the steered wheels. The control valve senses these requirements and directs fluid to the appropriate cylinder cavity in the steering gear (and in the auxiliary cylinder if it is a dual steering system) at the proper flow rate and pressure.

Pressure Means Work, Flow Means Speed

The higher pressure a steering gear can withstand, the more work it can perform. The maximum operating pressure for all TAS gears is 2,175 psi (150 bar), maximum flow rate for all TAS gears is 8 gal/min (30.3 L/min).

The TAS series gears can steer a vehicle within its front-end weight rating through a turn at low speed and engine idle. As the driver turns the steering wheel faster or slower, more or less fluid will be required by the gear. TAS series vehicle front-end weight ratings are as follows:

Gear	Front Axle Rating
TAS40	9,000 lb (4,100 kg)
TAS55	12,000 lb (5,400 kg)
TAS65	14,300 lb (6,500 kg)
TAS85	18,000 lb (8,200 kg)

The recommended minimum flow at 1½ steering wheel turns per second is as follows:

Gear	Minimum Flow Rate
TAS40	2.2 gal/min (8.3 L/min)
TAS55	2.6 gal/min (9.8 L/min)
TAS65	3.0 gal/min (11.4 L/min)
TAS85	3.6 gal/min (13.6 L/min)

If the steering gear valve is controlling an auxiliary cylinder, increased minimum flow is required (generally at least 75%) based on the size of the auxiliary cylinder and the vehicle's steering geometry.

Maximum internal leakage for all TAS gears is 1 gal/min.

General Operation

What Happens During a Steering Maneuver

When the driver turns the steering wheel, he transmits force from the steering wheel to the steering gear input shaft. A torsion bar, pinned at its one end to the input shaft and at its other end to the worm shaft, turns with the input shaft and exerts a rotational force on the worm shaft. In response to this rotational force, the worm shaft, acting through the recirculating ball mechanism, tries to move the rack piston axially through the gear housing cylinder bore.

The rack piston's axial movement is resisted by its engagement to the sector shaft, which is connected by linkage to the steered wheels. Because of this resistance, the torsion bar is twisted by the input shaft, thereby actuating the control valve. Pressurized fluid, directed by the control valve, assists in moving the rack piston axially through the cylinder bore. The rack piston then turns the sector shaft to steer the vehicle.

Shock Loads to the Gear

If the steered wheels receive a shock load, the shock forces are transmitted through the sector shaft to the rack piston, and on to the worm shaft. The internal geometry of the steering gear causes the control valve to send high-pressure fluid to the correct cylinder cavity to resist the shock forces. By absorbing the shock forces hydraulically, the steering gear prevents objectionable kickback at the steering wheel.

Unloading (Poppet) Valves

Most TAS gears are equipped with two unloading valves, one at each end of the rack piston. One valve or the other, depending on the direction of turn, will trip as the steered wheels approach the axle stops (which must be set according to manufacturer's specification). The tripped valve reduces pressure in the gear and helps to reduce heat generated by the pump. At the same time, the valves also reduce forces on the steering linkage. These valves are automatically set to axle stops after installation in vehicle at first full right and left turn.

Relief Valve

Some TAS gears, (with or without poppets), are supplied with a relief valve. The relief valve limits maximum supply pressure to protect the power steering gear, but it does not reduce pressure as the steered wheels approach the axle stops.

Bleed Systems

Some TAS gears which are mounted with the output shaft above the rack piston bore are equipped with either an automatic bleed system or a manual bleed screw.

The procedure for air bleeding the system is on page 17 of this manual. Replacement of damaged automatic bleed plugs, and manual bleed screws is described on page 62.

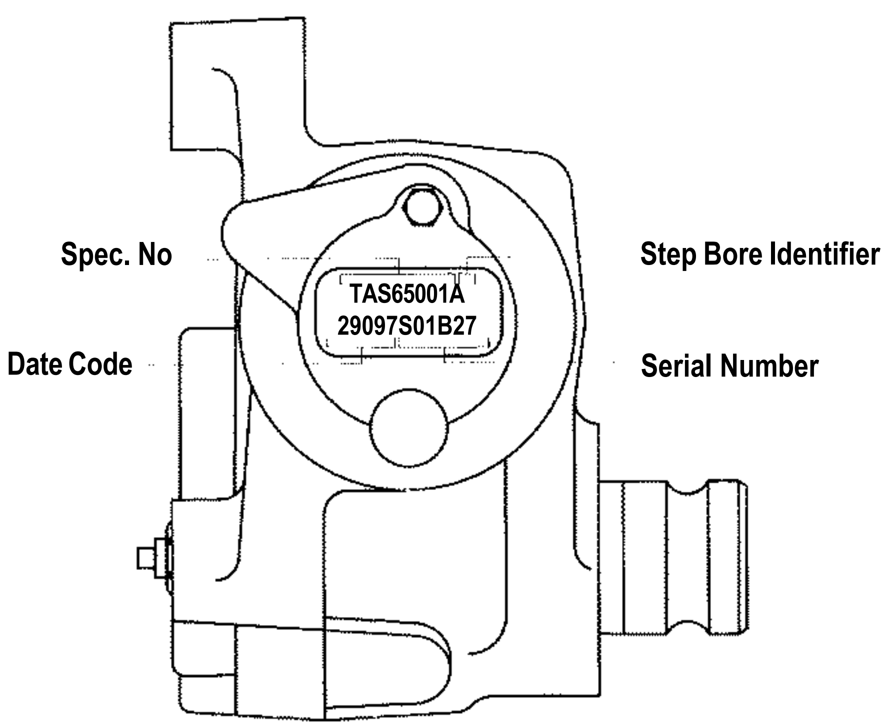
Approved Hydraulic Fluids

Automatic Transmission Fluid Dexron II
Automatic Transmission Fluid Type “E” or “F
Chevron 10W-40
Chevron Custom 10W-40 Motor Oil
Chevron Torque 5 Fluid
Exxon Nuto H32 Hydraulic Fluid
Fleetrite PSF (Can #990625C2)
Ford Spec. M2C138CJ
Mack EO-K2 Engine Oil
Mobil ATF 210
Mobil Super 10W-40 Motor Oil
Premium Blue 2000 - SAE 15VV-40
* Shell Rotella T30W
* Shell Rotella T SAE 30
Texaco 10W-40
Texaco TL-1833 Power Steering Fluid
Union 10W-40
Union 15W-40
Unocal Guardol 15W-40 Motor Oil

The steering system should be kept filled with one of the above fluids. Fluids marked with an asterisk (*) have not been approved for use with TRW’s pump.

WARNING **Completely flush the steering system with one of the recommended fluids above only. Do not mix oil types. Any mixture or any unapproved oil could lead to seal deterioration and leaks. A leak could ultimately cause the loss of fluid, which could result in a loss of power steering assist.**

Specification Numbers



The steering gear specification number and date code are stamped on a machined surface opposite the input shaft of every TAS gear. Newer gears include a serial number.

An example, date code would be 29097; this means the gear was built on the 290th day of 1997.

An “A” included at the end of the specification number indicates a step bore housing.

Torque Chart

Part Name	Item #	Torque Range Dry	Torque Range Lubricated
Auxiliary cylinder plug	54	25-35 lbf•ft (34-48 N•m)	
Ball return guide cap/strap bolts	31	14-22 lbf•ft (19-29 N•m)	
Bearing adjuster	17		11-15 lbf•ft (15-20 N•m)*
Locknut	18		101-122 lbf•ft (137-165 N•m)**
Manual bleed screw	50	40-50 lbf•in. (3.1-3.7 N•m)	
Plug, auto bleed	51	38-58 lbf•ft (52-79 N•m)	
Poppet sleeve assembly	22	16-20 lbf•ft (22-27 N•m)	
Poppet sealing nut, service	60	33-37 lbf•ft (45-50 N•m)	
Poppet fixed stop screw	52	38-42 lbf•ft (52-57 N•m)	
Poppet fixed stop screw	52A	38-58 lbf•ft (52-79 N•m)	
Relief valve cap	56	25-35 lbf•ft (34-48 N•m)	
Sector shaft adjusting screw jam nut	47	40-45 lbf•ft (54-61 N•m)	
Side cover bolts (TAS40)	48		108-128 lbf•ft (147-174 N•m)
Side cover bolts (TAS55, 65, 85)	48		160-180 lbf•ft (217-244 N•m)
Valve housing bolts (TAS40, 55, 65)	1		75-85 lbf•ft (102-115 N•m)
Valve housing bolts (TAS85)	1		108-128 lbf•ft (147-174 N•m)

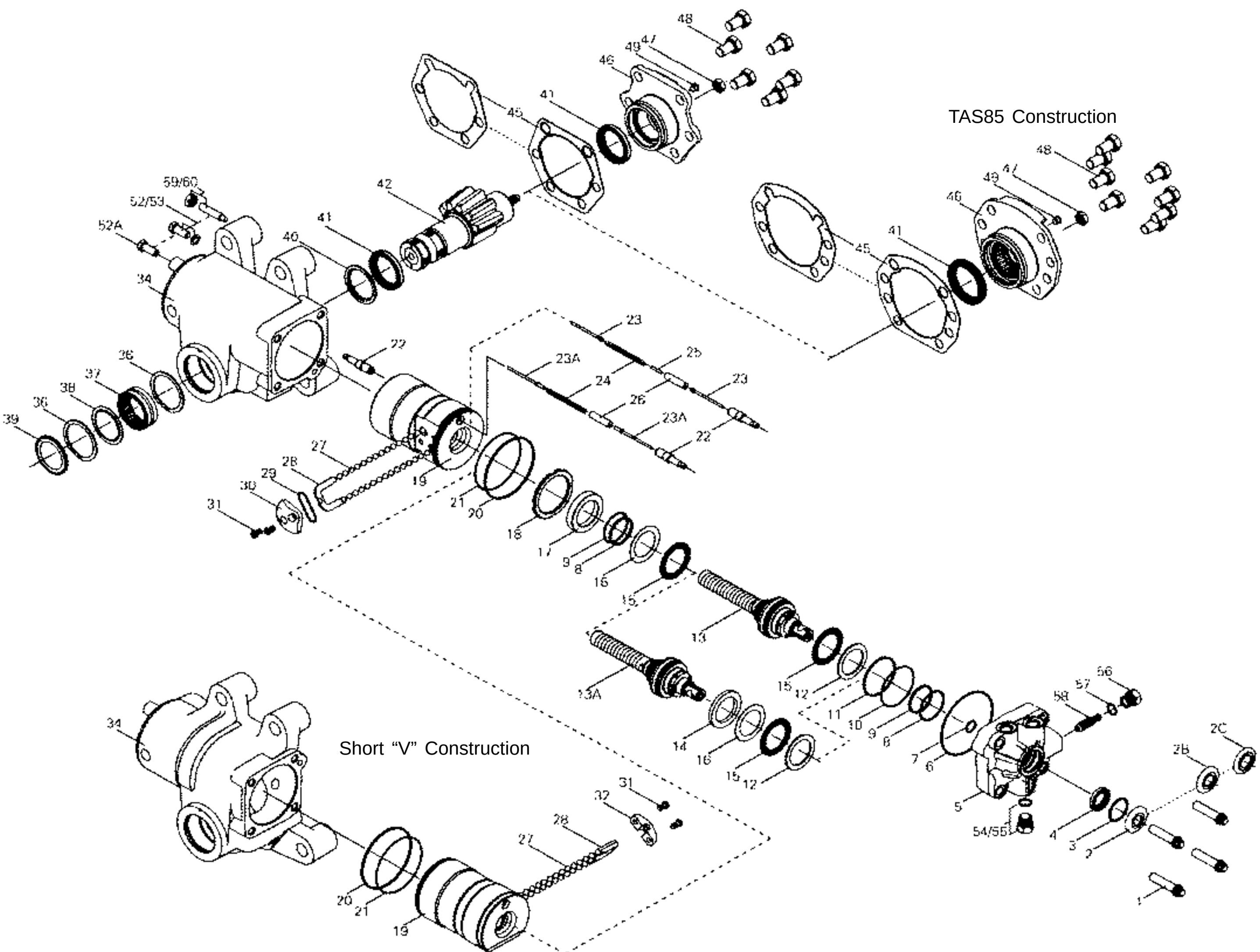
Item numbers referenced are shown on the exploded views, pages 10 and 12.

* After tightening to this torque value, the adjuster must be backed off ¼ to ½ of a turn as described in step 22 on page 57.

** Torque value indicated is using recommended tools.

Special tools can be purchased through:
SPX Corporation
Kent-Moore Tool Group
28635 Mound Road
Warren, MI 48092
1-800-328-6657

TAS Series Exploded View -- Standard



Item	Description
1	Bolts (4-Valve Housing)
*2	Dirt and Water Seal 13/16" Serr.
*2 B	Dirt and Water Seal 7/8" Serr.
*2 C	Dirt and Water Seal 1" Serr.
*3	Retaining Ring
*4	Seal (Input Shaft)
5	Valve Housing
*6	Seal Ring (Valve Housing)
*7	Seal Ring (Valve Housing)
*8	Seal Ring (2)
*9	O-ring (2)
*10	Seal Ring
*11	O-ring (Valve Housing)
12	Thrust Washer (Thick)
13	Input Shaft, Valve, Worm Assy.
13 A	Input Sh., Valve, Worm Assy. (Alt.)
14	Spacer Sleeve (Alt.)
15	Thrust Bearing (1 or 2)
16	Thrust Washer (Thin)
17	Bearing Adjuster
*18	Adjuster Locknut
19	Rack Piston
*20	Teflon Seal Ring
*21	O-ring (Back up; Rack Piston)
22	Poppet Seat and Sleeve Assy. (2)
23	Poppet (2)
24	Poppet Spring
25	Spacer Rod
26	Push Tube
27	Balls
28	Ball Return Guide Halves (2)
*29	Seal (Cap)
30	Ball Return Guide Cap
*31	Torx Screws (2-Cap/Strap)
*32	Ball Return Guide Strap
34	Housing
35	Grease Fitting
36	Retaining Ring (2)
37	Roller Bearing
*38	Dirt Seal
*39	Dirt and Water Seal (Trunnion)
40	Washer (Spacer)
*41	Seal (2-Output)
42	Sector Shaft
43	Adjusting Screw (Sector Shaft)
44	Retainer (Adjusting Screw)
*45	Gasket (Side Cover)
46	Side Cover Assembly
47	Jam Nut
48	Special Bolts (6 or 8-Side Cover)
*49	Vent Plug (Side Cover)
50	Bleed Screw (Manual)
51	Plug (Auto Bleed)
52	Fixed Stop Screw (Poppet)
52A	Fixed Stop Screw (Poppet-Alt)
53	Washer (Stop Screw)
54	Auxiliary Port Plug (2)
*55	O-ring (2-Aux. Port Plug)
56	Relief Valve Cap
*57	O-ring (Relief Valve)
58	Relief Valve (2 piece)
59	Service Poppet Adjusting Screw
60	Service Sealing Jam Nut

* These items are included in complete seal kits along with 406038 lubricant and a service bulletin.

Service Parts List - Standard

Common Parts

Item	Description	Part Number
1	Bolts (4-Valve Housing)	020251
2	Dirt and Water Seal 13/16" Serr.	478044
2B	Dirt and Water Seal 7/8" Serr.	478060
2C	Dirt and Water Seal 1" Ser	478050
3	Retaining Ring	401637
4	Seal (Input Shaft) (High Temp)	478076
7	Seal Ring (Valve Housing)	032823
8	Seal Ring (2)	029123
9	O-ring (2) (High Temp)	032200-158
10	Seal Ring	029116
11	O-ring (Valve Housing) (High Temp)	032200-152
12	Thrust Washer (Thick)	400143
15	Thrust Bearing (2)	070027
16	Thrust Washer (Thin)	400144
17	Bearing Adjuster	400149
18	Adjuster Locknut	027007
27	Balls	213684-X1
29	Seal (Cap)	478042
30	Ball Return Guide Cap	400161
31	Torx Screws (2-Cap/Strap)	020228
32	Ball Return Guide Strap	400167
35	Grease Fitting	037032
43	Adjusting Screw (Sector Shaft)	021200
44	Retainer (Adjusting Screw)	062005
47	Jam Nut	025150
49	Vent Plug (Side Cover)	036201
50	Bleed Screw (Manual)	213705
51	Plug (Auto Bleed)	021397
52A	Fixed stop screw	021426
54	Auxiliary Port Plug (2)	415437-A1
55	O-ring (2-Aux. Port Plug)	032229
57	O-ring (Relief Valve)	032200-153
59	Service Poppet Adjusting Screw	021407
60	Service Sealing Jam Nut	025119

Parts Vary by Specification*

Item	Description
5	Valve Housing
13	Input Shaft, Valve, Worm Assy.
13A	Input Shaft, Valve, Worm Assy. (Alt.)**
14	Spacer Sleeve (Alt.)**
19	Rack Piston
34	Housing
42	Sector Shaft
46	Side Cover Assembly
56	Relief Valve Cap
58	Relief Valve (2 piece)

*Contact Service/Sales for part numbers
**Applicable to TAS65 gears only

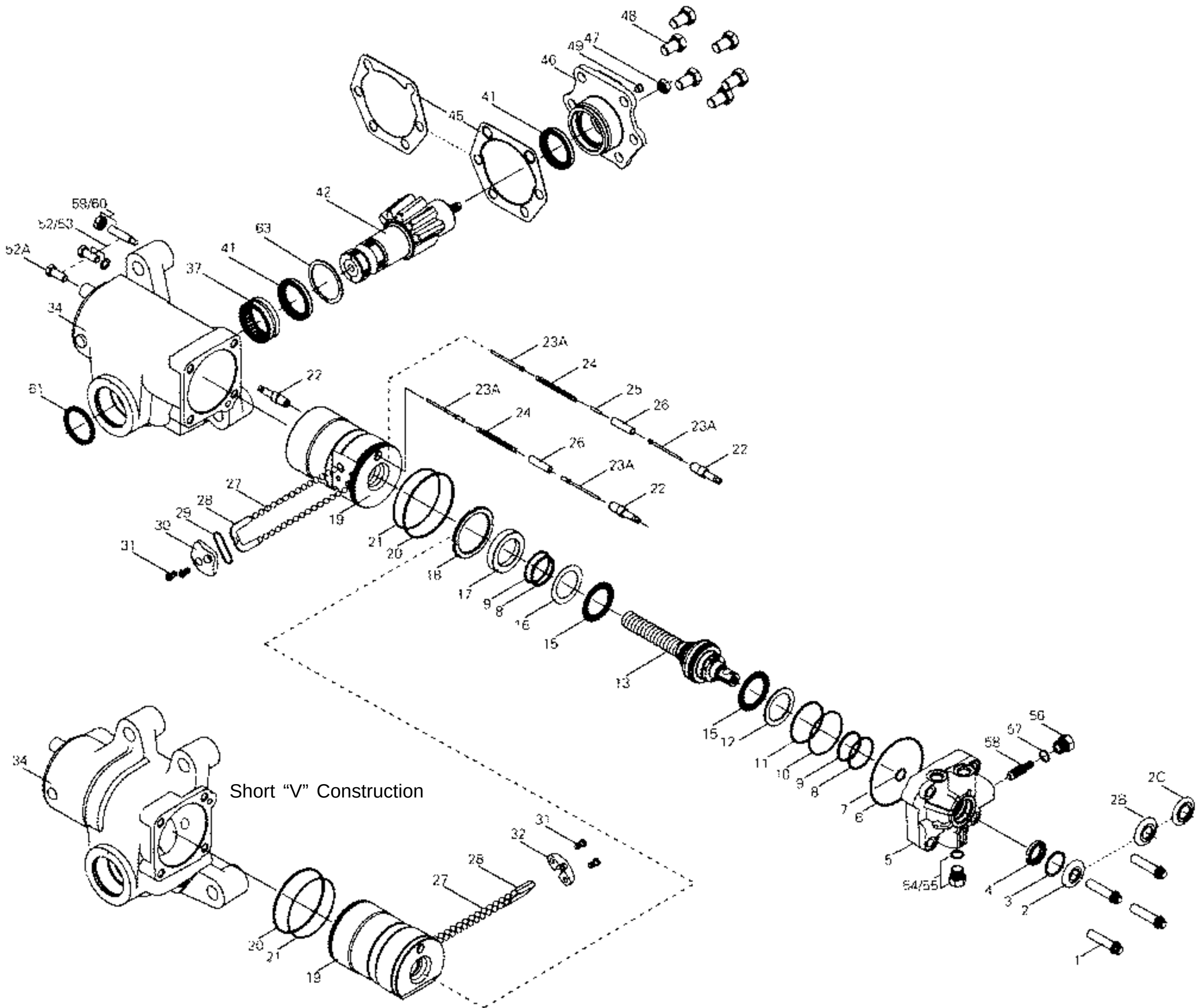
Kits

Items	Description	Part Number
54 & 55	Port Plug & O-ring	415437-A1
56 & 57	Relief Valve Cap & O-ring	411061-A1
59 & 60	Adj. Screw & Jam Nut	021407-X1
2, 2B, 2C, 3, 4	Input Shaft Seal Kit	TAS000001
	TAS40 Seal Kit	TAS400003
	TAS55 Seal Kit	TA5550004
	TAS65 Seal Kit	TAS650012
	TAS85 Seal Kit	TAS850003or4

Parts Vary by Gear Size

Item	Description	TAS40	TAS55	TAS65	TAS85
6	Seal Ring (Valve Housing)	032829	032829	032616	032834
20	Teflon Seal Ring	032828	032830	032590	032547
21	O-ring (Back up; Rack Piston)	032827	032831	032615	032556
22	Poppet Seat and Sleeve Assy. (2)	409118-A2	409118-A2	409118-A2	409118-A6
23	Poppet (2-old design)	040210	040210	040210	040217
23A	Poppet (2-new design)	040248	040248	040248	040249
24	Poppet Spring	401662	401662	401662	401684
25	Spacer Rod	040209	040209	040209	040218
26	Push Tube	080154	080154	080154	080158
28	Ball Return Guide Halves (2) R.H.	400158	400160	400156	400162
	L H.	400159	400165	400157	400163
36	Retaining Ring (2)	401674	401650	401650	401685
37	Boller Bearing	070030	071032	071033	072004
38	Dirt Seal	478052	478041	478041	478057
39	Dirt and Water Seal (Trunnion)	478053	478045	478045	478059
40	Washer (Spacer)	028527	028519	028519	028534
41	Seal (2-Output)	478051	478040	478040	478084
45	Gasket (Side Cover)	HFB529000	HFB649000	HFB649000	TAS859000
48	Special Bolts (6 or 8-Side Cover)	021277	021434	021434	021434

TAS Series Exploded View -- Step Bore



Item	Description
1	Bolts (4-Valve Housing)
*2	Dirt and Water Seal 13/16" Serr.
*2B	Dirt and Water Seal 7/8" Serr.
*2C	Dirt and Water Seal 1" Serr.
*3	Retaining Ring
*4	Seal (Input Shaft)
5	Valve Housing
*6	Seal Ring (Valve Housing)
*7	Seal Ring (Valve Housing)
*8	Seal Ring (2)
*9	O-ring (2)
*10	Seal Ring
*11	O-ring (Valve Housing)
12	Thrust Washer (Thick)
13	Input Shaft, Valve, Worm Assy.
15	Thrust Bearing (1 or 2)
16	Thrust Washer (Thin)
17	Bearing Adjuster
*18	Adjuster Locknut
19	Rack Piston
*20	Teflon Seal Ring
*21	O-ring (Back up; Rack Piston)
22	Poppet Seat and Sleeve Assy. (2)
23	Poppet (2)
24	Poppet Spring
26	Push Tube
27	Balls
28	Ball Return Guide Halves (2)
*29	Seal (Cap)
30	Ball Return Guide Cap
*31	Torx Screws (2-Cap/Strap)
*32	Ball Return Guide Strap
34	Housing
35	Grease Fitting
37	Roller Bearing
*41	Seal (2-Output)
42	Sector Shaft
43	Adjusting Screw (Sector Shaft)
44	Retainer (Adjusting Screw)
*45	Gasket (Side Cover)
46	Side Cover Assembly
47	Jam Nut
48	Special Bolts (6 or 8-Side Cover)
*49	Vent Plug (Side Cover)
50	Bleed Screw (Manual)
51	Plug (Auto Bleed)
52	Fixed Stop Screw (Poppet)
52A	Fixed Stop Screw (Poppet-Alt)
53	Washer (Stop Screw)
54	Auxiliary Port Plug (2)
*55	O-ring (2-Aux. Port Plug)
56	Relief Valve Cap
*57	O-ring (Relief Valve)
58	Relief Valve (2 piece)
59	Service Poppet Adjusting Screw
60	Service Sealing Jam Nut
*61	Dirt & Water Seal (Trunnion)
63	Retaining Ring

*These items are included in complete seal kits along with 406038 lubricant and a service bulletin.

Service Parts List - Step Bore

Common Parts

Item	Description	Part Number
1	Bolts (4-Valve Housing)	020251
2	Dirt and Water Seal 13/16" Serr.	478044
2B	Dirt and Water Seal 7/8" Serr.	478060
2C	Dirt and Water Seal 1" Ser	478050
3	Retaining Ring	401637
4	Seal (Input Shaft) (High Temp)	478076
7	Seal Ring (Valve Housing)	032823
8	Seal Ring (2)	029123
9	O-ring (2) (High Temp)	032200-158
10	Seal Ring	029116
11	O-ring (Valve Housing) (High Temp)	032200-152
12	Thrust Washer (Thick)	400143
15	Thrust Bearing (2)	070027
16	Thrust Washer (Thin)	400144
17	Bearing Adjuster	400149
18	Adjuster Locknut	027007
27	Balls	213684-X1
29	Seal (Cap)	478042
30	Ball Return Guide Cap	400161
31	Torx Screws (2-Cap/Strap)	020228
32	Ball Return Guide Strap	400167
35	Grease Fitting	037032
43	Adjusting Screw (Sector Shaft)	021200
44	Retainer (Adjusting Screw)	062005
47	Jam Nut	G9419666
49	Vent Plug (Side Cover)	036201
50	Bleed Screw (Manual)	213705
51	Plug (Auto Bleed)	021397
52A	Fixed stop screw	021426
54	Auxiliary Port Plug (2)	G9410358
55	O-ring (2-Aux. Port Plug)	032229
57	O-ring (Relief Valve)	032200-153
59	Service Poppet Adjusting Screw	021407
60	Service Sealing Jam Nut	025119

Parts Vary by Specification*

Item	Description
5	Valve Housing
13	Input Shaft, Valve, Worm Assy.
19	Rack Piston
34	Housing
42	Sector Shaft
46	Side Cover Assembly
56	Relief Valve Cap
58	Relief Valve (2 piece)

*Contact Service/Sales for part numbers

Kits

Items	Description	Part Number
54 & 55	Port Plug & O-ring	415437-A1
56 & 57	Relief Valve Cap & O-ring	411061-A1
59 & 60	Adj. Screw & Jam Nut	021407-X1
2, 2B, 2C, 3, 4	Input Shaft Seal Kit	TAS000001
	TAS40 Seal Kit	TAS400003
	TAS55 Seal Kit	TAS550004
	TAS65 Seal Kit	TAS650012
	TAS85 Seal Kit	TAS850003or4

Parts Vary by Gear Size

Item	Description	TAS40	TAS55	TAS65	TAS85
6	Seal Ring (Valve Housing)	032829	032829	032616	032834
20	Teflon Seal Ring	032828	032830	032590	032547
21	O-ring (Back up-, Rack Piston)	032827	032831	032615	032556
22	Poppet Seat and Sleeve Assy. (2)	409118-A2	409118-A2	409118-A2	409118-A6
23	Poppet (2-old design)	040210	040210	040210	040217
23A	Poppet (2-new design)	040248	040248	040248	040249
24	Poppet Spring	401662	401662	401662	401684
26	Push Tube	080154	080154	080154	080158
28	Ball Return Guide Halves (2) R.H.	400158	400160	400156	400162
	L. H.	400159	400165	400157	400163
37	Roller Bearing	070030	071032	071033	072004
41	Seal (2-Output)	478051	478040	478040	478084
45	Gasket (Side Cover)	HFB529000	HFB649000	HFB649000	TAS859000
48	Special Bolts (6 or 8-Side Cover)	021277	G223734	G223734	G223734
61	Dirt & Water Seal (Trunnion)	K301963	478095	478095	478096
63	Retaining Ring	401674	401650	401650	401685

Initial TAS Installation

- Bolt gear to frame, torque to vehicle manufacturer's recommendation.
- Connect return line to TAS return port.
- Connect hydraulic line from pump to pressure port in TAS unit.
- Connect steering column to input shaft, torque pinch bolt to vehicle manufacturer's recommendation.
- Install pitman arm on output shaft, torque bolt to vehicle manufacturer's recommendation.

Initial Poppet Setting

For this procedure to work correctly, you must have: A new gear received from TRW or your vehicle manufacturer's aftermarket system, **or** a used gear on which poppet seats have been replaced or reset during gear disassembly procedures. **ALSO:** A fixed stop screw installed in the housing, or a poppet adjusting screw installed so that it duplicates the fixed stop screw length.

CAUTION **The axle stops and all steering linkage must be set according to vehicle manufacturer's specifications, and the pitman arm must be correctly aligned on the sector shaft for poppets to be set correctly.**

Full turn in one direction

1. With the engine at idle and the vehicle unloaded, turn the steering wheel to full travel in one direction until axle stop contact is made. Maximum input torque to be applied during this procedure is 40 lb rim pull (178 N) on a 20 in. (508mm) diameter steering wheel.

NOTE If you encounter excess rim pull effort, allow the vehicle to roll forward or jack up the vehicle at the front axle.

Full turn in other direction

2. Follow the same procedure while turning the steering wheel in the other direction. The poppets are now positioned to trip and reduce pressure as the steered wheels approach the axle stops in either direction.

Maintenance Tips

Never high-pressure wash or steam clean a power steering gear while on or off the vehicle. Doing so could force contaminants inside the gear and cause it to malfunction.

Make sure vehicle wheel cut or clearances meet manufacturer's specifications, and make sure pitman arm timing marks are aligned properly to **prevent internal bottoming** of the steering gear.

Regularly check the fluid and the fluid level in the power steering reservoir.

Keep tires inflated to correct pressure.

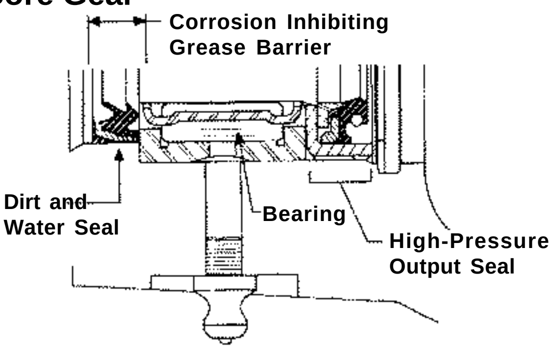
Never use a torch to remove pitman arm.

Investigate and immediately **correct the cause of any play, rattle, or shimmy** in any part of the steering system.

Make sure the steering column is aligned properly.

Encourage drivers to report any malfunctions or accidents that could have damaged steering components.

Step Bore Gear



Do not attempt to weld any broken steering component. Replace the component with original equipment only.

Do not cold straighten, hot straighten, or bend any steering system component.

Always **clean off around the reservoir filler cap** before you remove it. Prevent dirt or other foreign matter from entering the hydraulic system.

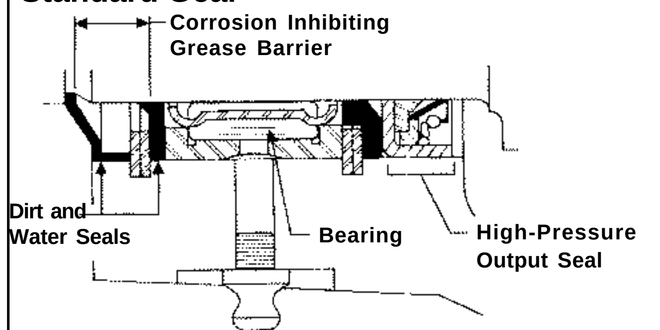
Investigate and correct any external leaks, no matter how minor.

Replace reservoir filters according to requirements.

If you feel the vehicle is developing excessively **high hydraulic fluid temperatures**, consult with your vehicle manufacturer for recommendations.

Maintain grease pack behind the output shaft dirt and water seal as a general maintenance procedure at least twice a year, in the Spring and Fall. Grease fitting is provided in housing trunnion. Use only NLGI grade 2 multipurpose chassis lube, and use only a hand operated grease gun on fitting. Add grease until it begins to extrude past the sector shaft dirt and water seal.

Standard Gear



Filling and Air Bleeding the System

Tools Required	Materials Required
$^5/_{16}$" Socket Lbf•in. Torque wrench	Hydraulic fluid

⚠ CAUTION **Make sure poppets are set correctly before beginning this procedure.**

Run engine for 10 seconds, turn off and fill reservoir

Hydraulic fluid

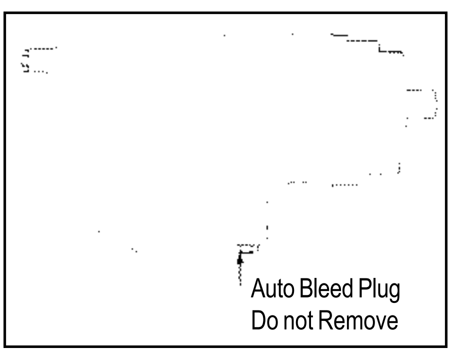
1. Fill the reservoir nearly full. Do not steer. Start and run the engine for 10 seconds, then shut it off. Check and refill the reservoir. Repeat at least three times, checking the reservoir each time

⚠ CAUTION **Do not allow the fluid level to drop significantly or run out of the reservoir. This may induce air into the system.**

Run engine for 2 minutes, turn off and fill reservoir

Hydraulic fluid

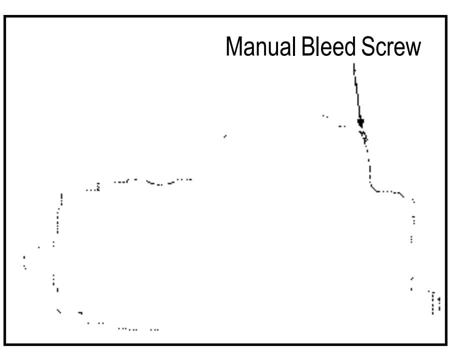
2. Start the engine and let it idle for 2 minutes. Do not steer. Shut off the engine and check the fluid level in the reservoir. Refill as required.



Steer vehicle

3. Start the engine again. Steer the vehicle from full left to full right several times. Add fluid, as necessary, to the full line on the dip stick.

   Automatic bleed systems should now be free from trapped air. **Manual bleed systems continue with step 4.**



Allow air to bleed out from bleed screw

Lbf•in. Torque wrench
$^5/_{16}$" Socket

4. With engine idling, steer from full left turn to full right turn several times. Stop steering and loosen the manual bleed screw about one turn. Allow air and aerated fluid to "bleed out" until only clear fluid is seen. Close the bleed screw, refill the reservoir if required.

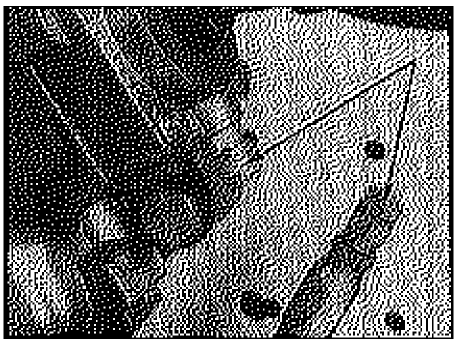
   Repeat step 4 three to four times until all the air is discharged. Torque manual bleed screw to **45 lbf•in.**

⚠ CAUTION **Do not turn steering wheel bleed screw loosened.**

Input Shaft Seal Replacement

Tools Required	Materials Required
Hammer J37073 Screwdriver	Clean cloth Drip pan High pressure fitting Hydraulic fluid Plug Shop towel

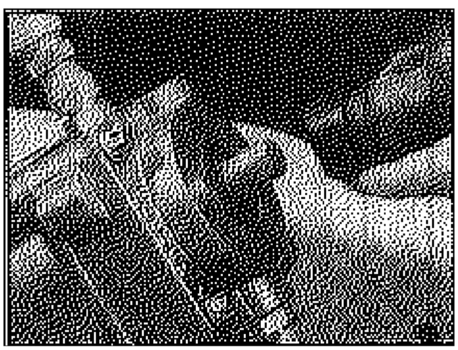
This procedure uses the vehicle's power steering pump to force out the input shaft seal. To use this procedure, the power steering pump should have a minimum of 1,500 psi available.



Disconnect return line

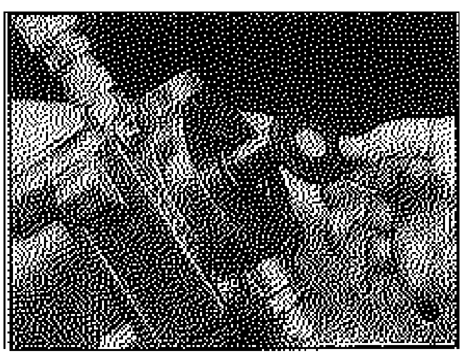
High pressure fitting
Plug

1. Disconnect return line from the steering gear and plug the line. Also cap the return port of the gear with a high pressure fitting.



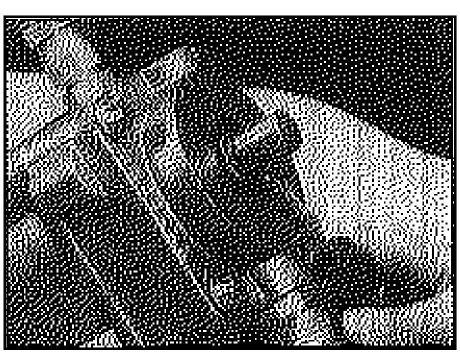
Disconnect column

2. Remove the steering column from the gear input shaft.



Remove dirt & water seal

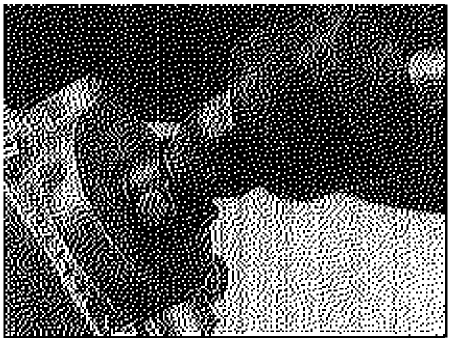
3. Remove the dirt and water seal from the steering gear. Save this seal to match the new seal to the correct size.



Remove retaining ring

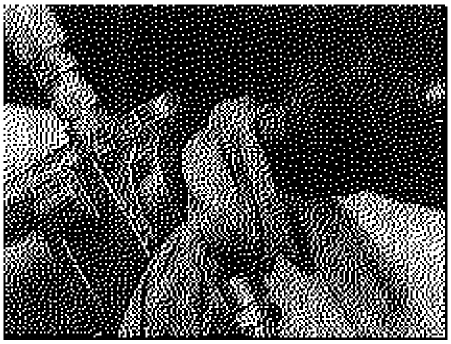
Clean cloth
Screwdriver

4. Wipe out the grease and then remove the spiral retaining ring. Use a screwdriver inserted into the notch formed in the end of the ring. Be careful not to scratch the bore with the screwdriver.



Replace column

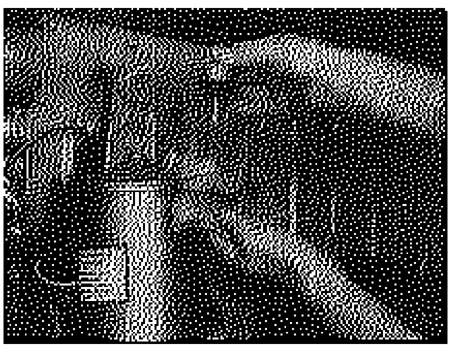
5. Slip the steering column back onto the input shaft with the pinch bolt installed, but not tightened.



Wrap exposed area

Drip pan
Shop towel

6. Tie or wrap a shop towel around the input shaft area and place a drip pan under the vehicle to catch the oil.



Fill reservoir

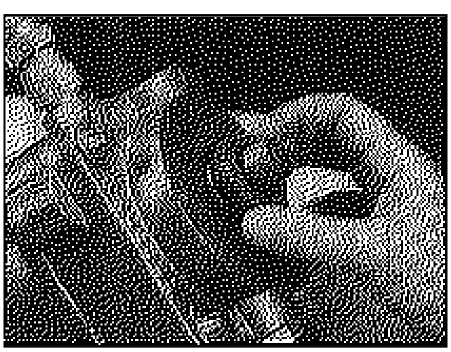
Hydraulic fluid

7. Add fluid as necessary, to the full line on the dip-stick. Do not mix fluid types.

⚠ WARNING **Any mixture of fluid types, or use of any unapproved fluid could lead to seal deterioration and leaks. A leak could ultimately cause the loss of fluid, which could result in a loss of power steering assist.**

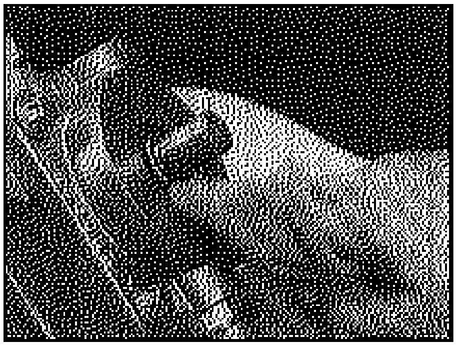
Force out the seal

8. With the vehicle in neutral, momentarily turn the starter (quickly turn off the engine if it starts).



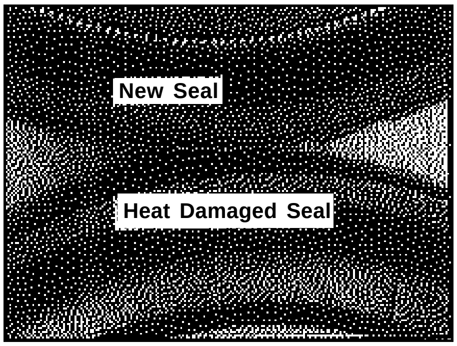
Remove input shaft seal

9. Remove the shop towel. Disconnect the steering column, and remove the input shaft seal.



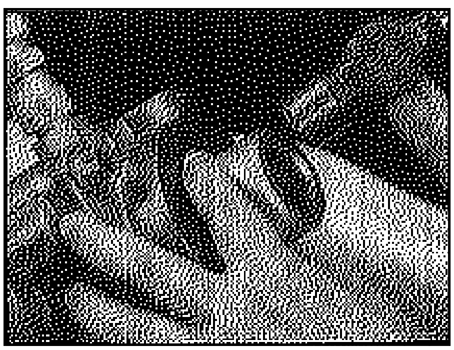
Inspect seal area

10. Check the seal area of the valve housing for any seal fragments. Remove any that are found.



Inspect old seal

11. Check the seal for heat damage. If the seal is stiff and brittle, and not pliable like the new seal, it is probably heat damaged. Determine and fix the cause of excessive heat in the vehicle.

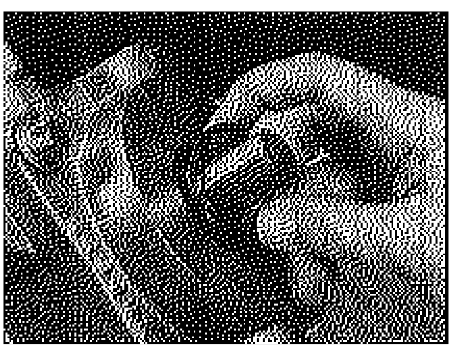


Install new seal

Hammer
J37073

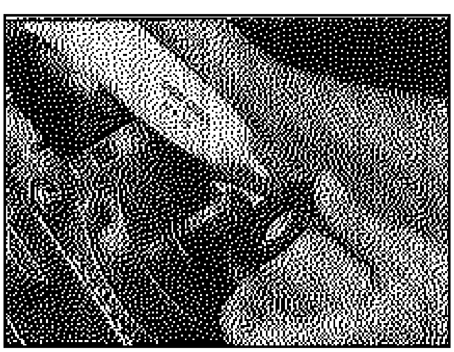
12. Put clean grease 406038 on the inside dia, of the new input shaft seal, and place it over the input shaft. With the small dia. of tool J37073 against the seal, tap the tool until the tool shoulder is square against the valve housing. Remove any seal material that may have sheared off in the seal bore or retaining ring groove.

CAUTION **Do not use a socket to install this seal because you will not be able to control seal installation depth, possibly causing a leak.**



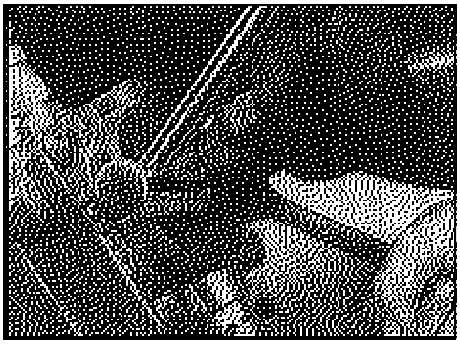
Install retaining ring

13. Insert new retaining ring into the groove.



Install dirt & water seal

14. Pack the end of the valve housing bore around the input shaft with grease 406038. Choose the correct size dirt & water seal by comparing the choices to the old seal, or by measuring the major diameter of the input shaft serrations (see chart next page). Apply more grease 406038 to the new dirt & water seal and install it over the input shaft. Seat it in the groove behind the serrations and against the valve housing.



Reconnect column

15. Reconnect the steering column to the input shaft and tighten the pinch bolt to torque level specified.

Reconnect return line

16. Reconnect the return line to the steering gear return port.

Air bleed system

17. Air bleed the system using the procedure on page 17.

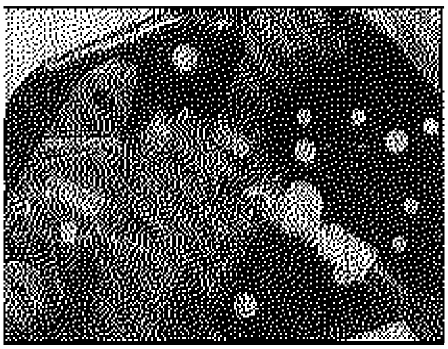
Seal Part No.	Serration Size	Major Serration Dia.
478044	13/16" x 36	0.807 / 0.799
478060	7/8 x 36	0.866 / 0.857
478050	1" x 36	0.987 / 0.977
478050	1" x 79	1.008 / 1.000

Sector Shaft Adjustment

Tools Required	Materials Required
Screwdriver	
¾" Socket	
¾" Open end wrench	

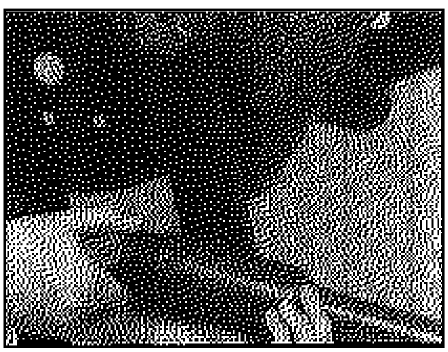
This adjustment can only be completed on the vehicle if the adjusting screw jam nut is accessible. This nut is located on the side cover.

Photos in this section were taken on a mock frame rail for clarity.



Center the sector shaft

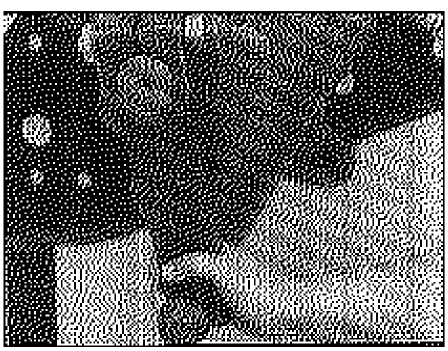
1. With the engine on, rotate the steering wheel (input shaft) until the timing mark on the sector shaft lines up with the mark on the housing. The line on the sector shaft should be at a 90° angle from the input shaft. The sector shaft is now on its "center of travel". Turn the vehicle off.



Remove the drag link

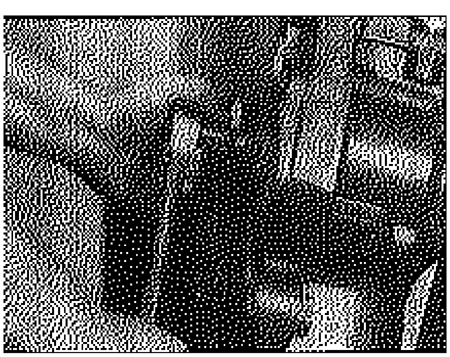
2. Remove the drag link from the pitman arm.

⚠CAUTION **To avoid resetting the poppets, do not rotate the input shaft more than 1 ½ turns from the "center of travel" position while the drag link is disconnected.**



Check for sector shaft lash

3. From the "center of travel" position, grasp the pitman arm and gently try to rotate it back and forth. If looseness or lash is felt at this point, the sector shaft is out of adjustment.

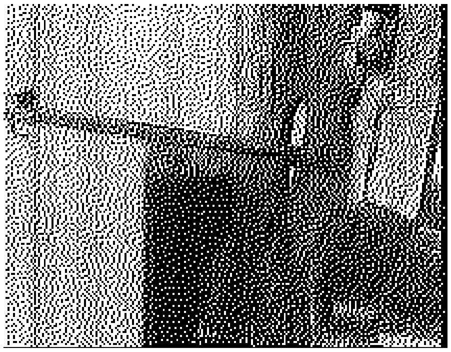


Loosen jam nut

¾" Socket

4. Loosen the jam nut.

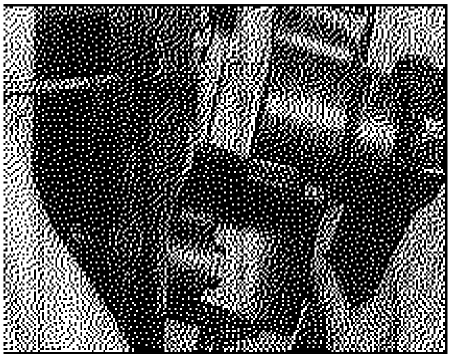
NOTE If the gear is removed from the vehicle to adjust the lash:
- Leave the pitman arm connected to the gear.
- Best option is to follow the Final Adjustment procedure on page 63.
- Alternate option is to continue with step 5 of this procedure.



Position adjusting screw

Screwdriver

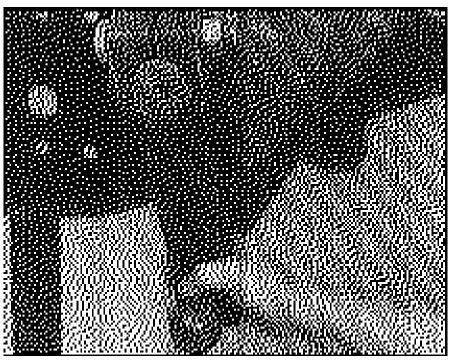
5. If no lash was detected in step 3, turn the shaft adjusting screw counterclockwise until you feel lash at the output shaft.



Adjust shaft

Screwdriver ¾" Open end wrench

6. Slowly turn the shaft adjusting screw clockwise until you feel no lash at the output shaft without using more than 10 lbf•ft (14 N•m) of torclue. From this position, turn the screw clockwise $^{1}/_{8}$ to $^{3}/_{16}$ of a turn more. Hold the adjusting screw in place, and tighten the jam nut. **Final jam nuttorque 43 lbf•ft** (58 N•m).



Recheck for lash

7. Turn the steering wheel ¼ turn each side of center, then back to center and recheck the pitman arm for lash. You should feel no lash; if there is lash, repeat steps 4, 6 and 7.

Connect drag link

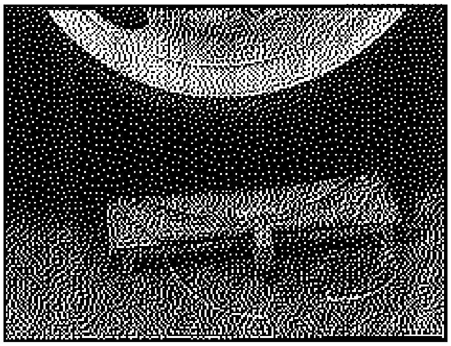
8. Reconnect the drag link to the pitman arm according to manufacturer's specifications.

> **⚠ CAUTION** **Maintain grease in the sector shaft bearing through the grease fitting in the housing using only a hand operated grease gun. Add grease until it begins to extrude past the dirt and water seal. Do not use a power grease gun because it will supply grease too fast; this could adversely affect the high pressure seal and contaminate the hydraulic fluid.**

Poppet Readjustment - Single Gears

Tools Required	Materials Required
$^{7}/_{32}$" Allen wrench	Hydraulic fluid
$^{5}/_{8}$" Open end wrench	Jack
¾" Open end wrench	
¾" Socket	
Lbf•lb Torque wrench	

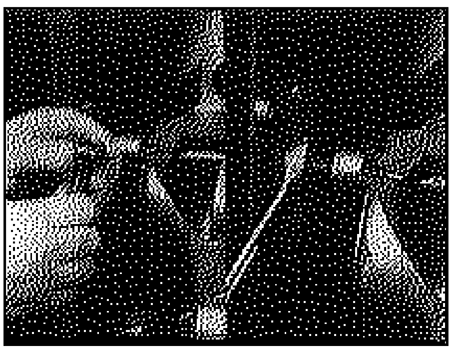
This resetting procedure will work in most cases with at least 1¾ hand-wheel-turns from each side of center. If you're making a large reduction in wheelcut and this procedure does not work, you may have to replace or internally reset the poppets using the procedure described in the Poppet Component section of this Service Manual.



Set axle stops, warm-up system

1. Set the axle stops to vehicle manufacturer's wheelcut or clearance specifications.

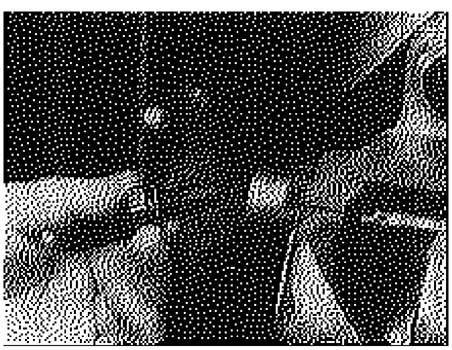
   Start the engine and allow the vehicle to idle for 5-10 minutes to warm the hydraulic fluid. Shut off the engine.



Assemble adjusting screw into nut

2. If a new poppet adjusting screw and nut are being used, turn the screw into the non-sealing end of the jam nut until the drive end of screw is flush with the nut.

   Your steering gear will have either a fixed stop bolt or an adjusting screw. If the adjusting screw is already part of the steering gear, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.

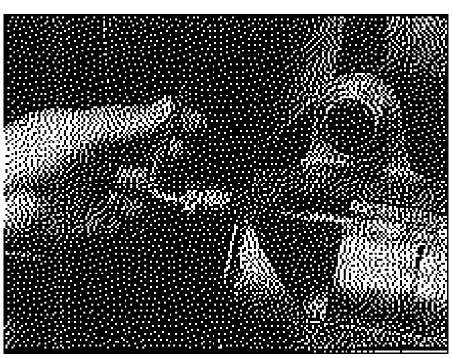


Remove poppet stop bolt

$^{5}/_{8}$" Open end wrench

3. Make sure the engine is off and the road wheels are in straight ahead position. Remove and discard the poppet fixed stop bolt (if equipped) and washer (if equipped) from the lower end of the housing.

   If the unit has a poppet adjusting screw and sealing nut that need to be replaced, remove and discard them.

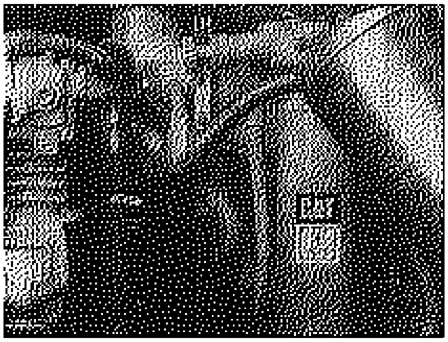


Turn adjusting screw assembly into housing

$^{7}/_{32}$" Allen wrench

4. Turn the adjusting screw and sealing nut assembly, without rotating the nut on the screw, into the housing until the nut is firmly against the housing using a $^{7}/_{32}$" Allen wrench. Tighten the sealing nut against the housing.

CAUTION **If the drive end of the screw is below the face of the nut, the popet seat flange will break during step 7d.**

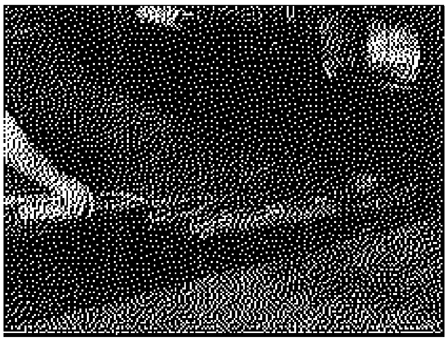


Refill reservoir

Hydraulic fluid

5. Refill the system reservoir with approved hydraulic fluid.

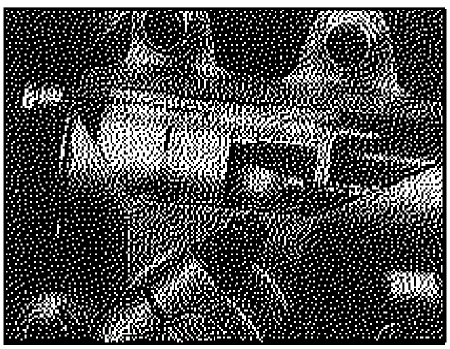
> **CAUTION** Do not mix fluid types. Mixing of transmission fluid, motor oil, or other hydraulic fluids will cause seals to deteriorate faster.



Jack up vehicle

Jack

6. Place a jack under the center of the front axle and jack up the front end of the vehicle so the steer axle tires are off the ground.



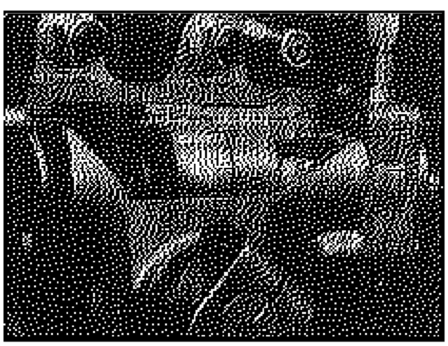
Push upper poppet out to prepare it for setting

7. **a)** Start the engine and let it run at idle speed.

   b) Note which output shaft timing mark is nearest the housing piston bore.

   c) Turn the steering wheel in the direction that makes this timing mark move toward the adjusting screw just installed. Turn in this direction until axle stop contact is made.

   d) Pull hard on the steering wheel (put up to 40 lb rim pull on a 20" dia. steering wheel) after the axle stop is contacted.

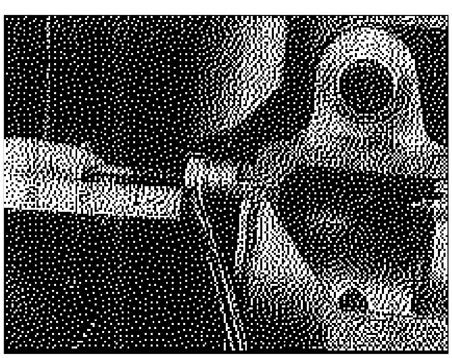


Set upper poppet

8. **a)** Turn the steering wheel in the opposite direction (end of timing mark away from adjusting screw) until the other axle stop is contacted.

   b) Pull hard on the steering wheel (put up to 40 lb rim pull on a 20" dia. steering wheel).

   c) Release the steering wheel and shut off the engine.

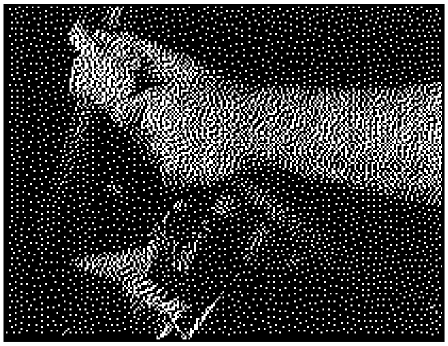


Back out adjusting screw

7/32" Allen wrench
¾" Open end wrench

9. Loosen the sealing nut and back out the adjusting screw until 1" is past the nut. Tighten the sealing nut against the housing.

> **CAUTION** Do not hold the steering wheel at full turn for more than 10 seconds at a time; the heat build-up at pump relief pressure may damage components.

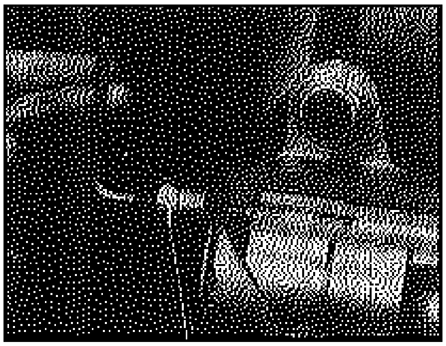


Set lower poppet

10. **a)** Start the engine and let it idle.

b) Turn the steering wheel in the original direction (end of timing mark toward adjusting screw), until axle stop contact is made.

c) Hold the steering wheel in this position (with up to 40 lb rim pull) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing step 11.



Position adjusting screw

$^{7}/_{32}$" Allen wrench
¾" Open end wrench
¾" Socket
Lbf•ft Torque wrench

11. **a)** With steering wheel held tightly at full turn loosen the jam nut and hold it in place with a wrench.

b) Turn the adjusting screw in (clockwise) using **finger-pressure only (don't use a ratchet),** until the Allen wrench stops. Do not attempt to turn it in further. Pause the turning-in process each time the driver releases the steering wheel; continue turning only while the wheel is held at full turn.

c) Back off the adjusting screw $3^{1}/_{4}$ turns and tighten the sealing nut. Torque sealing nut to **35 lbf•ft.**

The procedure is complete

12. The poppets have now been completely reset. Lower the vehicle. Check the reservoir and fill if required.

WARNING **The length of the adjusting screw beyond the nut must be no more than $1^{1}/_{16}$" for proper thread engagement.**

NOTE The length of adjusting screw beyond the sealing nut may be different for each vehicle.

Poppet Readjustment - Dual Gears

Mirror Image Systems and Reversed Image Systems

Before setting poppets on a dual gear system, you must determine whether the system has mirror image gears or reversed image gears. The procedures are slightly different for each type of system.

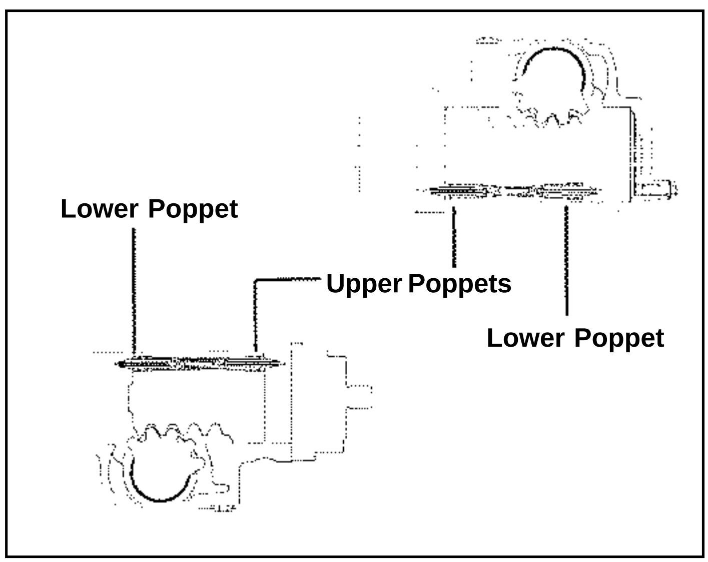
1. Park the vehicle with the wheels turned all the way to the axle stop in either direction. Turn the vehicle off.

2. Look at the output shaft timing mark nearest the housing piston bore on the master gear. Is this mark pointing toward the poppet screw or away from it?

3. Now check the same timing mark on the rotary cylinder. Does it point toward the poppet screw or away from it?

   If they point to opposite ends of the gears you have a mirror image system.

   If they both point toward the poppet screws or both point toward the end opposite the poppet screws, you have a reversed image system.



Poppet Readjustment - Dual Gears - Mirror Image

Tools Required	Materials Required
$^{7}/_{32}$" Allen wrench $^{5}/_{8}$" Open end wrench ¾" Open end wrench ¾" Socket Lbf•lb Torque wrench	Hydraulic fluid Jack

This resetting procedure will work in most cases with at least 1¾ hand-wheel-turns from each side of center. If you're making a large reduction in wheelcut and this procedure does not work, you may have to replace or internally reset the poppets using the procedure described in the Poppet Component section of this Service Manual.

1. Set the axle stops to vehicle manufacturer's wheelcut or clearance specifications.

   Start the engine, and allow the vehicle to idle for 5-10 minutes to warm the hydraulic fluid. Shut off the engine.

2. If new poppet adjusting screws and nuts will be used, turn each screw into the non-sealing end of the jam nut until the drive end of screw is flush with the nut.

   Your steering gear and rotary cylinder will both have either fixed stop bolts or adjusting screws. If the adjusting screw is already part of the gear or cylinder, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.

3. Make sure the engine is off and the road wheels are in straight ahead position. Remove and discard the poppet fixed stop bolt (if equipped) and washer (if equipped) from the lower end of housing on both the gear and the cylinder.

   If either unit has a poppet adjusting screw and sealing nut that need to be replaced, remove and discard them.

4. On both the master gear and the rotary cylinder, turn the adjusting screw and sealing nut assembly, without rotating the nut on the screw, into the housing until the nut is firmly against the housing using a $^{7}/_{32}$" allen wrench. Tighten the sealing nut against the housing.

5. Refill system reservoir with approved hydraulic fluid.

   ⚠ CAUTION **Do not mix fluid types, Mixing of transmission fluid, motor oil, or other hydraulic fluids will cause seals to deteriorate faster.**

6. Place a jack under the center of the front axle and jack up the front end of the vehicle so the steer axle tires are off the ground.

7. **a)** Start the engine and let it run at idle speed.

   b) Turn the steering wheel in the direction that makes the timing mark on the master gear move toward the adjusting screw just installed. Turn in this direction until axle stop contact is made.

   c) Pull hard on the steering wheel (put 40 lbs. rim pull on a 20" dia. steering wheel) after the axle stop is contacted.

8. **a)** Turn the steering wheel in the opposite direction (end of timing mark on the master gear away from adjusting screw) until the other axle stop is contacted.

   b) Pull hard on the steering wheel (put 40 lbs. rim pull on a 20" dia. steering wheel).

   c) Release the steering wheel and shut off the engine.

9. Loosen the sealing nut and back out the adjusting screw on the master gear until 1" is past the nut. Tighten the sealing nut against the housing.

   ⚠ CAUTION **Do not hold the steering wheel at full turn for more than 10 seconds at a time; the heat build-up at pump relief pressure may damage components.**

10. **a)** Start the engine and let it idle.

    b) Turn the steering wheel in the original direction (end of timing mark on the gears toward adjusting screw), until axle stop contact is made.

    c) Hold the steering wheel in this position (with 40 lbs. rim pull) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing steps 11 & 12.

11. **a)** With steering wheel held at full turn, loosen the jam out on the master gear and hold it in place with a wrench.

    b) Turn the adjusting screw in (clockwise) using finger - pressure only (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.

    c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque the sealing nut to **33-37 lbf•ft.**

    d) Release the steering wheel and shut off the engine.

12. Loosen the sealing nut and back out the adjusting screw on the rotary cylinder until 1 " is past the nut. Tighten the sealing nut against the housing.

13. **a)** Start the engine and let it idle.

    b) Turn the steering wheel in the opposite direction (end of timing mark on master gear away from adjusting screw), until axle stop contact is made.

    c) Hold the steering wheel in this position (put up to 40 lb. rim pull on a 20" dia. steering wheel) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing step 14

14. **a)** With steering wheel held at full turn, loosen the jam nut on the rotary cylinder and hold it in place with a wrench.

    b) Turn the adjusting screw in (clockwise) using finger- pressure only (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.

    c) Back off the adjusting screw 3¼ turns and tighten the sealing nut. Torque the sealing nut to **33-37 lbf•ft.**

    d) Release the steering wheel and shut off the engine.

15. The poppets have now been completely reset. Lower the vehicle. Check the reservoir and fill if required.

WARNING **The length of the adjusting screw beyond the nut must be no more than $1^{1}/_{16}$" for proper thread engagement.**

NOTE The lenght of adjusting screw beyond the sealing nut may be different for each vehicle.

Poppet Readjustment - Dual Gears - Reversed Image

Tools Required	Materials Required
7/32" Allen wrench 5/8" Open end wrench ¾" Open end wrench ¾" Socket Lbf•lb Torque wrench	Hydraulic fluid Jack

This resetting procedure will work in most cases with at least 1¾ hand-wheel-turns from each side of center. If you're making a large reduction in wheelcut and this procedure does not work, you may have to replace or internally reset the poppets using the procedure described in the Poppet Component section of this Service Manual.

1. Set the axle stops to vehicle manufacturer's wheelcut or clearance specifications.

   Start the engine, and allow the vehicle to idle for 5-10 minutes to warm the hydraulic fluid. Shut off the engine.

2. If new poppet adjusting screws and nuts are being used, turn each screw into the non-sealing end of the jam nut until the drive end of screw is flush with the nut.

   Your steering gear and rotary cylinder will have either fixed stop bolts or adjusting screws. If the adjusting screw is already part of the steering gear or cylinder, back the nut off of the adjusting screw until it is flush with the end of the adjusting screw.

3. Make sure the engine is off and the road wheels are in straight ahead position. Remove and discard the poppet fixed stop bolts (if equipped) and washer (if equipped) from the lower end of housing on both the master gear and the rotary cylinder.

   If the unit has a poppet adjusting screw and sealing nut that need to be replaced, remove and discard them.

4. Turn the adjusting screws and sealing nut assemblies, without rotating the nut on the screw, into the housing until the nut is firmly against the housing on both the master gear and the rotary cylinder, using a 7/32" allen wrench. Tighten the sealing nut against the housing.

5. Refill system reservoir with approved hydraulic fluid.

   ⚠ CAUTION **Do not mix fluid types, Mixing of transmission fluid, motor oil, or other hydraulic fluids will cause seals to deteriorate faster.**

6. Place a jack under the center of the front axle and jack up the front end of the vehicle so the steer axle tires are off the ground.

7. **a)** Start the engine and let it run at idle speed.

   b) Note which output shaft timing mark is nearest the housing piston bore.

   c) Turn the steering wheel in the direction that makes the timing mark move toward the adjusting screw just installed on both the gear and the cylinder. Turn in this direction until axle stop contact is made.

   d) Pull hard on the steering wheel (put 40 lbs. rim pull on a 20" dia. steering wheel) after the axle stop is contacted.

8. **a)** Turn the steering wheel in the opposite direction (end of timing mark away from adjusting screw) until the other axle stop is contacted.

   b) Pull hard on the steering wheel (put 40 lbs. rim pull on a 20" dia. steering wheel).

   c) Release the steering wheel and shut off the engine.

9. Loosen the sealing nut and back out the adjusting screw until 1" is past the nut on both the master gear and the rotary cylinder. Tighten the sealing nut against the housing.

   ⚠ CAUTION **Do not hold the steering wheel at full turn for more than 10 seconds at a time; the heat build-up at pump relief pressure may damage components.**

10. **a)** Start the engine and let it idle.

    b) Turn the steering wheel in the original direction (end of timing mark toward adjusting screw), until axle stop contact is made.

    c) Hold the steering wheel in this position (with 40 lbs. rim pull) for 10 seconds, then release. Repeat this hold and release process as many times as necessary while completing steps 11 and 12, first on the master, gear then on the rotary cylinder.

11. **a)** With steering wheel held at full turn, loosen the jam out on the master gear and hold it in place with a wrench.

    b) Turn the adjusting screw in (clockwise) using finger - pressure only (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.

    c) Back off the adjusting screw $3^1/_4$ turns and tighten the sealing nut. Torque the sealing nut to **33-37 lbf•ft.**

12. **a)** With steering wheel held at full turn, loosen the jam nut on the rotary cylinder and hold it in place with a wrench.

    b) Turn the adjusting screw in (clockwise) using finger- pressure only (don't use a ratchet), until the Allen wrench comes to a stop. Do not attempt to turn it in farther. Pause the turning-in process each time the driver releases the steering wheel; Continue turning only while the wheel is held at full turn.

    c) Back off the adjusting screw $3^1/_4$ turns and tighten the sealing nut. Torque the sealing nut to **33-37lbf•ft.**

13. The poppets on both the master gear and rotary cylinder have now been completely reset. Lower the vehicle. Check the reservoir and fill if required.

WARNING **The length of the adjusting screw beyond the nut must be no more than $1^1/_{16}$" for proper thread engagement.**

NOTE The lenght of adjusting screw beyond the sealing nut may be different for each vehicle.

Disassembly Preparation

Stop the vehicle with wheels pointed straight ahead.

Clean off all outside dirt from around fittings and hose connections before you remove the gear.

Remove input and output shaft connections per vehicle manufacturer's instructions.

WARNING When using a chisel to spread a pinch bolt-type pitman arm boss for assembly or removal from the shaft, maintain a firm grip on the chisel at all times. Failure to do this may result in the chisel flying loose which could cause an injury. Never leave the chisel wedged in the pitman arm boss. If you cannot remove the pitman arm from the shaft with a chisel and your hands, remove the chisel from the arm boss and use a puller only to remove pitman arm.

CAUTION Do not use a hammer on the pitman arm to remove it from sector shaft as internal damage to steering gear could result. Be sure there is no spreading wedge left in the pitman arm boss before tightening pitman arm clamp bolt after assembly on sector shaft. Do not pound the universal joint or input shaft coupling on or off the input shaft as internal damage to the steering gear can result.

CAUTION Unless the poppet adjuster seat and sleeve assemblies (22) are to be removed and replaced or reset for automatic poppet adjustment, or a manual adjustment with a service poppet adjuster screw (59) and nut (60) is anticipated, do not allow the input shaft on a steering gear with the automatic poppet adjustment feature to rotate more than 1.5 input shaft revolutions from "straight ahead position" when the output shaft is disconnected from the vehicle steering linkage; this could disrupt the poppet setting achieved at initial installation. The steering gear is in the "straight ahead position" when the timing marks on the end of the housing trunnion and sector shaft are aligned.

Remove the supply and return lines from the gear, and immediately plug all port holes and fluid lines.

WARNING TAS steering gears can weigh up to 110 pounds dry. Exercise caution when you remove, lift, carry, or fix in a bench vise.

Remove the steering gear from the vehicle and take it to a clean work surface.

Clean and dry the gear before you start to disassemble it.

As you disassemble the gear, clean all parts in clean, OSHA approved solvent, and air blow-dry them only.

WARNING Because they are flammable, be extremely careful when using any solvents. Even a small explosion or fire could cause injury or death.

WARNING Wear eye protection and be sure to comply with OSHA or other maximum air pressure requirements.

CAUTION Never steam clean or high-pressure wash hydraulic steering components. Do not force or abuse closely fitted parts. Use care that bearing and sealing surfaces are not damaged by the assembly and disassembly procedures.

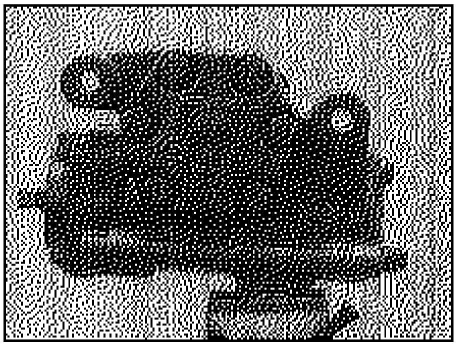
Keep each part separate to avoid nicks and burrs.

Discard all seals, o-rings, and gaskets removed from the gear. Replace them with new parts only.

The steering gear should be identified to the vehicle from which it was removed. The poppet adjuster seat and sleeve assemblies are set for that particular vehicle only.

Disassembly

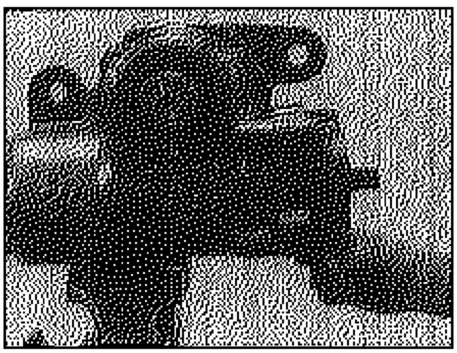
Tools Required		Materials Required
Allen wrenches Pocket knife Ratchet Rolling head pry bar Rubber mallet	Screwdriver Sockets: ● Standard ● Torx Vise	Emery cloth Masking tape



Position gear in vise

1. Put the steering gear in a vise, clamping firmly against the housing mounting flange or boss. Input shaft should be horizontal; side cover and valve housing are accessible for disassembly.

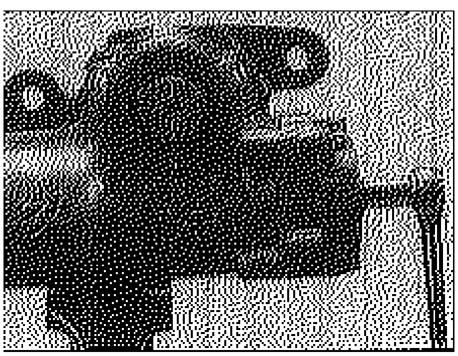
⚠ CAUTION **Do not clamp against body of housing. If mounting boss or flange is not accessible, fabricate and attach a mounting plate to the housing mounting bosses.**



Unplug ports

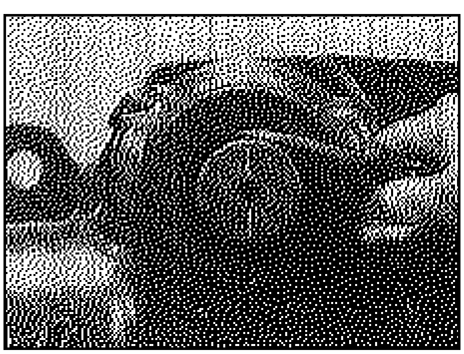
Appropriate size socket or open-end wrench

2. Prepare for fluid drainage and unplug hydraulic ports.



Position sector shaft

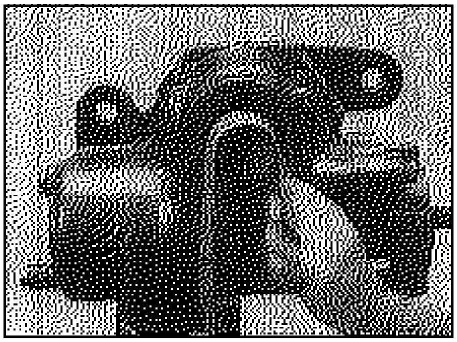
3. Rotate the input shaft until the timing mark on the end of the sector shaft is in line with the timing mark on the end of the housing. This will position the sector shaft for removal.



Remove dirt & water seal

Small screwdriver

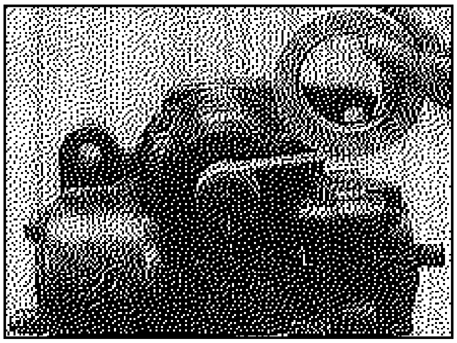
4. **Standard gears only** - Remove and discard dirt & water seal (39) from the housing trunnion.



Clean sector shaft

Fine grade emery cloth

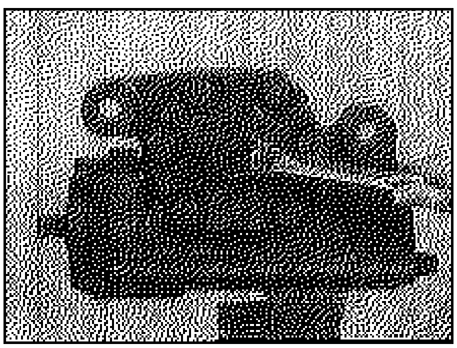
5. Remove any paint or corrosion from the exposed area of the sector shaft (42).



Tape sector shaft

Masking tape

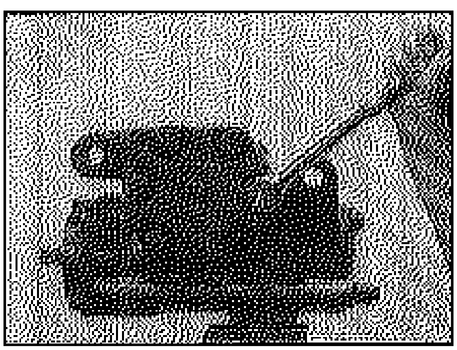
6. Tape the serrations and bolt groove of the sector shaft with one layer of masking tape. The tape should not extend onto the sector shaft bearing diameter.



Remove jam nut

¾" Socket

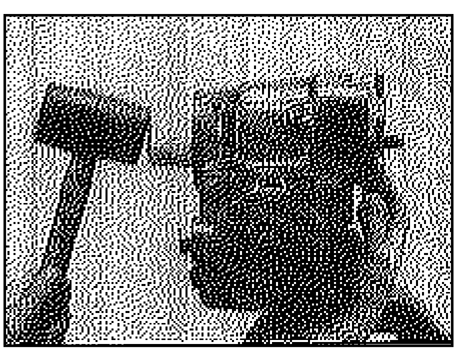
7. Remove the sector shaft adjusting screw jam nut (47).



Remove side cover bolts

15/16" Socket or 13/16" Socket

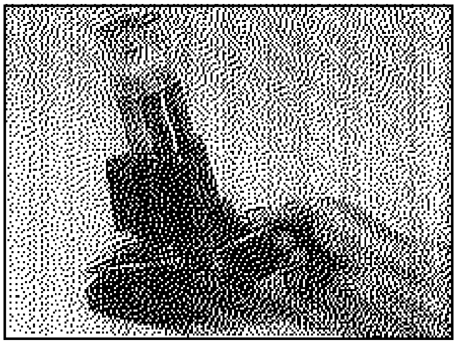
8. Be prepared for more fluid drainage and remove the six or eight special bolts (48) from the side cover (46).



Remove side cover

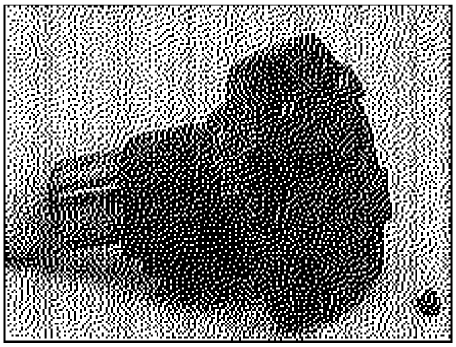
Soft Mallet

9. Be prepared for more fluid drainage and remove the side cover and sector shaft assembly from the gear. You may start the shaft and cover assembly removal by tapping the end of the shaft lightly with a soft mallet or wooden hammer handle.



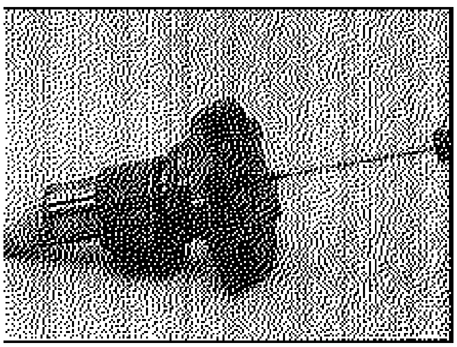
Discard gasket

10. Remove and discard the side cover gasket (45).



Remove vent plug

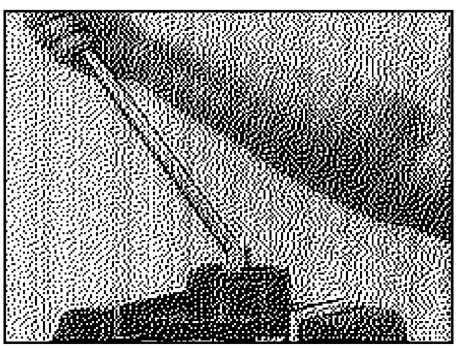
11. Remove and discard the vent plug (49).



Remove sector shaft from cover

Screwdriver

12. Screw sector shaft adjusting screw (43) clockwise through the side cover and pull the sector shaft out of the side cover.

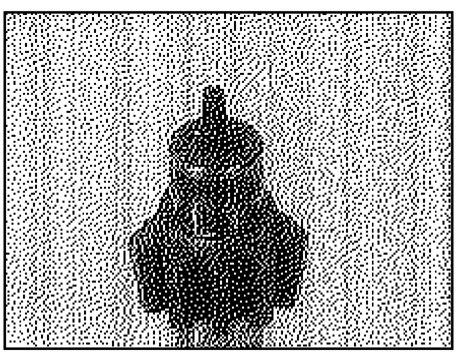


Remove side cover seal

$^3/_8$" Drive socket
Rolling head pry bar

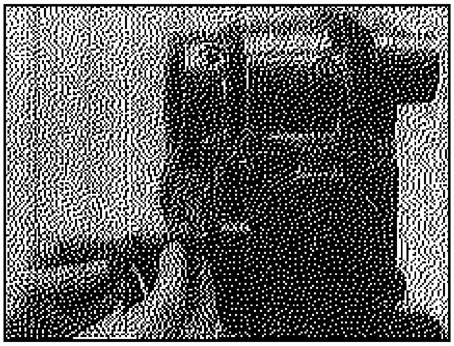
13. **CAUTION** **Don't damage the bore or DU bushing when removing the seal. TAS85 gears are not equipped with the DU bushing.**

Clamp the side cover in a vise Place a standard $^5/_8$" or $^{11}/_{16}$" - $^3/_8$ drive socket in the center of the side cover. pry the seal (41) out with a rolling head pry bar, using the socket for support. Discard the seal and remove the socket.



Inspect adjusting screw and retainer

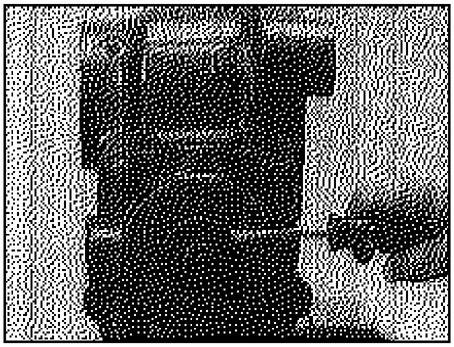
14. Inspect the sector shaft assembly for damaged adjusting screw threads. The retainer (44) must be securely staked in place. The adjusting screw must rotate by hand with no perceptible end play (lash).



Remove relief valve components

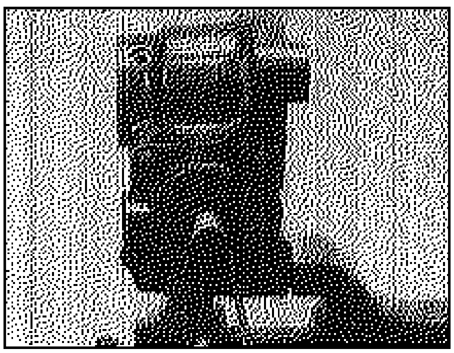
$^7/_8$" Socket

15. If equipped, remove relief valve cap (56), o-ring (57) and two-piece relief valve (58) from the valve housing. Discard the o-ring.



Remove dirt & water seal

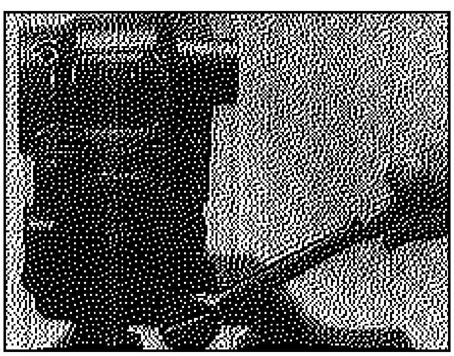
16. Remove and discard the dirt & water seal (2, 2B or 2C) from the input shaft (13 or 13A). Save this seal for comparison with the new seal.



Clean input shaft

Fine grade emery cloth

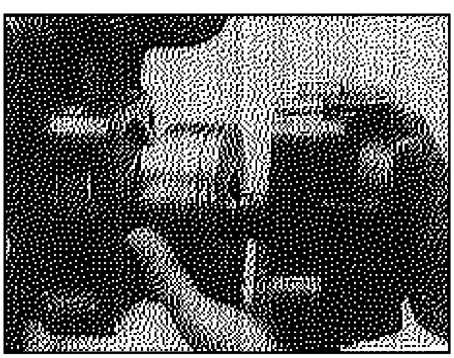
17. Clean any paint or corrosion from the exposed area of the input shaft.



Remove valve housing bolts

Torx socket E-16 or E-18

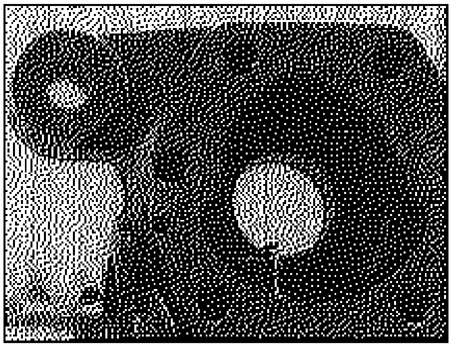
18. Remove the four torx head valve housing bolts (1).



Remove valve housing, worm and rack subassembly

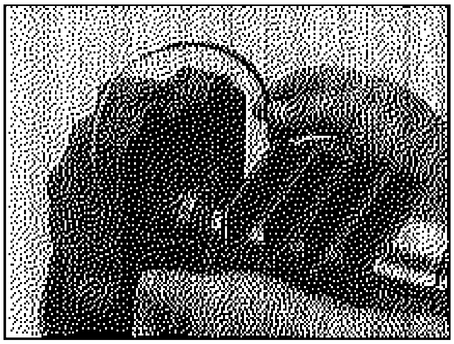
19. Be prepared for more fluid drainage and remove the rack piston subassembly. Place the assembly on a clean cloth. For the TAS85 it may help to rotate the input shaft to move the rack piston toward the lower end of the housing. This will force the valve housing to exit the main housing.

CAUTION **The set position of poppet seat and sleeve assemblies (22) must not be disturbed if the poppets are not going to be replaced or reset during disassembly.**



Pocket knife

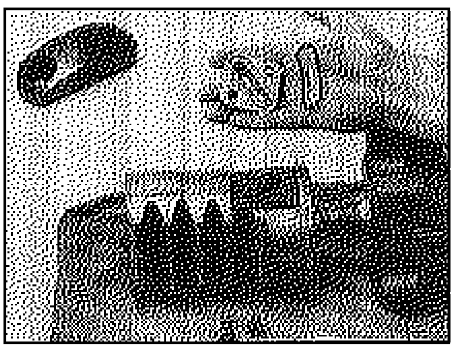
19A. **NOTE** If your gear is short “V” construction, the rack piston seal is on the end of the rack piston farthest from the input shaft. Remove the seal before removing the valve housing assembly to prevent the Teflon rack piston seal ring (20) from “hanging up” when it exits the housing. Expose the seal through the sector shaft cavity, then cut and remove the seal ring from the rack piston.



Remove seals

20. Remove and discard the valve housing seal rings (6 & 7).

⚠ CAUTION **Do not remove the input shaft, valve worm assembly or balls from the rack piston until the ball return guides are removed as damage to the ball guides will occur.**

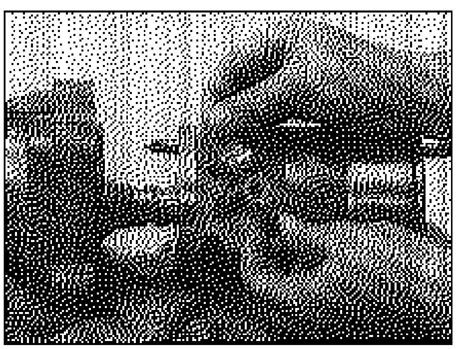


Remove ball return guide cap/strap

$^{5}/_{32}$" Allen wrench or T-30 Torx wrench

21. Remove and discard the two special sealing screws (31). Remove the ball return cap (30) and seal (29), or strap (32), discard the seal.

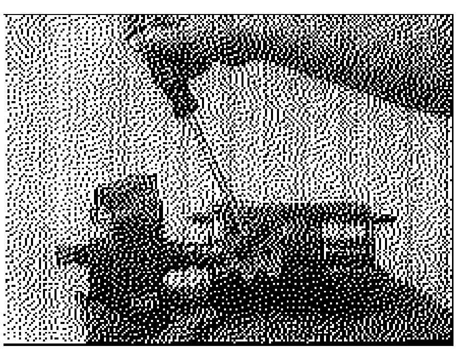
OR



Remove ball return guide clip

½" Socket

21A. Bend down the two tabs (tangs) that are against the hex head bolts. Remove two bolts and the clip. Discard the clip.

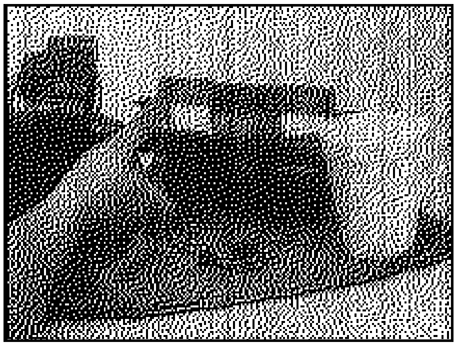


Remove ball return guides

Screwdriver

22. Make sure the rack piston is on a cloth so the steel balls that fall out won’t roll very far. Remove ball return guide halves (28) by carefully inserting a screwdriver between the rack piston and guides.

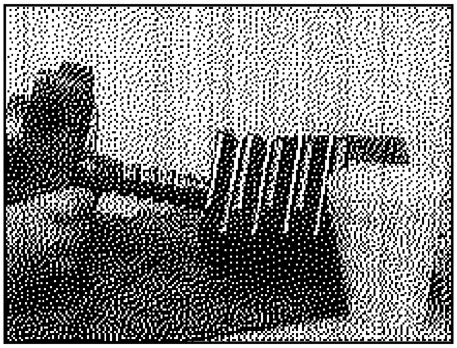
NOTE Left hand ball return guide halves are copper plated for identification and right hand guides are not plated. **Retain the guides for reassembly**



Remove steel balls

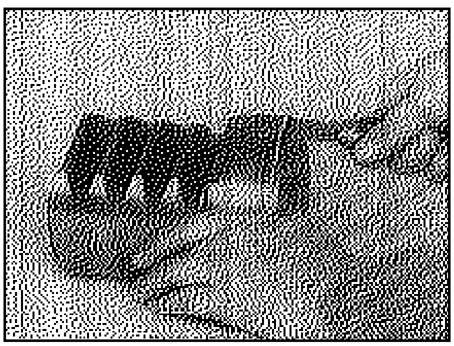
23. Remove the steel balls (27) from the rack piston (19) by rotating the input shaft, valve worm assembly until the balls fall out. Place the balls and return guides in a cup or other container. Count the balls, and make sure all have been removed.

CAUTION The steel balls are a matched set. If any are lost, the set must be replaced by service balls. Number of factory balls installed: TAS40-29, TAS55-31 (30 if date code is 337-89 or earlier), TAS65-32, TAS85-34.



Separate rack piston from worm subassembly

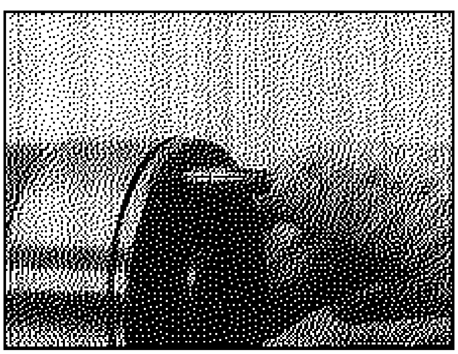
24. Remove the input shaft, valve/worm, valve housing subassembly from the rack piston.



Remove seal ring and o-ring

Pocket knife

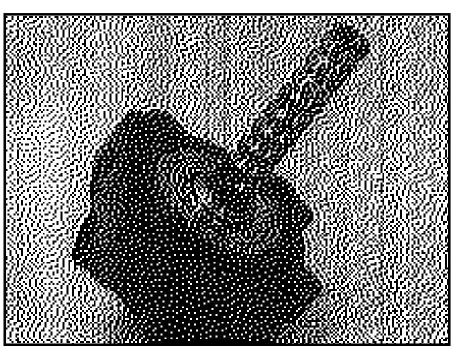
25. Cut and remove the Teflon seal ring (20) and o-ring (21) from the rack piston if not removed during disassembly step 19A.



Inspect poppet assemblies

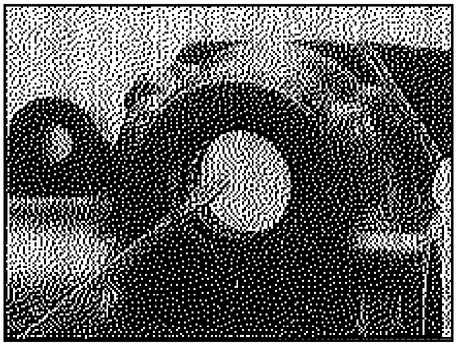
26. Push poppet stems, they should spring back. Push poppet seat, it should not move by hand. If components are bent or broken, poppet stems don't spring back, or poppet seat moves by hand, go to **Poppet Component Replacement** section on page 51. Otherwise, proceed to step 27.

NOTE TRW recommends the poppet adjuster seat and sleeve assemblies (22) not be removed unless replacement of poppet components is required.



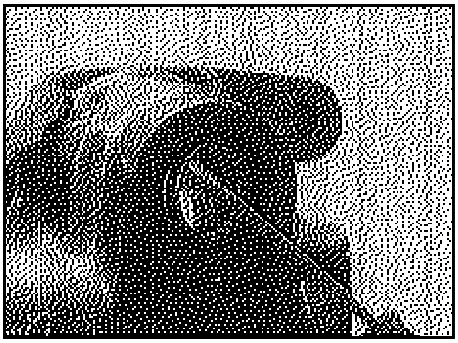
Inspect valve housing and worm screw

27. Inspect valve housing/worm screw subassembly for heat damage or bearing roughne3s. If these conditions are present, or if there was excessive internal leakage, or if preload adjustment is required, go to **Valve Housing/Worm Screw Disassembly** procedures on page 53. If not, proceed to step 28.



Remove retaining ring (if equipped)

28. **Standard gears only -** Remove the retaining ring (36) that is closest to the output end of the housing trunnion.

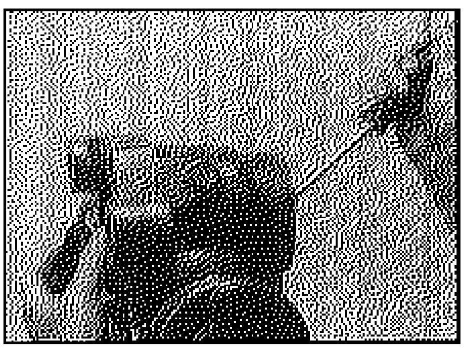


Remove dirt seal

Screwdriver

29. **Standard gears -** Remove and discard dirt seal (38).

    Step bore gears - Remove and discard the dirt and water seal (61).

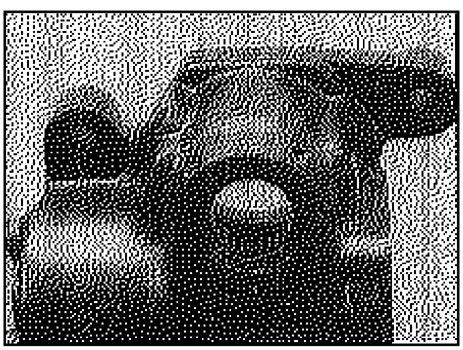


Remove pressure seal (and spacer washer if equipped)

Screwdriver

30. **Standard gears -** Insert a screwdriver into the housing bearing bore from the trunnion end, and carefully push the seal (41) and spacer washer (40) out of the other end of the bearing bore ***without damaging the sealing area of the bore.*** Discard the seal.

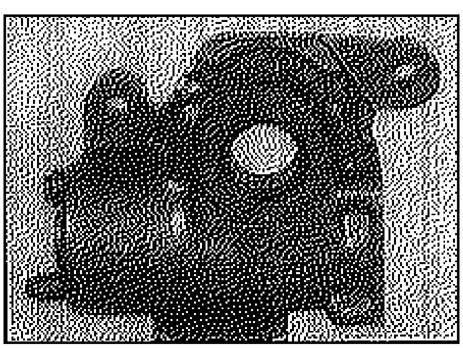
    Step Bore gears - Remove the retaining ring (63) through the side cover opening. Then insert a screwdriver through the trunnion opening, and carefully push the seal (41) out ***without damaging the sealing area of the bore.*** Discard the seal.



Inspect roller bearing

31. **Standard gears -** Inspect roller bearing (37) in the housing for brinelling or spalling. Inspect retaining ring for damage. If replacement of either part is required, go to **Roller Bearing or Retaining Ring Replacement** on page 60. If not, proceed to step 32.

    Step Bore gears - Inspect the roller bearing (37) for brinelling or spalling. If replacement is required, go to **Roller Bearing Replacement - Step Bore** on page 61. If not, proceed to step 32.



Inspect housing screws, and plugs

32. Inspect the following for damage:

    - Poppet fixed stop screw (52 or 52A) and washer (53) if equipped.
    - Poppet adjusting screw (59) and sealing nut (60)
    - Auto-bleed plug (51)
    - Manual bleed screw (50)
    - Auxiliary port plugs (54) and o-rings (55)

    If any are damaged, go to **Replace Housing Ports, Plugs and Screws** on page 62. If not, proceed to the Inspection Section.

Inspection

Make sure all sealing surfaces and seal cavities are free from nicks and corrosion. Any nicked or corroded surface requires part replacement to ensure proper sealing.

Wash all parts in clean, OSHA approved solvent. Air blow them dry only.

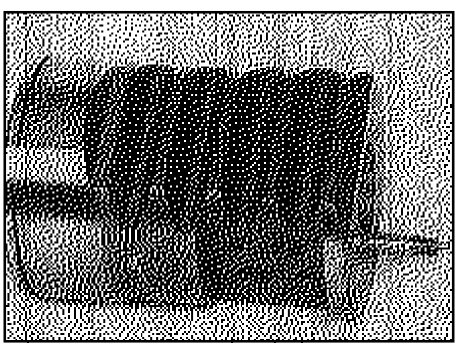
WARNING Because they are flammable, be extremely careful when using any solvents. Even a small explosion or fire could cause injury or death.

WARNING Wear protection and be sure to comply with OSHA or other maximum air pressure requirements.

WARNING Any of the following conditions present in the steering part indicates impact damage.

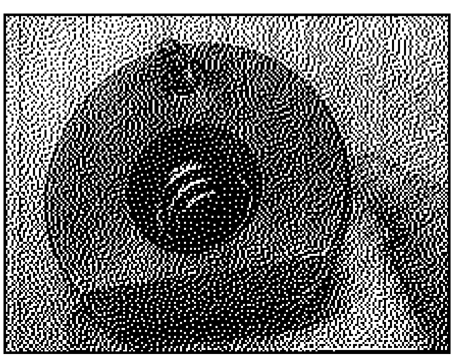
Condition	Area
Brinelling	● Ball track grooves of rack piston ● Ball track grooves of worm screw ● Bearing area of sector shaft ● Thrust washers and bearings in valve housing
Cracks or Breaks	● Bearing area of sector shaft ● Sector shaft teeth ● Rack piston teeth ● Housing ● Thrust washers and bearings in valve housing ● Worm screw
Twisted serrations	● Output shaft serrations

If one of these conditions is found in one component, be sure to inspect all components carefully for signs of impact damage. Replace components noted in individual inspection steps below if you suspect impact damage. Failure to replace all damaged components could result in a serious vehicle accident.



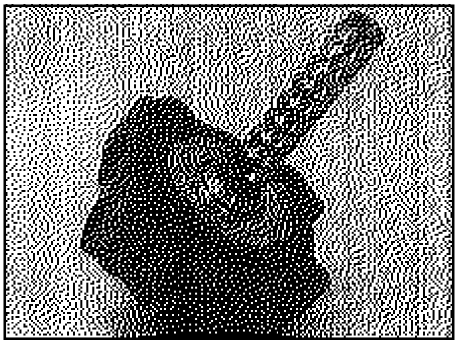
Inspect rack piston teeth

1. Inspect the rack piston (19) teeth for cracks or obvious damage. If teeth are damaged, replace the rack piston, sector shaft (42) and set of balls (27).



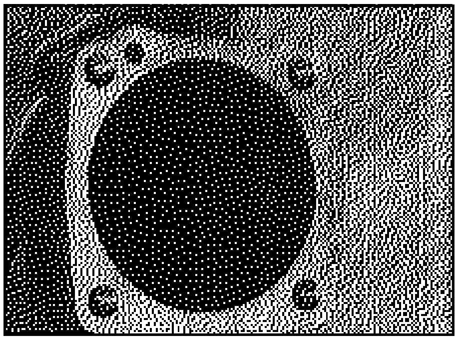
Inspect rack piston and worm ball track grooves

2. Inspect the rack piston (19) ball track grooves for brinelling or spalling. If either condition exists, replace the input shaft, valve/worm assembly, valve housing, rack piston subassembly and balls.



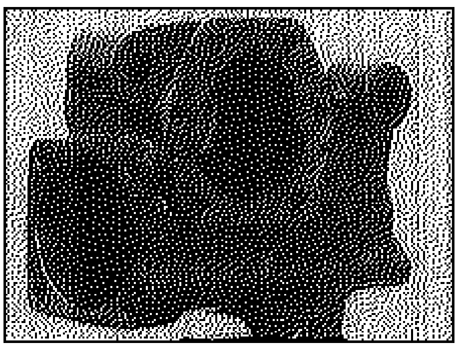
Inspect input shaft, valve/worm assembly sealing areas

3. Inspect the sealing area of input shaft and valve (13 or 13A) for nicks, and damage. Inspect for discoloration from excess heat. Inspect input shaft ball-track grooves for brinelling or spalling. If any of these conditions exist, replace the input shaft, valve worm assembly, valve housing and balls. Also replace rack piston if brinelling or spalling is found.



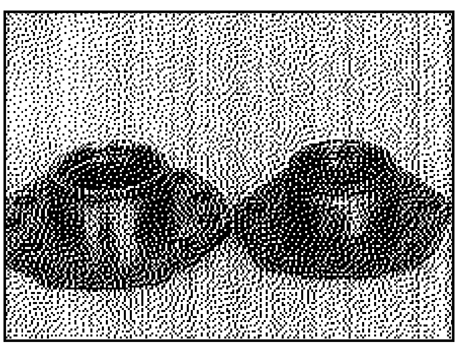
Inspect housing cylinder bore

4. Inspect the housing (34) cylinder bore. some scoring marks are normal. If there was internal leakage greater than 1 gal/min, make sure there are no damaged seals before replacing the housing.



Inspect housing faces

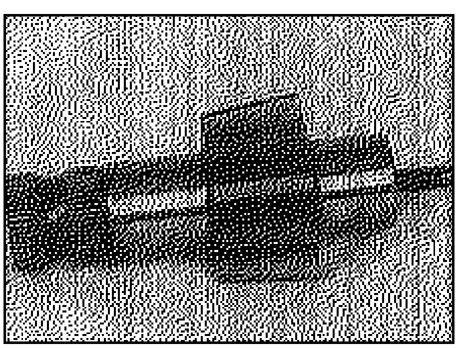
5. Inspect the housing faces for nicks that would prevent proper sealing. Replace the gear housing if these nicks are present and cannot be easily removed with a fine-tooth flat file without changing the dimensional characteristics.



Inspect side cover bushing/bearing

6. **TAS40, 55, 65:** Inspect side cover (46) DU bushing for damage. Also check side cover bushing to sector shaft clearance. If damage exists, or if clearance exceeds .008" (0.20 mm) replace side cover/bushing assembly.

TAS85: Inspect roller bearing in side cover assembly (46) for brinelling or spalling. If either condition exists, replace the side cover and bearing assembly.



Inspect sector shaft assembly

7. Inspect the sector shaft (42) bearing and sealing areas and sector teeth contact surfaces for brinelling, spalling or cracks. Run your fingernail edge across these areas to detect steps. Remove masking tape from the shaft and inspect for twisted or otherwise damaged serrations. If any of these conditions exist, replace the sector shaft.

NOTE A service sector shaft will come assembled with the adjusting screw (43) and retainer (44).

Assembly Preparation

Wash all parts in clean, OSHA approved solvent. Air blow-dry them only.

⚠WARNING	Because they are flammable, be extremely careful when using any solvents. Even a small explosion or fire could cause injury or death.

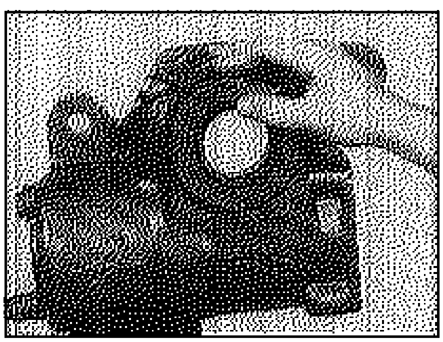
⚠WARNING	Wear eye protection and be sure to comply with OSHA or other maximum air pressure requirements.

Replace all seals, seal rings, and gaskets with new ones each time you disassemble the gear.

TRW Commercial Steering Division makes complete seal kits available. These parts can be purchased through most OEM parts distributors. Contact your local dealer for availability.

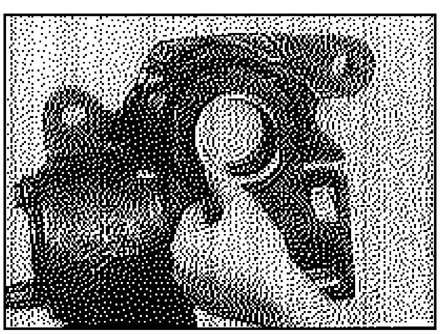
Assembly

Tools Required			Materials Required	
5/32" Allen wrench Lbf•ft Torque wrench Hammer J37705 (TAS40)	J37071 (TAS55/65) or J37071-A J38779 (TAS85) Press Punch	Ratchet Screwdriver Sockets Torx sockets Vise	ATF oil Grease (Exxon Unirex* RS460 Masking tape 7/16"-14 x 7 1/4" All Thread	Seal kit: Ross TAS400003 TAS550004 TAS650012 TAS850003or4



Install dirt seal

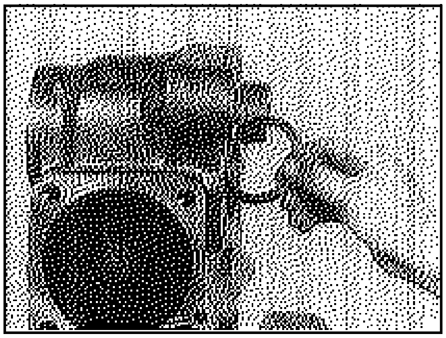
1. **Standard Gears -** Install new dirt seal (38) into the trunnion end of the housing sector shaft bore and against the bearing, with the seal lip out.



Install retaining ring

2. **Standard gears only -** Install the outside retaining ring (36), seating it firmly in the housing retaining ring groove.

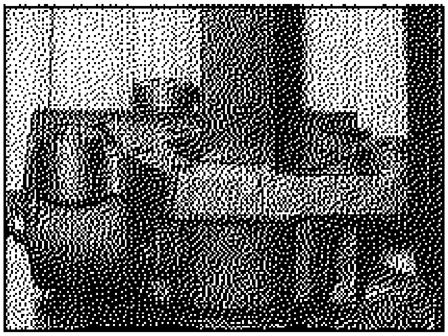
*Trademark of Exxon Oil Corp.



Install washer

1. **Standard gears only -** Install washer (40) into the side cover side of the housing seal bore with the small diameter piloted into the retaining ring.

> **NOTE** If you are working with a housing with an unmachined trunnion face, you may need to square the housing to the press with shims for step 4.

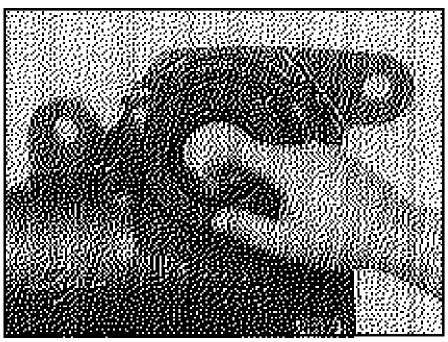


Press seal into housing

> J37705 (TAS40)
> J37071 or J37071-A (TAS55/65)
> J38779 (TAS85)
> Press

2. **All gears -** Assemble new seal (41) onto bearing and seal tool (short end) so the lip with the garter spring is toward the shoulder of the tool. Working from the side cover side of the housing, pilot the seal tool into the washer and bearing and press with a force of 100-800 lb (445-3,560 N) until the seal is seated firmly.

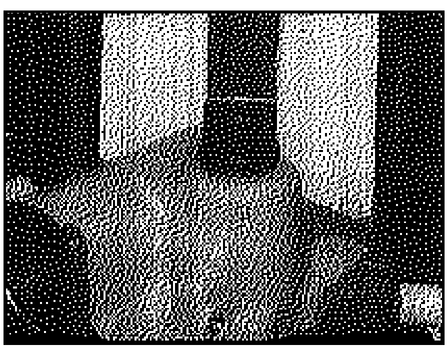
3. **Step Bore gears only -** Install the inside retaining ring (63) from the side cover opening. Seat the ring firmly in the retaining ring groove.



Grease the bearing and seal area

> Grease

4. **Standard gears -** Liberally pack the area between dirt seal (38) and pressure seal (41) including roller bearing with clean, high temperature industrial grease, 045422 Exxon Unirex* RS460.

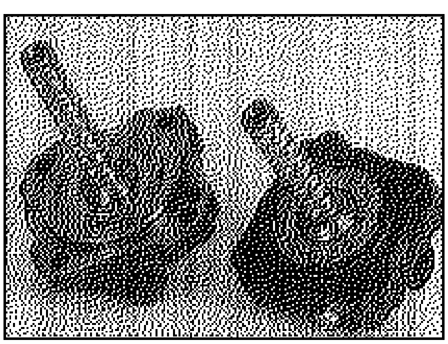


Install dirt & water seal

> J37071 or J37071-A
> Press

5. **Step Bore gears -** Install the dirt & water seal (61) with the bearing and seal tool (long end), making sure it is not cocked. <u>Press the seal only until it seats against the bearing, don't push it in farther.</u>

6. Liberally pack the roller bearing and new seals with clean, high temperature industrial grease, Exxon Unirex* RS460.



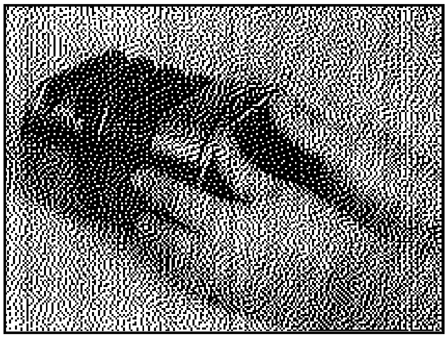
Assemble seal rings

7. Lightly oil new seal ring (7) and assemble in valve housing mounting face groove.

   TAS40,55,65: Oil new seal ring (6) and assemble in valve housing mounting face groove.

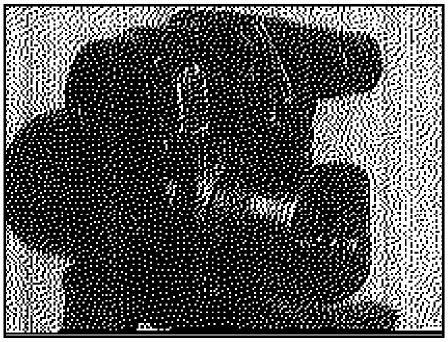
   TAS85: Oil new seal ring (6) and assemble in valve housing pilot groove.

*Trademark of Exxon Oil Corp.



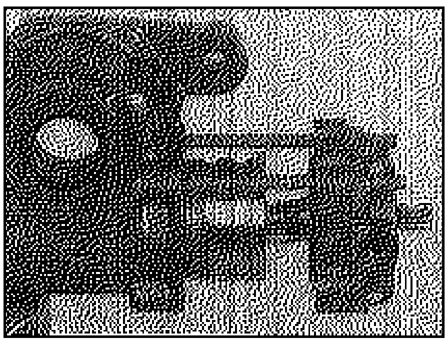
Install rack piston o-ring and seal ring

8. Install a new backup o-ring (21) and then a new Teflon seal ring (20) on rack piston (19). Do not over-stretch these rings as you install them. Do not allow the Teflon seal ring to be twisted.



Position rack piston in housing

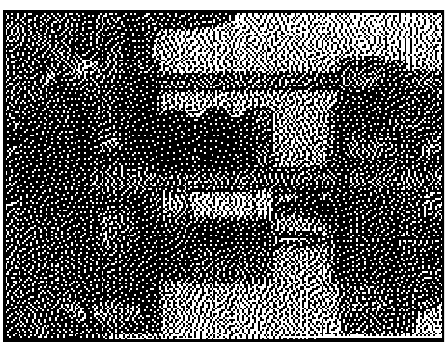
9. Apply clean oil to housing cylinder bore. Place the rack piston (19) in the housing piston bore with ball return guide holes up.



Insert worm and valve assembly into rack piston

$^{7}/_{16}$"-14 x 7$^{1}/_{4}$" All Thread

10. Insert the worm screw into the rack piston close to maximum depth, without the valve housing making contact with the poppet stem. Insert two 7/16"-14 All threads through valve housing bolt holes and tighten into housing to support the worm screw. Line up rack piston ball guide holes with the worm ball track grooves by rotating the input shaft.



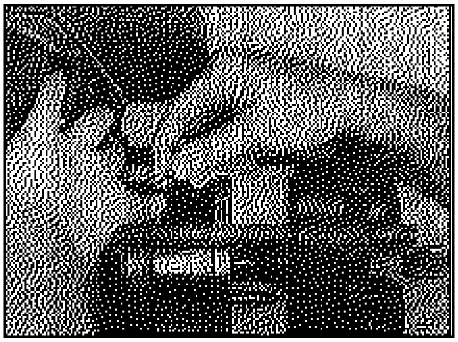
Assemble ball return guide halves

11. Assemble the ball return guide halves (28) into the rack piston until seated, rotate the input shaft slightly if necessary.

⚠ WARNING **Do not seat guides with a hammer. Damage to guides can result in subsequent lockup or loss of steering.**

⚠ CAUTION **If a new rack piston (19) or a new input shaft, valve, worm subassembly (13 or 13A) is being assembled, the balls (27) removed from the unit must be discarded and a service ball kit utilized. The balls in a service ball kit are sized to function in the ball track guide path as altered by component replacement.**

⚠ CAUTION **When using the service ball kit, use the correct quantity of service balls: TAS40-29,TAS55-31,TAS65-32,TAS85-34.**



Assemble balls

12. **Hold the ball return guides (28) firmly in place during this entire procedure.** Insert as many of the steel balls as you can through the hole in the top of the ball return guides. Rotate the input shaft to pull the balls down and around the ball track guide path. Continue until the correct number of balls are in the ball track guide path.

⚠ WARNING Hold down the ball return guides until cap or clip is reinstalled. Failure to hold the guides will result in a trapped ball or balls, which could cause a vehicle accident. If the ball guides become unseated (raise up) at any time, repeat the procedure starting at step 9.

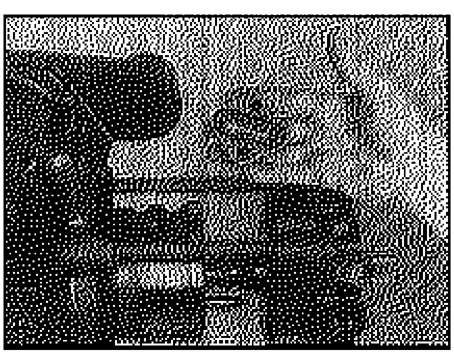
⚠ WARNING The correct number of balls are required for proper gear operation. Count the balls and insert each carefully as in step 11.

	TAS40	TAS55	TAS65	TAS85
Original	29	30/311*	32	34
Service	29	31	32	34

*TAS55 gears built prior to 338-89 were equipped with 30 balls

⚠ CAUTION Do not allow valve housing to contact the poppet stem or move more than 21/2 inches (69.1 mm) from upper end of rack piston during these procedures. This could incorrectly reset the poppet, or back out worm beyond closed ball loop, trapping balls.

⚠ CAUTION Remove any fluid present in the two screw holes. Fluid in these holes could cause improper clamp load when torquing the cap or strap screws.

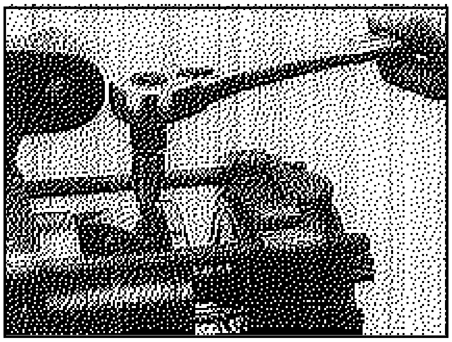


Assemble ball return guide cap

5/32" Allen or T-30 Torx socket
Lbf•in. Torque wrench
Grease

13. Place a new ball return guide cap seal (29) in the seal groove of the cap (30). Make sure the seal makes full contact with the rack piston surface. Install two new Allen or Torx head screws (31) and torque each screw alternately until a final torque of **18 lbf•ft** (24.5 N•m) is achieved.

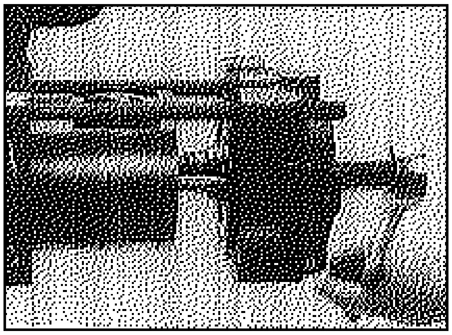
⚠ CAUTION Ball cap seal is greased to hold seal in groove while assembling. Be sure not to trap the seal outside of the groove during reassembly.



Assemble ball return guide strap

5/32" Allen or T-30 Torx socket Lbf•in. Torque wrench Grease

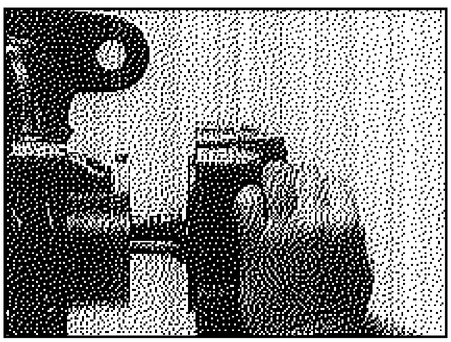
14. If your gear was equipped with the ball return guide strap (32), or if it was equipped with the clip, install the new ball return guide strap. Position it on the rack piston, install two new Allen or Torx head screws (31) and torque each screw alternately until a final torque of **18 lbf•ft** (24.5 N•m) is achieved.



Rotate input shaft to check for proper installation of balls

15. Rotate the input shaft from one end of travel to the other without contacting the poppet stem to the valve housing, and without moving the valve housing face more than 21/2" (69.1 mm) from input end (upper end) of rack piston. If you cannot rotate the input shaft, remove the balls and reassemble them.

> **⚠ WARNING** **If you install a gear on a vehicle with the worm shaft unable to rotate, the gear will not function correctly. Steering and gear failure may result.**



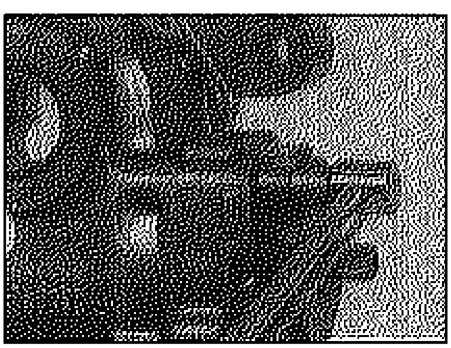
Install rack piston, worm, valve assembly

Oil

16. Apply clean oil to Teflon seal ring (20) on rack piston. Make sure there is a space of 3/8 - 1/2" (10.0-13.0 mm)
between valve housing (5) and poppet stem to prevent poppet contact at either end. Remove the All Threads, and push the rack piston assembly into the housing with the rack piston teeth toward the sector shaft cavity. Line up the valve housing cylinder feed hole with the gear housing feed hole. Make sure both o-rings in the valve housing remain in position.

> **⚠ CAUTION** **Do not damage the seal ring (19) while installing the rack piston into housing. If the seal ring end of rack piston enters the housing first, the seal ring will be destroyed when the rack is removed.**

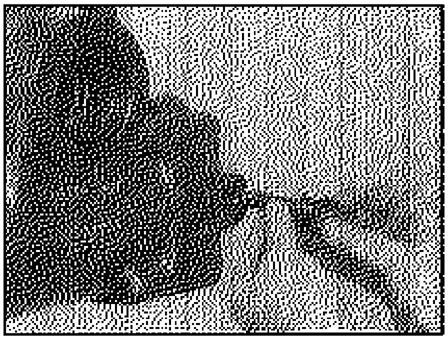
> **⚠ CAUTION** **The poppet seat and sleeve assemblies (22) must not bottom against the internal poppet stops in the steering gear until the gear is installed on the vehicle and the poppet adjustment procedures are performed.**



Install valve housing bolts

E-16 Torx socket (TAS40, 55,65) E-18 Torx socket (TAS85 Lbf•ft Torque wrench

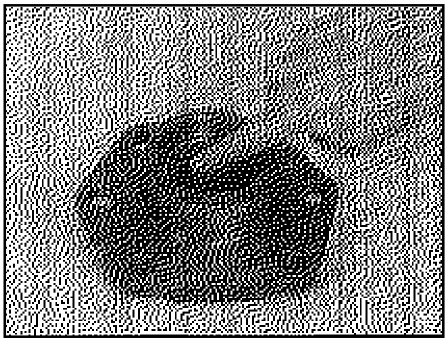
17. Lubricate and install the four valve housing bolts (1) into the housing. Torque the **TAS40, 55 and 65 bolts alternately to 80 lbf ft** (108.5 N•m). **Torque TAS85 bolts to 118 lbf-ft** (160 N•m).



Install relief valve parts

$^7/_8$" Socket
Lbf-ft Torque wrench

18. If the gear is equipped with a relief valve, assemble a new o-ring (57) on relief valve cap (56). Assemble the small end of tapered spring onto the pin on the relief valve cartridge and insert the assembly (58), (large end of tapered spring end first) into the relief valve cap cavity. Turn the relief valve cap as assembled into the valve housing and torque to **30 lbf•ft** (41 N•m).

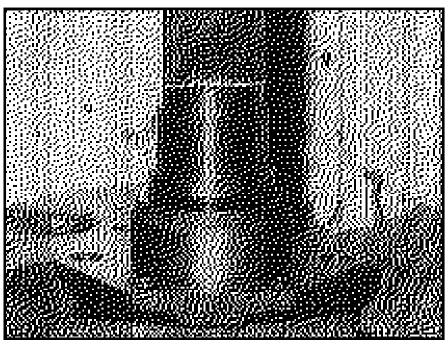


Lubricate side cover bushing/ bearing

19. **TAS40, 55, 65:** Lightly oil DU bushing. **Do not grease.**

    TAS85 only: Apply a generous amount of Exxon Unirex* RS460 (do not substitute another type of grease) to the caged bearing assembly inside the side cover.

    CAUTION **This bearing is sealed and will receive no lubrication from the hydraulic fluid in the gear. Failure to use the proper grease could result in premature bearing wear.**

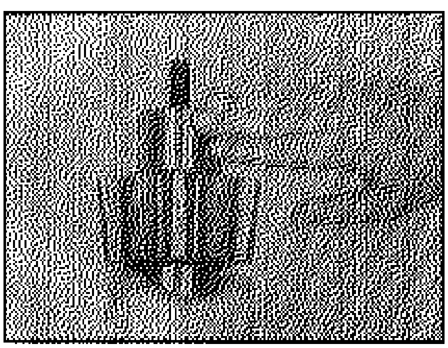


Press seal in side cover

J37705 (TAS40)
J37071 or J37071-A (TAS55/65)
J38779 (TAS85)
Press

20. Grease and assemble new seal (41) onto installation tool so the side with the garter spring is against the shoulder of the tool. Pilot the tool into the side cover (46) with a force of 100-800 lb (445-3560 N) until it is seated against the bearing or bushing.

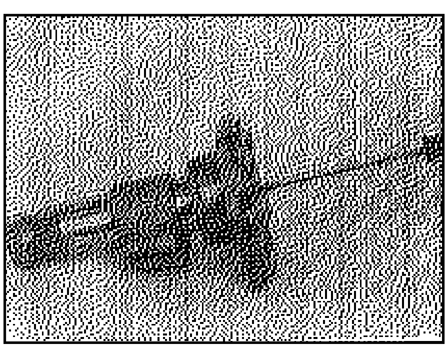
    CAUTION **Make sure the OD of the seal, and the ID of the bore are free from grease and dust, for proper engagement of the seal.**



Lubricate sector shaft

21. **TAS40, 55, 65:** Lightly oil short bearing area of sector shaft. **Do not grease**.

    TAS85 only: Apply a generous amount of Exxon Unirex* RS460 to the short bearing area of the sector shaft.



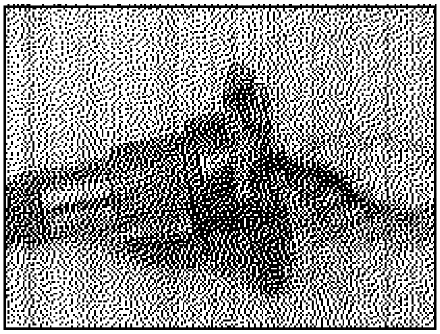
Install sector shaft into side cover

Screwdriver

22. Insert the sector shaft (42) into the side cover subassembly (46), and screw the sector shaft adjusting screw (43) counterclockwise into the side cover until the screw reaches solid height.

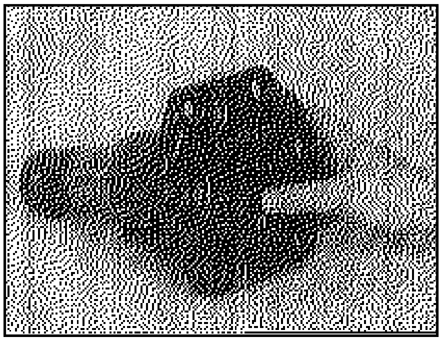
    Rotate the adjusting screw clockwise one half turn so the side cover will rotate freely on the sector shaft.

    *Trademark of Exxon Oil Corp.



Install jam nut

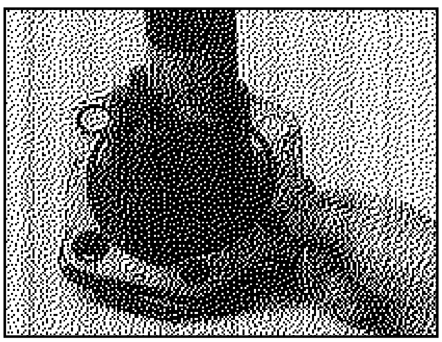
23. Install the sector shaft adjusting screw jam nut (47) onto the sector shaft adjusting screw (43) a few threads. Final adjustment will be made later.



Assemble vent plug

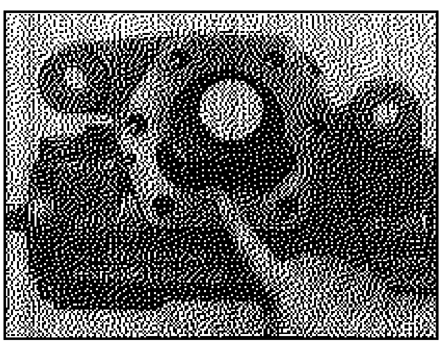
24. Press the new vent plug (49) into the hole provided in the side cover until the plug is bottomed.

⚠ WARNING Do not weld or otherwise plug this hole in any permanent manner. This is a safety vent which functions only if the side cover seal fails. If the seal fails and the plug cannot vent, the steering gear may lock-up or otherwise malfunction.



Install side cover gasket

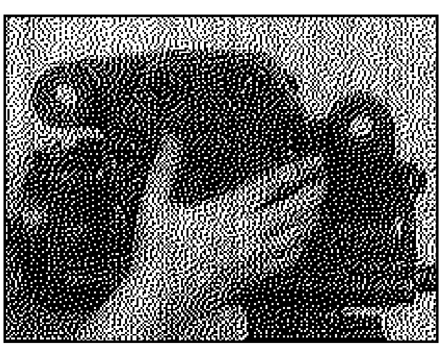
25. Apply clean grease to the new side cover gasket (45) to hold it in place and assemble it onto the side cover (46).



Center rack piston

26. There are four teeth on the rack piston. Rotate input shaft to position the rack piston so the space between the second and third tooth is in the center of the sector shaft opening. This will center the rack piston for assembly of sector shaft.

⚠ WARNING If the rack piston is not centered when sector shaft is installed, gear travel will be severely limited in one direction. This could result in an accident.

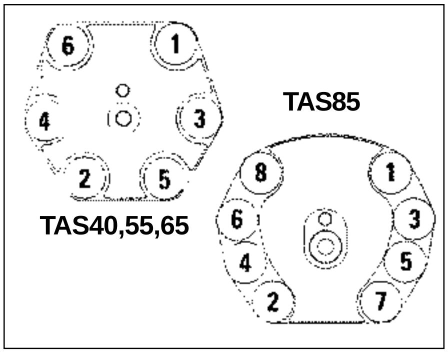


Install sector shaft and side cover into housing

Masking tape

27. Clean off any old tape on the serrations. Reapply one layer of masking tape. Install the sector shaft assembly into the housing. The center tooth of the sector shaft must engage the center space (between the second and third tooth) of the rack piston, with side cover gasket in place.

⚠ CAUTION If the serrations are not properly taped, they will damage the output seal (38) in housing, causing the seal to leak.

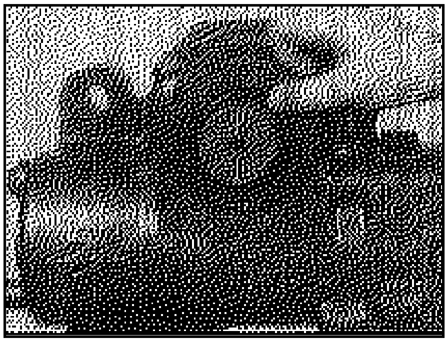


Install side cover bolts

$^{13}/_{16}$" Socket (TAS40) 15/16" Socket (TAS55,65,85) Lbf•ft Torque wrench

28. Install TAS40, 55 and 65 bolts in positions 3 and 4 first, by hand. For TAS85, Install in positions 3 and 6 first, by hand. Install the remaining special side cover bolts (48) into the side cover and torque them in the sequence shown. If bolts must be replaced, use bolts of the same design, type and length as those you removed. Do not use a substitute.

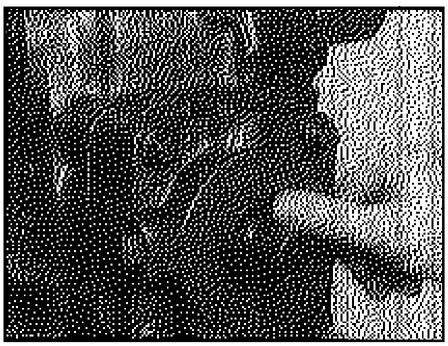
    Lubricate side cover bolts and torque TAS40 bolts to **118 lbf•ft** (160 N m), TAS55, 65 and 85 bolts to **170 lbf•ft** (230 N m).



Remove tape

29. **Standard gears** - Remove tape from sector shaft and pack the end of the housing trunnion area at the sector shaft with clean, high temperature industrial grease, Exxon Unirex* RS460. Apply more of the grease to the inside of the new trunnion dirt seal (39) and assemble it over the sector shaft and into the trunnion bore.

    Step bore gears - remove tape from the sector shaft.



Install dirt& water seal

Grease

30. Pack the end of the valve housing bore around the input shaft with clean, high temperature industrial grease, Exxon Unirex* RS460. Apply more of the grease to the inside of a new dirt and water seal (2, 2B or 2C) and install it over the input shaft. Seat the seal in the groove behind the serrations and against the valve housing.

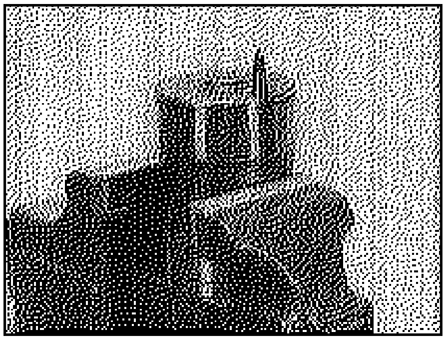
    This step may have already been completed if you disassembled the valve housing and worm screw for repair.

    Proceed to Final Adjustments on page 63.

*Trademark of Exxon Oil Corp.

Poppet Component Replacement

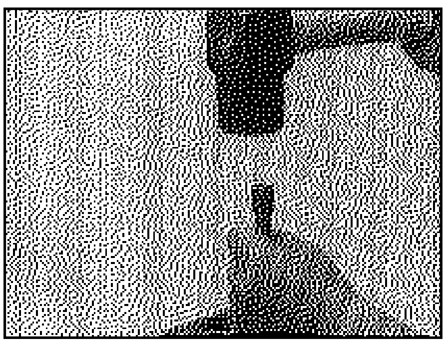
Tools Required		Materials Required
2 lb Sledge Lbf-ft Torque wrench J36452-A Press 3/8" x 6" drill rod	Ratchet Soft-jawed vise	Locquic "T" primer Loctite RC680



Place rack piston in vise

Soft-jawed vise

1. If the poppet assemblies are to be removed for replacement, place rack piston in a soft-jawed vise.

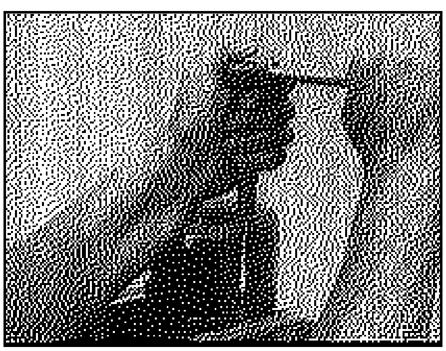


Loosen poppet adjuster seat

J36452-A
2 Lb Sledge

2. Slide special tool #J36452-A over the seat of poppet adjuster seat and sleeve assembly (22) and engage tool in the slots in the threaded sleeve. Hit the end of the tool firmly four or five times with a 2 lb sledge hammer to loosen Loctite.

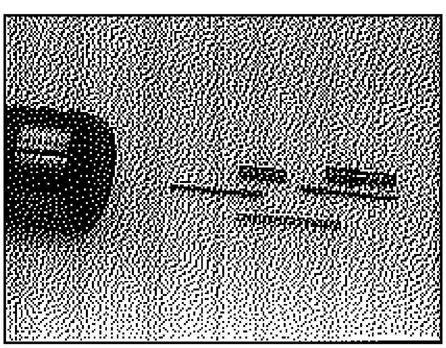
CAUTION **Poppet adjuster seat and sleeve assemblies (22) are retained by Loctite applied to the threads which makes the assemblies difficult to remove.**



Remove poppet adjuster seat

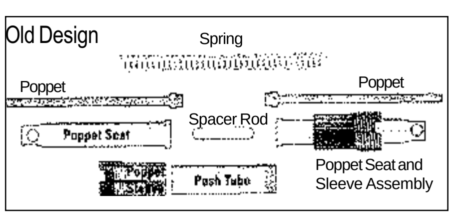
J36452-A

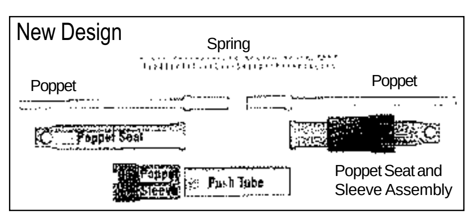
3. With a ratchet applied to the tool, turn one adjuster seat and sleeve assembly out of the rack piston. If the ratchet does not turn easily, strike the adjuster removal tool again with a hammer. If the engaging tangs won't stay in place while torquing, it might be necessary to hold in place with an arbor press while applying loosening torque. Discard poppet seat and sleeve assembly.

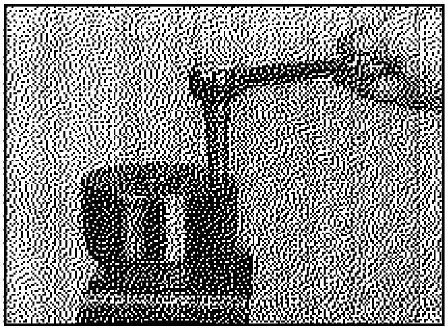


Remove poppet components

4. Remove the two poppets (23 or 23A), spring (24), and push tube (26). Some gears will also have a spacer rod (25) to be removed.



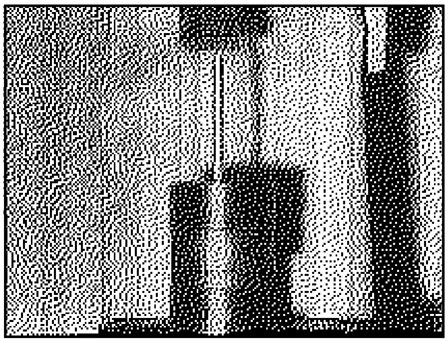




Remove other seat & sleeve if necessary

5. Remove and discard remaining poppet seat and sleeve assembly only if required.

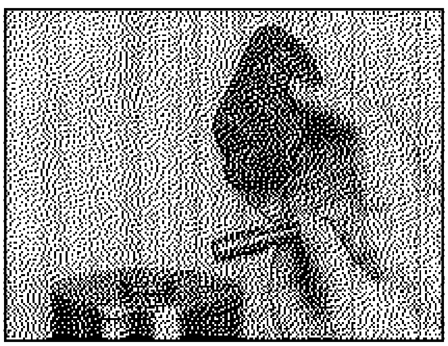
NOTE
It is possible to reset one poppet adjuster seat and sleeve assembly for automatic poppet adjustment while it is in the rack piston if one adjuster seat and sleeve assembly and the poppets, spring, spacer rod and push tube are removed.



Reset remaining poppet seat and sleeve assembly

Press
3/8" X 6" Drill rod

6. It one poppet seat and sleeve assy. (22) was left in rack piston, it can be reset for automatic poppet adjustment by inserting a 3/8" (9.52 mm) diameter X 6" (152.4 mm) drill rod down through the poppet seat hole at the opposite end of the rack piston and against the adjuster seat to press the seat in until it bottoms against the adjuster sleeve.

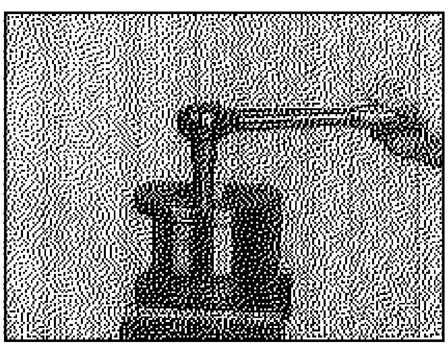


Apply Locquic "T" primer and Loctite RC680

Locquic "T" primer
Loctite RC680

7. Carefully apply Locquic "T" primer to the threads in poppet holes, and threads on the new seat and sleeve assemblies (22). Allow to dry for ten minutes; then carefully apply Loctite R RC680 to same threads.

CAUTION
Do not allow Loctite or Locquic to get on the adjuster seat component of the adjuster seat and sleeve assembly. The poppets will not function properly.



Install one poppet seat and sleeve assembly

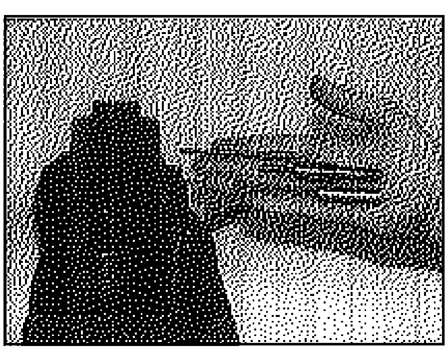
Soft-jawed vise

8.

WARNING
Wear eye protection while assembling poppets, as spring loaded poppets could eject and cause eye injury.

Place rack piston (19) in a soft-jawed vise and turn one new poppet adjuster seat and sleeve assembly (22), (slotted end out) into the poppet hole in one end of rack piston.

WARNING
Do not use the spacer with the new poppet design. You must install the spacer with the old poppet design.

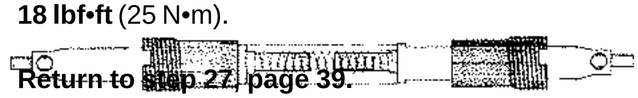


Install remaining poppet components

J36452-A
Lbf•ft Torque wrench

9. From the other end of the poppet hole in the rack piston, install: one poppet (23A), poppet spring (24), push tube (26), other poppet (23A), and the other new poppet adjuster seat and sleeve assembly (22). The new components will stack up as shown below.

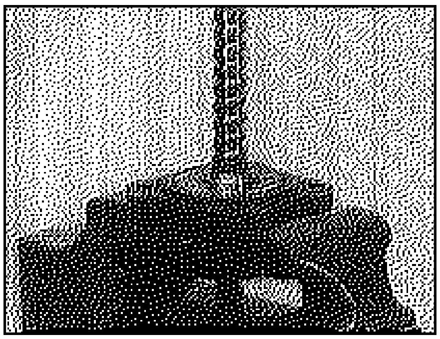
Torque both poppet seat and sleeve assemblies to **18 lbf•ft** (25 N•m).



Return to step 27, page 39.

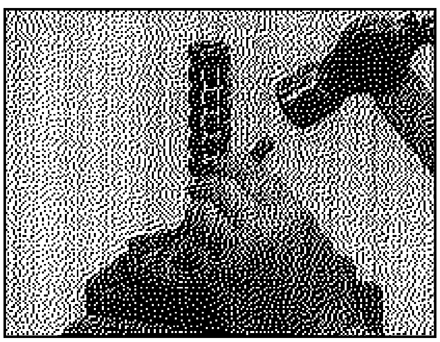
Valve Housing/Worm Screw Disassembly

Tools Required			Materials Required
Hammer Lbf-ft Torque wrench Punch, center Punch, roll pin	Lbf-in. Torque wrench J37464 J37070 J37073 Screwdriver	Small probe or pick Sockets 12-point sockets	



Place valve housing and valve assembly in vise

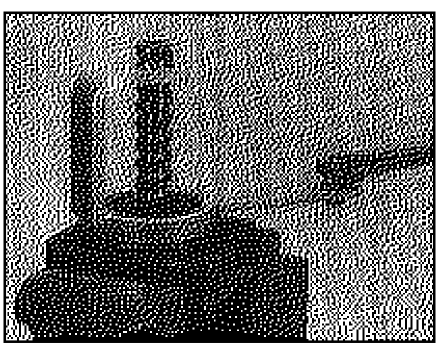
1. With worm vertical, place the valve housing, input shaft, valve/worm assembly in a vise.



Unstake adjuster locknut

Roll pin punch
Hammer

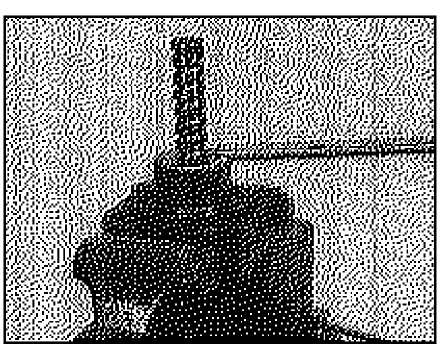
2. Unstake the valve housing (5) where it was upset into the adjuster locknut (18) slot. Also unstake adjuster nut from adjuster (17).



Remove bearing adjuster locknut

J37464

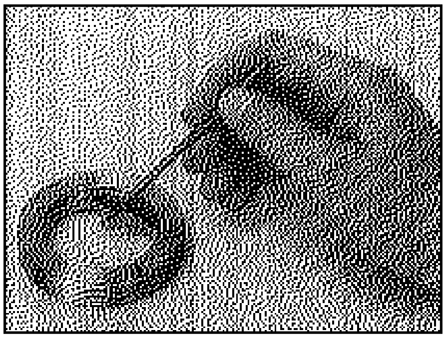
3. Turn bearing adjuster locknut (18) out of the valve housing.



Remove bearing adjuster

J37070

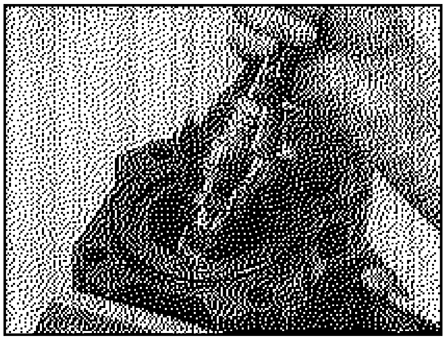
4. Turn bearing adjuster (17) out of the valve housing.



Remove seal ring and o-ring

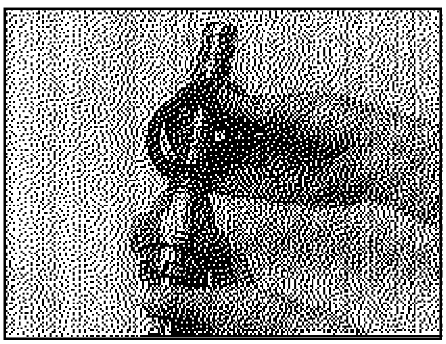
Small probe or pick

5. Remove and discard seal ring (8) and o-ring (9) from bearing adjuster.



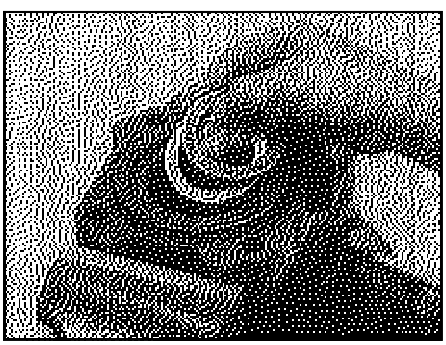
Remove input shaft

6. Remove the input shaft, valve/worm assembly (13 or 13A) from the valve housing.



Remove thin washer and bearing

7. Remove thin thrust washer (16) and thrust bearing (15) from input shaft.

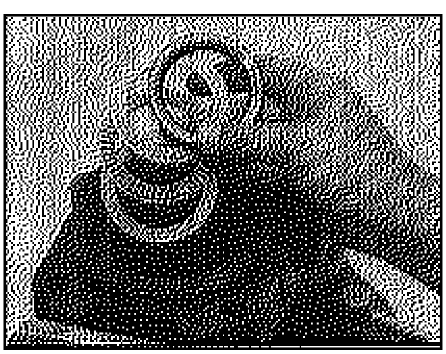


Remove thick washer and bearing

8. Remove thick thrust washer (12) and thrust bearing (15) from valve housing.

⚠ CAUTION **Input shaft, valve worm assembly must not be disassembled further. The components were a select fit at assembly and are available only as part of this subassembly. If disassembled further, the subassembly must be replaced.**

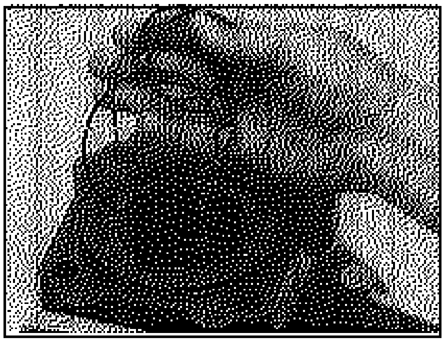
OR



Remove bearing components

8A. For alternate construction TAS65 gears, remove spacer sleeve (14), thin washer (16), thrust bearing (15) and thick washer (12).

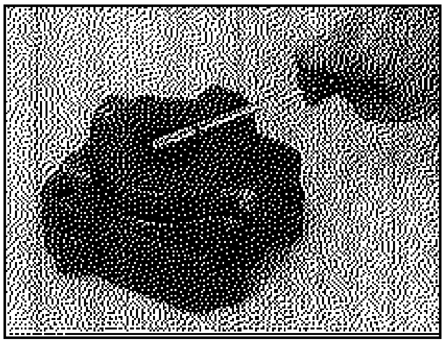
⚠ WARNING **If the TAS65 gear has a ball bearing and ball race in the valve housing, remove them and call TRW for disposition. Do not rebuild the gear.**



Remove seal rings and o-rings

Small probe or pick

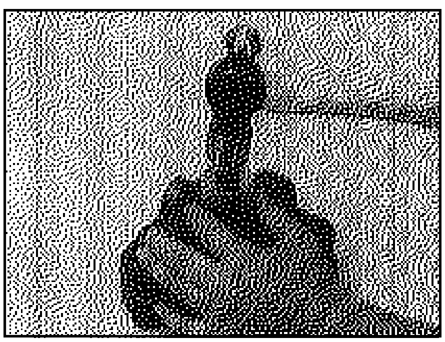
9. Remove and discard seal rings (10) and (8) and o-rings (11) and (9) from valve housing (5).



Remove retaining ring

Screwdriver

10. Turn over valve housing and remove retaining ring (3).



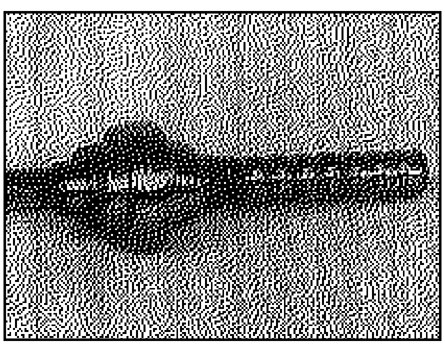
Remove seal

$1^1/_8$" Socket
Hammer

11. **CAUTION** **Exercise special care when removing seal (4) to prevent damaging the valve housing seal bore.**

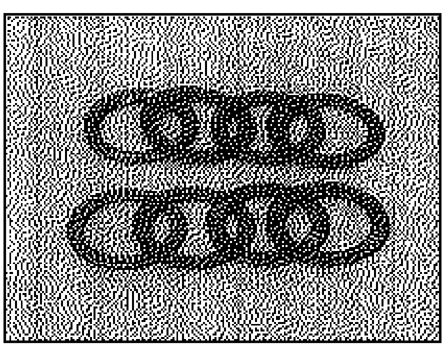
Tap input shaft seal (4) out of valve housing. Discard seal.

NOTE The valve housing also utilizes a ball plug for manufacturing purposes that must not be removed.



Inspect input shaft, valve worm assembly sealing areas

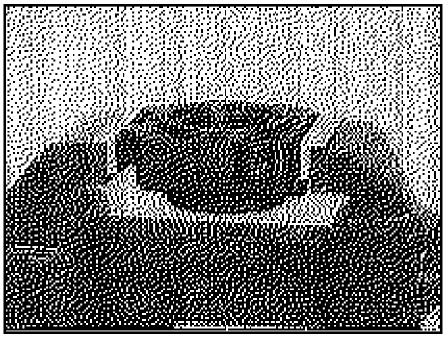
12. Inspect the sealing areas of input shaft and valve (13 or 13A) for nicks and run your fingernail edge across the sealing surfaces to detect step3. Inspect for discoloration from excess heat. Inspect input shaft ball-track grooves for brinelling or spalling. If any of these conditions exist, you must replace the input shaft, valve/worm assembly, valve housing and balls. Also replace rack piston if brinelling or spalling is found.



Inspect thrust washers and bearings

13. Inspect the thrust bearing (15) rollers for any deterioration. Inspect thrust washers (12 & 16) for brinelling, spalling, or cracks. Replace any part with these conditions.

Alternate Construction TAS65: If spacer sleeve (14) is damaged, **replace the input shaft/valve/worm subassembly** and use thick washer and roller bearing only during reassembly.



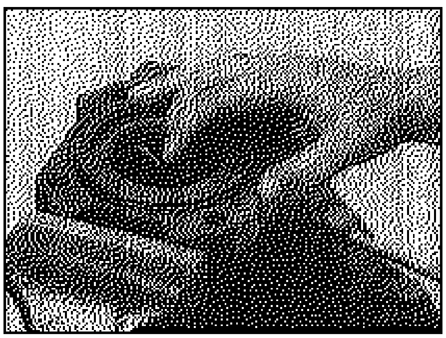
Place valve housing in vise

14. Place valve housing (5) firmly in a vise so the input shaft, valve/worm assembly (13 or 13A) can be assembled vertically with the worm end up.

CAUTION **Do not clamp against threaded port hole or relief valve hole sealing faces when placing valve housing in vise.**

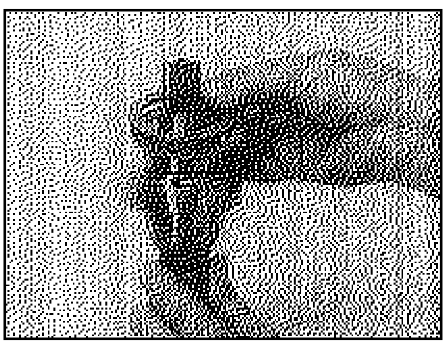
Assemble o-ring

15. Oil and assemble a new o-ring (9) into its counterbore in valve housing.



Assemble other o-ring and seal ring

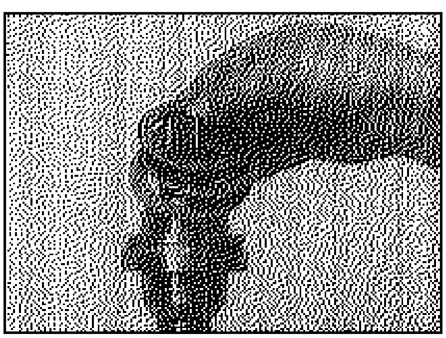
16. Lightly oil and assemble new o-ring (11) and new seal ring (10) into the large diameter seal ring groove in valve housing, bending and working them in and smoothing them out as necessary.



Install roller thrust bearing and washer

17. Install roller thrust bearing (15) and then the thick washer (12) (square side out) onto input shaft end of input shaft, valve, worm subassembly, seating them against the input shaft thrust face.

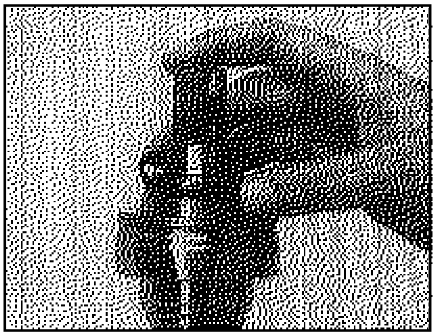
OR



Install bearing components

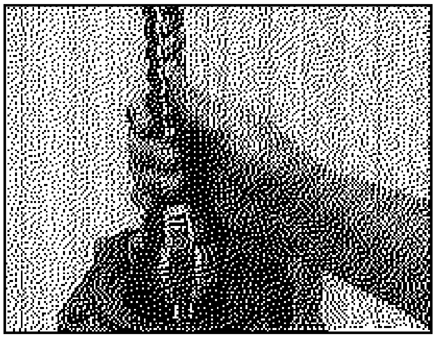
17A. **Alternate construction TAS65:** Assemble spacer sleeve (14) onto input shaft with radiused side toward valve. Make sure sleeve is square. Assemble thin washer (16), thrust bearing (15) and thick washer (12) onto input shaft behind spacer sleeve.

CAUTION **If you are replacing the input shaft valve/worm assembly, discard spacer sleeve and thin washer.**



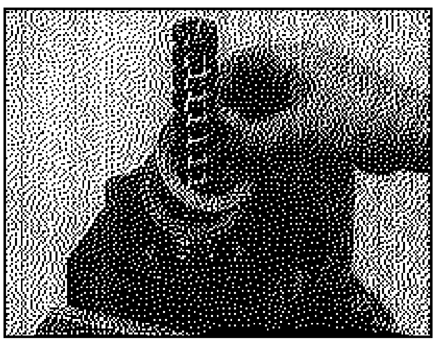
Install seal ring

18. Lightly oil and assemble new seal ring (8) onto input shaft and against the thick thrust washer (12) to hold the bearing components in place.



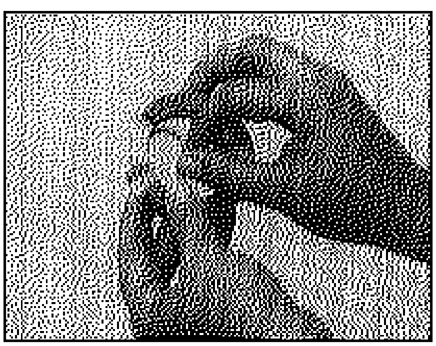
Assemble input shaft, valve worm & bearing assembly

19. Dip the input end of the input shaft, valve, worm assembly (13 or 13A) into oil up to the worm lead. Assemble the input shaft end of the assembly into the valve housing (5) until it is firmly seated.



Assemble bearing and thrust washer

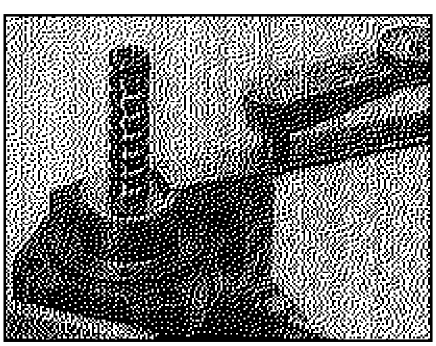
20. Apply oil and assemble the other thrust bearing (15) then the thin thrust washer (16) over the ball groove end of worm, and seat them against the shoulder of input shaft, valve, worm assembly



Assemble seals in bearing adjuster

21. Lightly oil a new o-ring (9) and assemble into the seal groove in bearing adjuster (17). Oil and work a new seal ring (8) into the same groove and smooth it out.

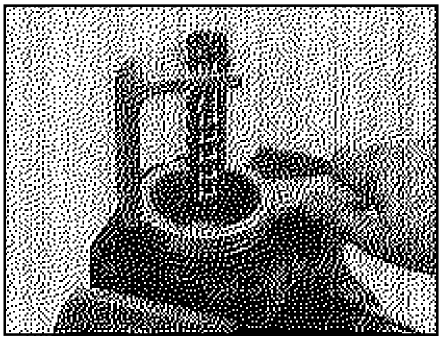
NOTE Be sure the valve housing, adjuster locknut and bearing adjuster threads are clean and free of any staking burrs that would impede the locknut from turning freely on adjuster or the adjuster turning freely in valve housing.



Assemble bearing adjuster

J37070
Lbf•ft Torque
wrench

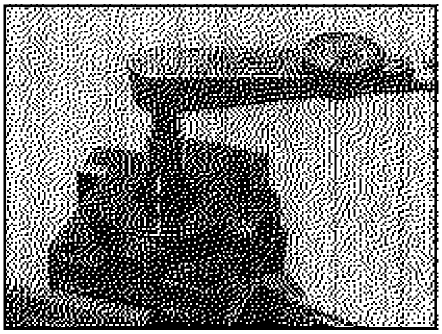
22. Lightly oil and assemble bearing adjuster (17) over worm and into valve housing. Torque adjuster to **13 lbf•ft** (18N•m) indicated torque using a torque wrench inserted in adjuster tool #J37070. This will seat the components. Back off adjuster 1/4 to 1/2 of a turn.



Assemble new locknut

J37464

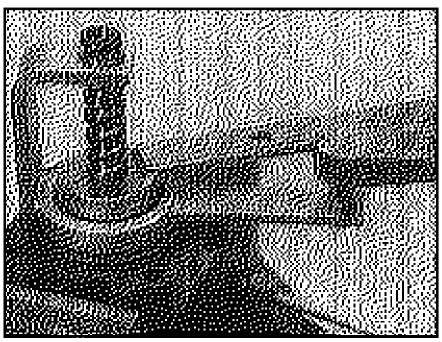
23. Lightly oil and assemble new locknut (18) onto bearing adjuster (17) with radius (slightly rounded) side down. Tighten slightly to keep the bearing adjuster in place.



Adjust to required input torque

$^{3}/_{4}$" or 11/16" 12-point socket
Lbf•in. Torque wrench

24. Reverse assembly in vise so the worm end is down. With an inch pound torque wrench on the input shaft, note torque required to rotate the input shaft 360° in each direction. Tighten the bearing adjuster to increase the maximum torque at the input shaft 5-10 lbf•in. (.5-1.0 N•m) over that which was previously noted.

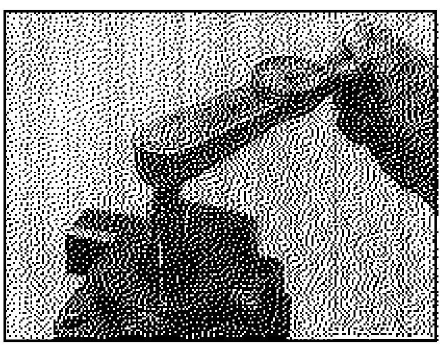


Torque locknut

J37070
J37464
Lbf•ft Torque wrench

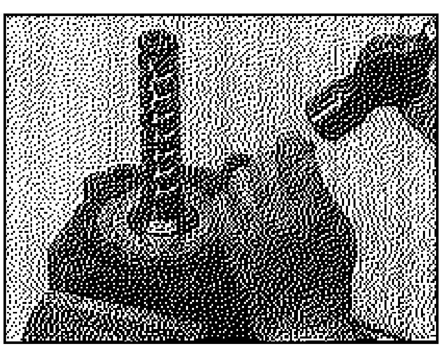
25. Again reverse the assembly in vise. Torque locknut while holding bearing adjuster in position established in step 24 with appropriate adjuster tool. When using a torque wrench in locknut tool J37464, the torque wrench reading should be **112 lbf•ft** (152 N•m).

NOTE The bearing adjuster, locknut and valve housing flange should be flush. If not, the seal ring (8) or o-ring (9) may the out of position; which will result in axial lash.



Check input shaft torque

26. Recheck input shaft torque. It should match torque measured in step 24. Repeat steps 24 and 25 if necessary.

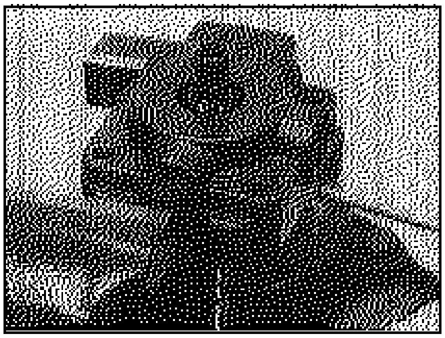


Stake valve housing and locknut

Center punch
Hammer
$^{13}/_{16}$" Socket
Lbf•in. Torque wrench

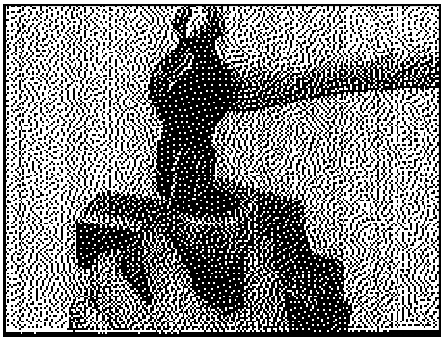
27. Stake valve housing into the clockwise most corner of two opposing slots in locknut (18). Stake the locknut into the adjuster (17) in two places (180 apart) at threaded area. Choose areas that have not been previously staked.

After staking, torque required to rotate input shaft must be between **5-10 lbf•in.** (.5-1.0 N•m) **greater** than the torque noted in step 24. Torque value must **not exceed 22 lbf•in**. (2.5 N•m). Unstake and readjust if necessary.



Reposition subassembly in vise

28. Reposition worm screw/valve housing subassembly in soft-jawed vise, clamping tightly against valve housing, so the worm screw is pointing down.



Install input shaft seal

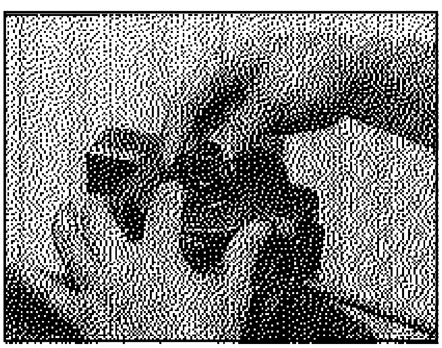
J37073
Hammer

29. Apply clean grease (Exxon Unirex* RS460) to the outside and inside diameters (fill cavity between the lips) of the new input shaft seal (4) and assemble it, garter spring side first over the input shaft. Align seal in the valve housing seal bore.

Assemble seal installer tool #J37073, small diameter end first, over the input shaft and against the seal. Tap the seal installer tool until the tool shoulder is squarely against the valve housing. This will correctly position the seal in the housing bore just beyond the retaining ring groove.

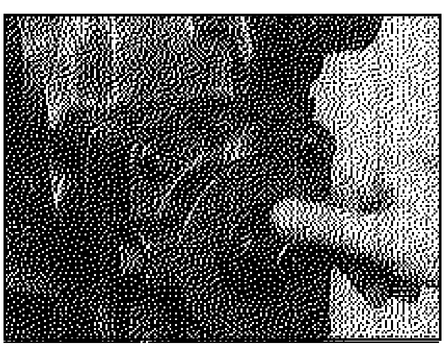
Remove any seal material that may have sheared off and is in seal bore and retaining ring groove.

CAUTION **The input shaft seal must be square in the seal bore and installed to the correct depth.**



Insert retaining ring

30. Insert new retaining ring (3) into its groove in valve housing.



Install dirt & water seal

Grease

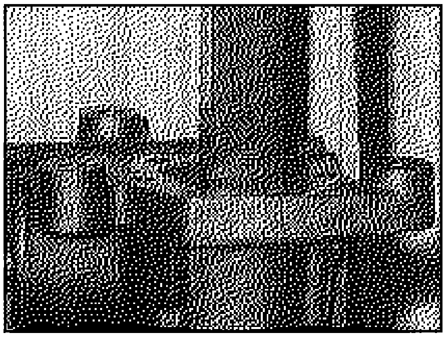
31. Pack the end of the valve housing bore around the input shaft with clean, high temperature industrial grease, Exxon Unirex* RS460. Apply more of the grease to the inside of a new dirt and water seal (2, 2B or 2C) and install it over the input shaft. Seat the seal in the groove behind the serrations and against the valve housing.

Return to step 28, page 40.

*Trademark of Exxon Oil Corp.

Roller Bearing or Ret. Ring Repl. - Standard

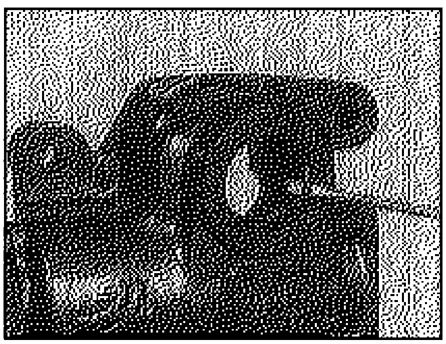
Tools Required		Materials Required
Press J37071 (TAS55, 65) or J37071-A (TAS55, 65) J37705(TAS40) J38779 (TAS85)	Screwdriver	



Remove roller bearing if required

J37705
J37071
or J37071-A
J38779
Press

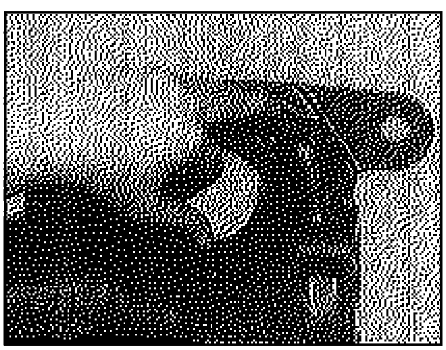
1. **Standard Gears Only:** If roller bearing (37) in housing needs to be replaced, place the bearing removal end (long end) of the bearing and seal tool against the side cover end of the bearing and press it out of trunnion end of the bearing bore. Discard bearing.



Remove retaining ring

Screwdriver

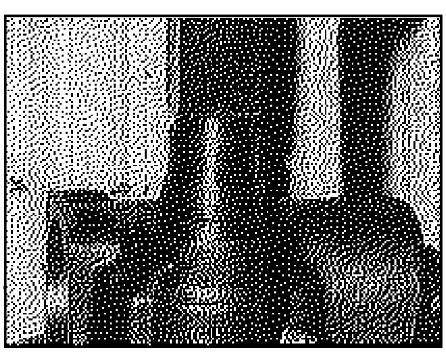
2. **Standard Gears Only:** If the retaining ring (36) that is still in the housing bearing bore needs to be re-placed, remove it through the trunnion end of the bearing bore to protect the pressure seal bore area from being damaged.



Install retaining ring

Grease

3. **Standard Gears Only:** Insert retaining ring (36), if it was removed, into the housing bore from the trunnion end (to protect sealing area). Make sure it is seated in the retaining ring groove closest to side cover end of the bearing bore. Lubricate the bearing bore.



Press in housing roller bearing

J37705
J37071 or
J37071-A
J38779
Press

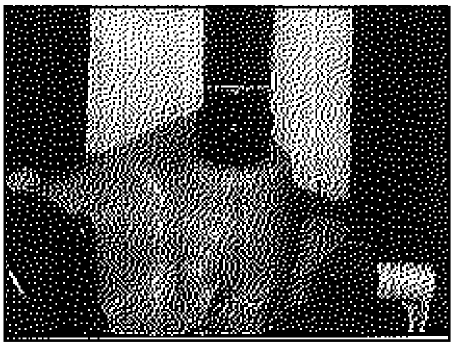
4. **Standard Gears Only:** Press the roller bearing (37) into the housing from the trunnion end of bearing bore until it is seated against the retaining ring. **Don't push it farther.** Be sure the housing is square with the press base and the bearing is not cocked.

CAUTION Use the bearing installation end of the tool (short end). If the bearing removal end of the bearing & seal tool is used to press in bearing, the cage on the new bearing may be damaged.

Return to step 32, page 40.

Roller Bearing Replacement - Step Bore

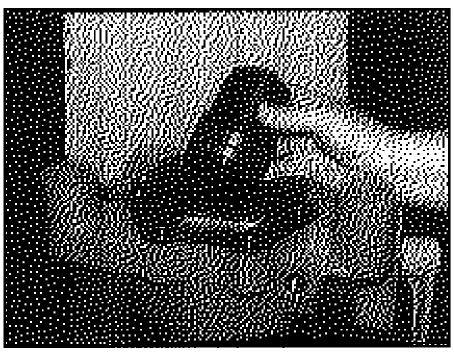
Tools Required	Materials Required
Press J37071-A (TAS65 Step Bore gear)	



Remove roller bearing if required

J37071 -A
Press

1. If roller bearing (37) in housing needs to be replaced, place the bearing removal end (long end) of the bearing and seal tool against the trunnion end of the bearing and press it out of the side cover end of the bearing bore. Discard bearing.



Press in housing roller bearing

J37071-A
Press

2. Press the roller bearing (37) into the housing from the side cover end of the bearing bore until it is seated against the step bore. Be sure the housing is square with the press base and the bearing is not cocked.

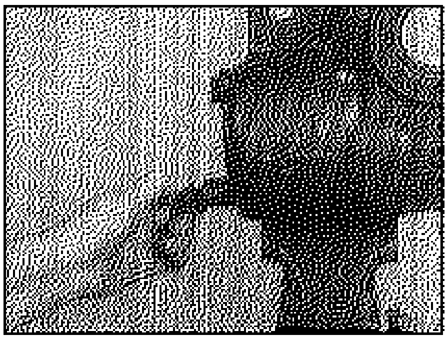
CAUTION **Use the bearing installation end of the tool (short end). If the bearing removal end of the bearing & seal tool is used to press in bearing, the cage on the new bearing may be damaged.**

NOTE If the unmachined trunnion face is not square, use shims to square it before pressing in the bearing.

Return to step 32, page 40.

Replace Housing Ports, Plugs, Screws, Fittings

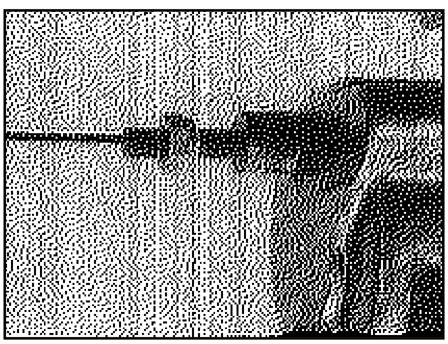
Tools Required	Materials Required
Allen wrench Torx sockets Sockets Lbf•in. Torque wrench Lbf•ft Torque wrench	



Replace poppet fixed stop screw

$^5/_8$" Socket or
E-14 Torx socket
lbf•ft Torque wrench

If damaged, remove and replace the poppet fixed stop screw (52 or 52A) and washer (53) if equipped. Replace with poppet fixed stop screw (52A), discard the washer. Torque to **48 lbf•ft** (65 N•m).

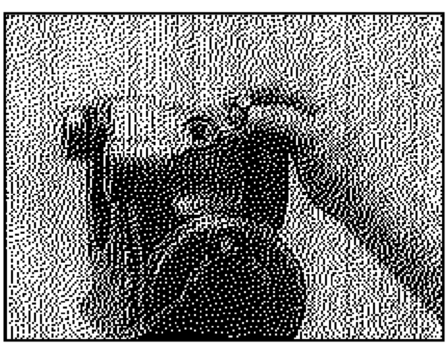


Replace poppet adjusting screw

$^7/_{32}$" Allen wrench
$^3/_4$" or $^5/_8$" closed-end wrench
Lbf•ft Torque wrench

If damaged, remove poppet adjusting screw (59) and sealing nut (60) without allowing the nut to change its position on the screw.

Assemble the new nut onto the new adjusting screw, matching its position to the nut and screw removed. Torque sealing nut to **35 lbf•ft** (47 N•m).

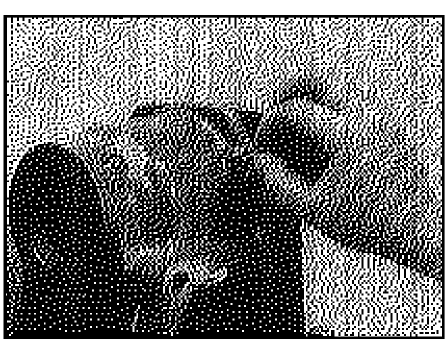


Replace automatic bleed screw, and aux. port plugs

E-14 Torx socket
Lbf•ft Torque wrench

If damaged, remove and replace automatic bleed plug (51). Torque to **48 lbf•ft** (65 N•m).

If damaged, remove and replace permanent auxiliary port plugs (54) and o-rings (55). Assemble new o-rings (55) on port plugs and torque to their respective ports in the housing or valve housing to **30 lbf•ft** (41 N•m).



Replace manual bleed screw

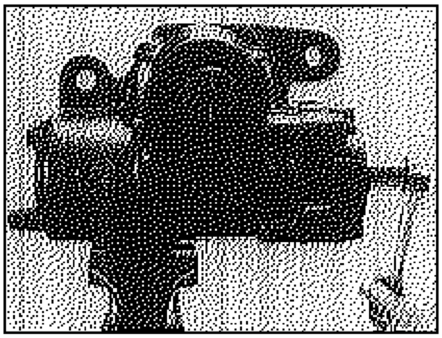
$^5/_{16}$" Hex socket
Lbf•in. Torque wrench

If damaged, remove and replace manual bleed screw (50). Torque to **45 lbf•in**. (3.4 N•m).

Return to inspection section, page 41.

Final Adjustments

Tools Required		Materials Required
Box-end wrench Lbf•ft Torque wrench Lbf•in. Torque wrench	Screwdriver Sockets	



Center steering gear

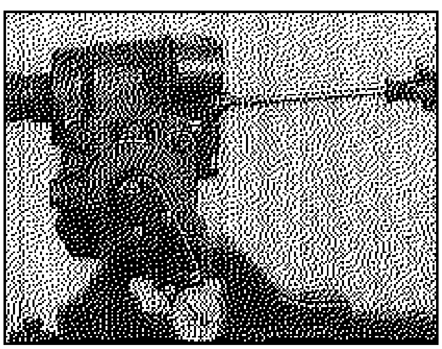
$^3/_4$" and $^{11}/_{16}$" Socket or box end wrench

1. To center the steering gear, rotate input shaft, valve worm assembly (13 or 13A) until the timing mark on the end of the sector shaft (42) is in line with the timing mark on the end of housing trunnion.

CAUTION **Do not rotate the input shaft more than 1.5 revolutions from center position until the steering gear is installed, during poppet setting procedure. Doing so could make the automatic poppets inoperative, which would require disassembly of steering gear to reposition poppet seat and sleeve assemblies.**

NOTE Initial poppet contact will occur at less than one input shaft rotation in one direction from steering gear center position, if new or reset poppet adjuster seat and sleeve assemblies are assembled in the unit.

NOTE Worm preload adjustment was set when input shaft, valve and worm were assembled into valve housing.

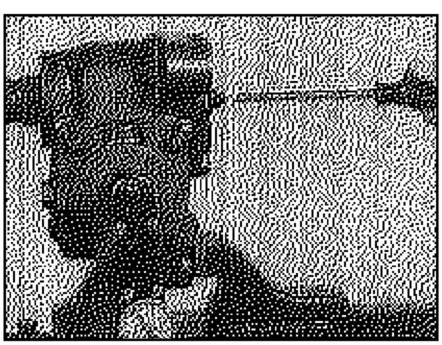


Tighten adjusting screw

Lbf•in. Torque wrench
Screwdriver
$^{11}/_{16}$ " or $^3/_4$" Socket

2. With adjusting screw jam nut (47) loose, turn sector shaft adjusting screw (43) clockwise to provide 45-50 lbf•in. (5-5.5 N•m) of torque required to rotate the input shaft, valve/worm assembly (13 or 13A) through one half turn (1800) each side of center.

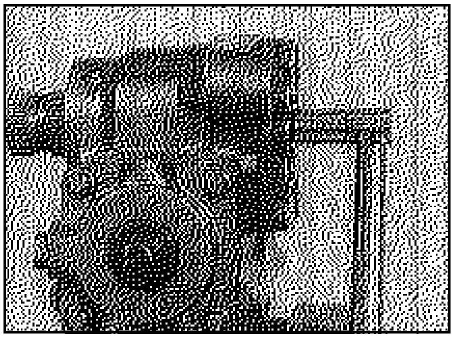
NOTE This procedure will properly mesh and seat the rack piston and sector shaft teeth for final adjustments.



Loosen adjusting screw and note torque

Lbf•in. Torque wrench
Screwdriver
$^{11}/_{16}$" Socket

3. Turn sector shaft adjusting screw (43) counterclockwise one half turn and **note maximum torque** required to rotate the input shaft, valve/worm assembly through one half turn (180°) each side of center.



Adjusting screw

$^{3}/_{4}$" Socket
$^{11}/_{16}$" Socket
Lbf•ft Torque wrench
Lbf•in. Torque wrench

4. Adjust sector shaft adjusting screw (43) clockwise **to increase** maximum torque noted in step 3 by **7 lbf•in** (.8 N•m). Tighten jam nut (47) firmly against side cover while holding the adjusting screw in position. **Final torque jam nut to 43 lbf•ft** (58 N•m) and check input shaft, valve/worm assembly torque again. Readjust if input shaft torque exceeds 40 lbf•in. (4.5 N•m).

Reinstallation

- Verify that axle stops are set to manufacturer's wheelcut or clearance specifications.
- Bolt gear to frame, torque to vehicle manufacturer's recommendation.
- Connect return line to reservoir in TAS return port.
- Connect hydraulic line from pump to pressure port in TAS unit.
- Connect steering column to input shaft, torque pinch bolt to vehicle manufacturer's recommendation.
- Install pitman arm on output shaft, with timing marks aligned. Torque bolt to vehicle manufacturer's recommendation.
- Connect drag link to pitman arm.

Poppet Resetting

IF Poppets remain unchanged from when gear was removed from vehicle, and gear is being installed on the same vehicle with no change in axle stops or linkage.	After installation, check to make sure poppets relieve in both turns just before axle stop contact is made. If not, use resetting procedure beginning on page 24.
IF Poppets were replaced with new components or reset during gear disassembly, and are ready for automatic positioning.	Use poppet setting procedure on page 15.
IF Poppets may have been moved during disassembly or reassembly procedures, or gear is being installed on a different vehicle.	Use poppet resetting procedure beginning on page 24.

Maintenance Tips

Never high-pressure wash or steam clean a power steering gear while on or off the vehicle. Doing so could force contaminants inside the gear and cause it to malfunction.

Make sure vehicle wheel cut or clearances meet manufacturer's specifications, and make sure pitman arm timing marks are aligned properly to **prevent internal bottoming** of the steering gear.

Regularly check the fluid and the fluid level in the power steering reservoir.

Keep tires inflated to correct pressure.

Never use a torch to remove pitman arm.

Investigate and immediately **correct the cause of any play, rattle, or shimmy** in any part of the steering system.

Make sure the steering column is aligned properly.

Encourage drivers to report any malfunctions or accidents that could have damaged steering components.

Do not attempt to weld any broken steering component. Replace the component with original equipment only.

Do not cold straighten, hot straighten, or bend any steering system component.

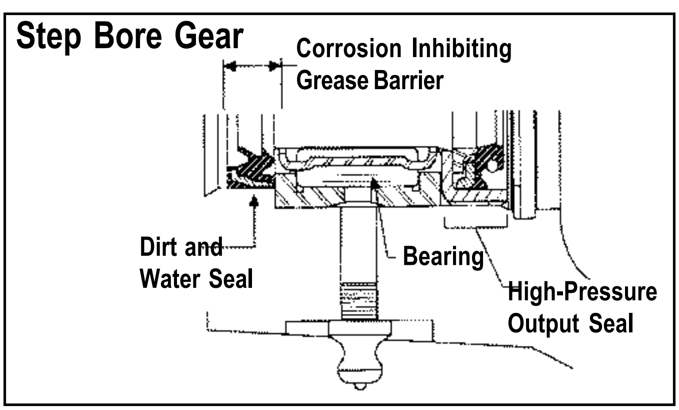
Always **clean off around the reservoir filler cap** before you remove it. Prevent dirt or other foreign matter from entering the hydraulic system.

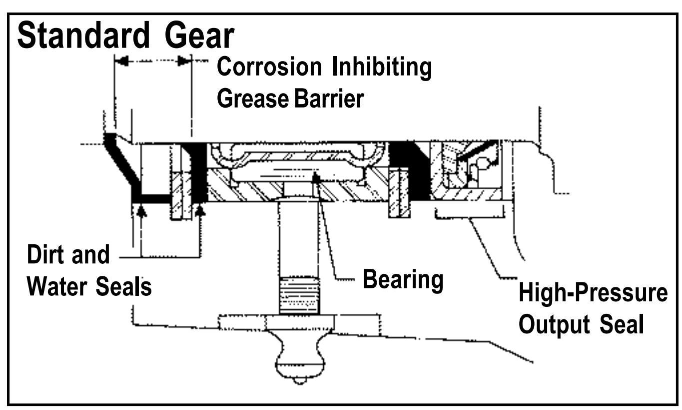
Investigate and correct any external leaks, no matter how minor.

Replace reservoir filters according to requirements.

If you feel the vehicle is developing excessively **high hydraulic fluid temperatures**, consult with your vehicle manufacturer for recommendations.

Maintain grease pack behind the output shaft dirt and water seal as a general maintenance procedure at least twice a year, in the Spring and Fall. Grease fitting is provided in housing trunnion. Use only NLGI grade 2 multipurpose chassis lube, and use only a hand operated grease gun on fitting. Add grease until it begins to extrude past the sector shaft dirt and water seal.





Glossary

Aerated Fluid
Fluid with air bubbles

Automatic Bleed Systems
Gears are mounted in such a way that trapped air can be forced out of the system "automatically" without loosening bleed screw. Follow procedure on page 13.

Axial
In-out movement along an axis (imaginary straight line on which an object moves)

Brinelling
Dents

Date Code
Date the steering gear was built (Julian date)

Discoloration
Change in color

External Leakage
Fluid Leaking out of the system or steering gear

Full Turn
Hub contacts axle stop

Integral Power Steering
Steering gear has manual steering mechanism, hydraulic control valve, and hydraulic power cylinder all within gear housing.

Impact
The application of torques and forces to steering gear components during accidents or other similar events which exceed the hydraulic capacity of the steering gear

Internal Leakage
Fluid leaking inside the gear

Lash
Free play

Manual Bleed Systems
Gears are mounted in such a way that an air pocket could form in one end of the steering gear. The bleed screw is positioned so trapped air can be forced out when loosened.
Follow procedure on page 13.

OSHA
Occupational Safety and Health Administration

Poppets
Unloading valves, reduce pressure in full turns.

Relief Valve
Limits maximum supply pressure

Return Line
Line that connects steering gear to reservoir to recirculate hydraulic fluid

Rotary Control Valve
Controls flow in internal cavities

Scoring
Scratch

Shock Load
Shake or jar

Spalling
Flaking or chipping

Subassembly
An assembled unit that fits into a larger unit

Supply Line
Line that connects pump to steering gear

Twisted Serrations
Output shaft serrations damaged by impact overload. Serrations can be twisted at the area between the large diameter of the shaft and the end of the serrations.

TAS Steering Gear Services Manual

WRITE OF CALL FOR INFORMATION AND ADDED DETAILS CONCERNING YOUR INSTALLATION AND APPLICATIONS.

PHONE: 765.423.5377

FAX: 765.429.1868

WRITE: **TRW Commercial Steering Division**
P.O. Box 60
800 Health Street
Lafayette, IN 47902

Price: $4.50

WA-TRW1108 REV.7/98

Ask for the Allison

HIGHWAY SERIES

Ask your truck dealer for a complete listing of vehicle models featuring
Allison Highway Series transmissions,
or contact your Authorized Allison Distributor.
For the representative close to you,
visit www.allisontransmission.com.

DRIVING TRANSMISSION TECHNOLOGY®

Information highway.

Visit www.allisontransmission.com for a comprehensive library of informational brochures, including Mechanic's Tips, Parts Catalogs, Troubleshooting Manuals and Service Manuals.

Allison Transmission.

OM5824EN 201001

Printed in USA

Allison Transmission®

DRIVING TRANSMISSION TECHNOLOGY®

3000/4000
OPERATOR'S MANUAL

HIGHWAY SERIES

JANUARY 2010

Operator's Manual

2010 JANUARY

OM5824EN

Allison Transmission

VOCATIONAL MODELS

Highway Series (HS)

3000 and 4000 Product Families
4th Generation Controls with Prognostics

3000 HS   4000 HS   4500 HS

Allison Transmission
Allison Transmission, Inc.
P.O. Box 894   Indianapolis, Indiana   46206-0894
www.allisontransmission.com

NOTES

TABLE OF CONTENTS

5.0 CARE AND MAINTENANCE

TRADEMARK USAGE

The following trademarks are the property of the companies indicated:

- Allison DOC® is a Registered Trademark of Allison Transmission, Inc.

IMPORTANT SAFETY INFORMATION

IT IS YOUR RESPONSIBILITY to be completely familiar with the warnings and cautions in this manual. These warnings and cautions advise of specific methods or actions that can result in personal injury, equipment damage, or cause the equipment to become unsafe. These warnings and cautions are not exhaustive. Allison Transmission could not possibly know, evaluate, or advise the service trade of all conceivable procedures by which service might be performed or of the possible hazardous consequences of each procedure. Accordingly, ANYONE WHO USES A SERVICE PROCEDURE OR TOOL WHICH IS NOT RECOMMENDED BY ALLISON TRANSMISSION MUST first be thoroughly satisfied that neither personal safety nor equipment safety will be jeopardized by the service methods used.

Vehicle manufacturers integrate Allison transmissions into vehicles used for a variety of vocations and services. The vehicle manufacturer is responsible for identifying the specific operating conditions to which the vehicle will be subjected and to communicate the appropriate means for preventing unintended vehicle movement within those conditions, in order to ensure vehicle and operator safety. The vehicle owner and operator should be aware of and follow the vehicle manufacturer's operating instructions and warnings related to parking and preventing unintended vehicle movement.

Proper service and repair is important to the safe and reliable operation of the equipment. The service procedures recommended by Allison Transmission (or the vehicle manufacturer) and described in this manual are effective methods for performing service and diagnostic operations. Some procedures require using specially designed tools. Use special tools when and in the manner recommended.

The WARNINGS, CAUTIONS, and NOTES in this manual apply only to the Allison transmission and not to other vehicle systems which may interact with the transmission. Be sure to review and observe any vehicle system information provided by the vehicle manufacturer and/or body builder at all times the Allison transmission is being serviced.

WARNINGS, CAUTIONS, NOTES

Three types of headings are used in this manual to attract your attention:

WARNING: A warning is used when an operating procedure, practice, etc., which, if not correctly followed, could result in personal injury or loss of life.

CAUTION: A caution is used when an operating procedure, practice, etc., which, if not strictly observed, could result in damage to or destruction of equipment.

NOTE: A note is used when an operating procedure, practice, etc., is essential to highlight.

1.0 SCOPE OF MANUAL

1.1 SCOPE OF MANUAL

This Operator's Manual contains a variety of information about the Allison 3000 and 4000 Product Families Transmission, and its Allison 4th Generation Controls with Prognostics features. Refer to the Table of Contents to locate information by subject in this publication.

Additional information about your transmission is available at *www.allisontransmission.com* using the publications links shown on the home page. Refer to the Sales and Service Locator at *www.allisontransmission.com* to find contact and location information for Allison Transmission distributors and dealers.

If you need to contact an Allison Transmission representative, refer to the Customer Service section at the end of this publication for contact information.

2.0 INTRODUCTION

2.1 KEEPING THAT ALLISON ADVANTAGE

Highway Series (HS) transmissions are designed to meet all of the horsepower needs of strictly on-highway vehicles that do not require Power

Takeoff (PTO) operation (refer to Figure 2–1 and Figure 2–2). All HS transmissions are available with optional retarders.

Abbreviations

ABS	Anti-lock Brake System
CMC	Customer Modifiable Constant
DMD	Display Mode/Diagnostic button
DOC™	Diagnostic Optimized Connection™
DTC	Diagnostic Trouble Code
EMI	Electromagnetic Interference
FCC	Federal Communications Commission
FM	Filter Life Monitor
HS	Highway Series
I/O	Input/Output
KOH	Potassium Hydroxide
LTL	Lighter Than Load
MIL	Malfunction Indicator Light—(OBD II).
MY	Model Year
OEM	Original Equipment Manufacturer
OLS	Oil Level Sensor
PTO	Power Takeoff
PWM	Pulse-Width Modulated
RFI	Radio Frequency Interference
RMR	Retarder Module Request
TAN	Total Acid Number
TCM	Transmission Control Module
TM	Transmission Health Monitor
TID	Transmission Identification Number
TPS	Throttle Position Sensor
VIM	Vehicle Interface Module

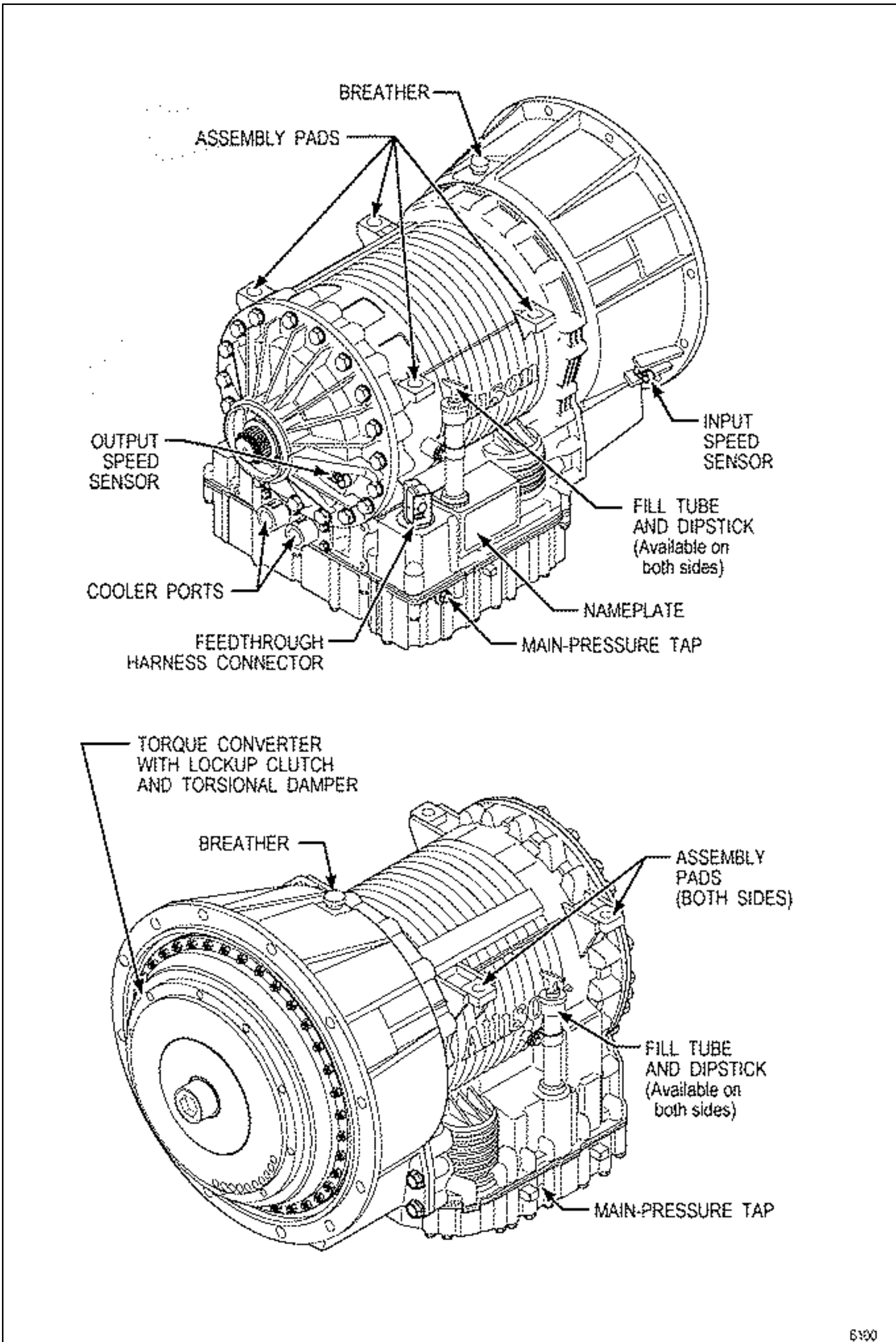


Figure 2–1. 3000 HS

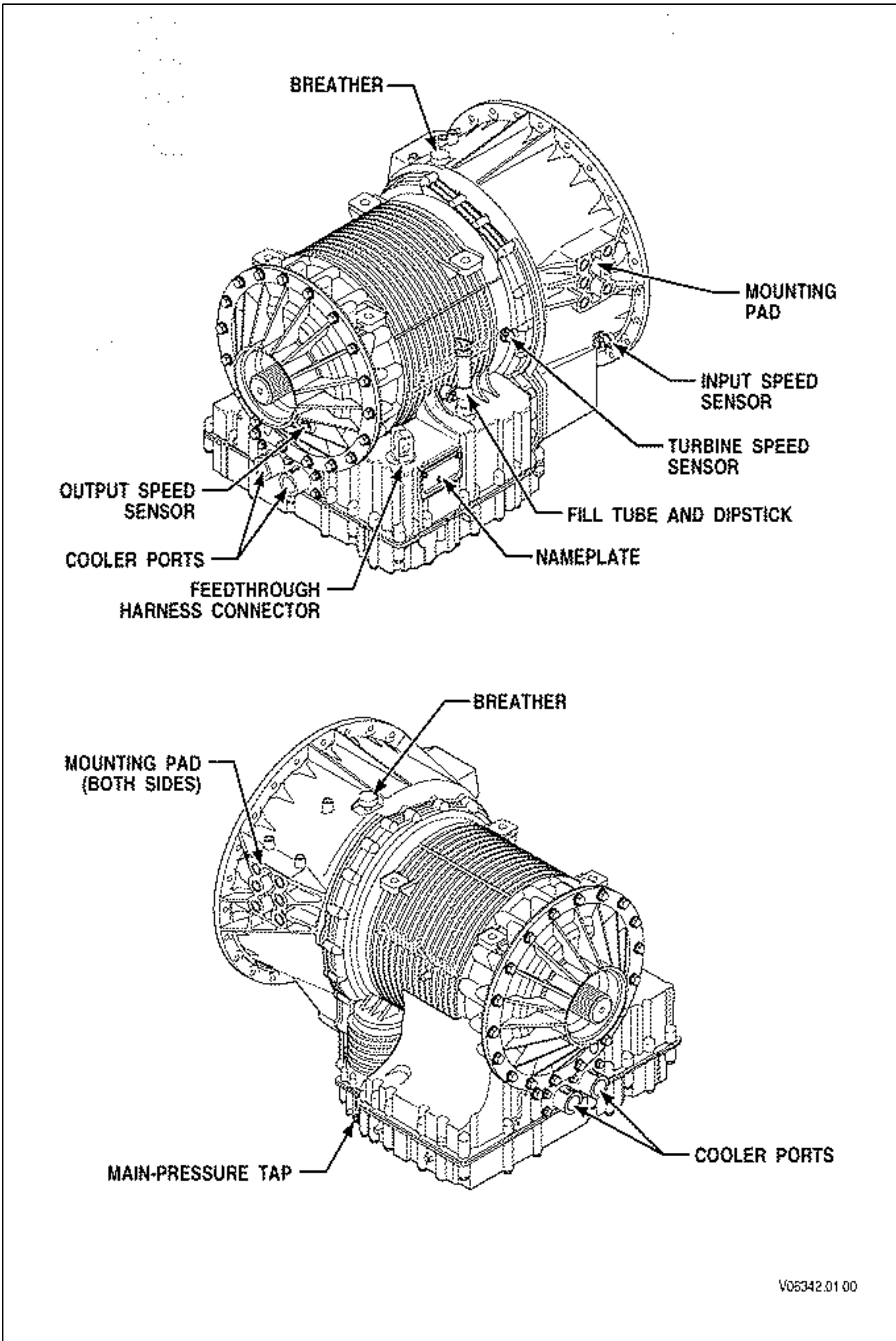


Figure 2–2. 4000/4500 HS

Typical truck vocations for this model include:

- Armored car
- Automobile transporter
- Beverage delivery
- Equipment hauler (no permit/escort)
- Flatbed
- Food distribution (dry/bulk)
- General freight
- General trucking
- Leasing
- Line haul
- Livestock hauler
- Manufacturing food distribution
- Manufacturing
- Moving/storage
- One-way rental truck
- Pickup and delivery
- Recycling
- Shorthaul/Lighter Than Load (LTL)
- Stake truck
- Van
- Walk-in van

3.0 DRIVING TIPS

3.1 THE AUTOMATIC EXPERIENCE

Smooth automatic upshifts and downshifts, without interruption of power to the wheels, occur in your Allison automatic transmission based on engine rpm, throttle position, vehicle load, road speed, and driver or feature request, such as manually preselecting ranges.

Allison automatic transmissions, along with a vehicle specification appropriate for the particular duty cycle, can provide superior fuel efficiency and optimum fuel economy. On trucks with a manual or automated manual transmission, the power interrupts that occur during shifts reduce the engine's inertia energy, resulting in lower average wheel horsepower. Because the engine is not working efficiently, it cannot run at full load. With an Allison automatic transmission, there is no power interrupt during shift changes. The inertia energy built up by the engine is maintained, equating to higher wheel horsepower. As a result, not as much engine horsepower is needed to get the job done. Allison automatic transmissions provide smooth, seamless shifts at all points of the power curve; there is no jarring power interrupts to jostle the truck, driver or damage valuable cargo. Allison automatic transmission equipped trucks are more nimble in traffic and easier to maneuver in congested loading zones, narrow alleys and around tight corners. You will have fewer freight claims and reduced cycle times, no matter how difficult the route.

As conditions permit, the Allison automatic transmission automatically upshifts until the highest range selected on the shift selector is attained. Your Allison automatic transmission model is programmed to have five or six forward gears. The 5th and 6th gear ratios are both overdrive ratios. If **D** (Drive) was selected then the transmission can upshift up to 5th range for a 5-speed or 6th range in the case of the 6-speed model. There is also a lockup clutch inside the torque converter that is applied during normal operation while in 2nd range or higher. Range upshifts and downshifts are accomplished without disengaging the lockup clutch.

NOTE: The number of forward ranges available is determined at the vehicle Original Equipment Manufacturer (OEM) based on a number of vehicle attributes, such as driveline design and governed engine speed. For example, if governed engine speed can exceed 2200 rpm in your vehicle, it is recommended the OEM program the Transmission Control Module (TCM) with 5 forward ranges instead of 6.

3.2 STARTING THE ENGINE

WARNING: When starting the engine, make sure the service brakes are applied. Failure to apply service brakes may result in unexpected vehicle movement.

No special procedure is required. Verify the brakes are applied and **N** (Neutral) has been selected. If the vehicle is equipped with a lever style selector, **the neutral start circuit will not allow the engine to start if the lever is not in the N (Neutral) position.**

The keypad pushbutton shifter automatically initializes in Neutral. When this condition is present and the ignition is turned on, the digital display indicates "N" for Neutral in both the SELECT and MONITOR display windows. This indicates **N** (Neutral) has been both selected and attained and the engine may now be started. Refer to Figure 4–1 and Table 4–1 for additional information.

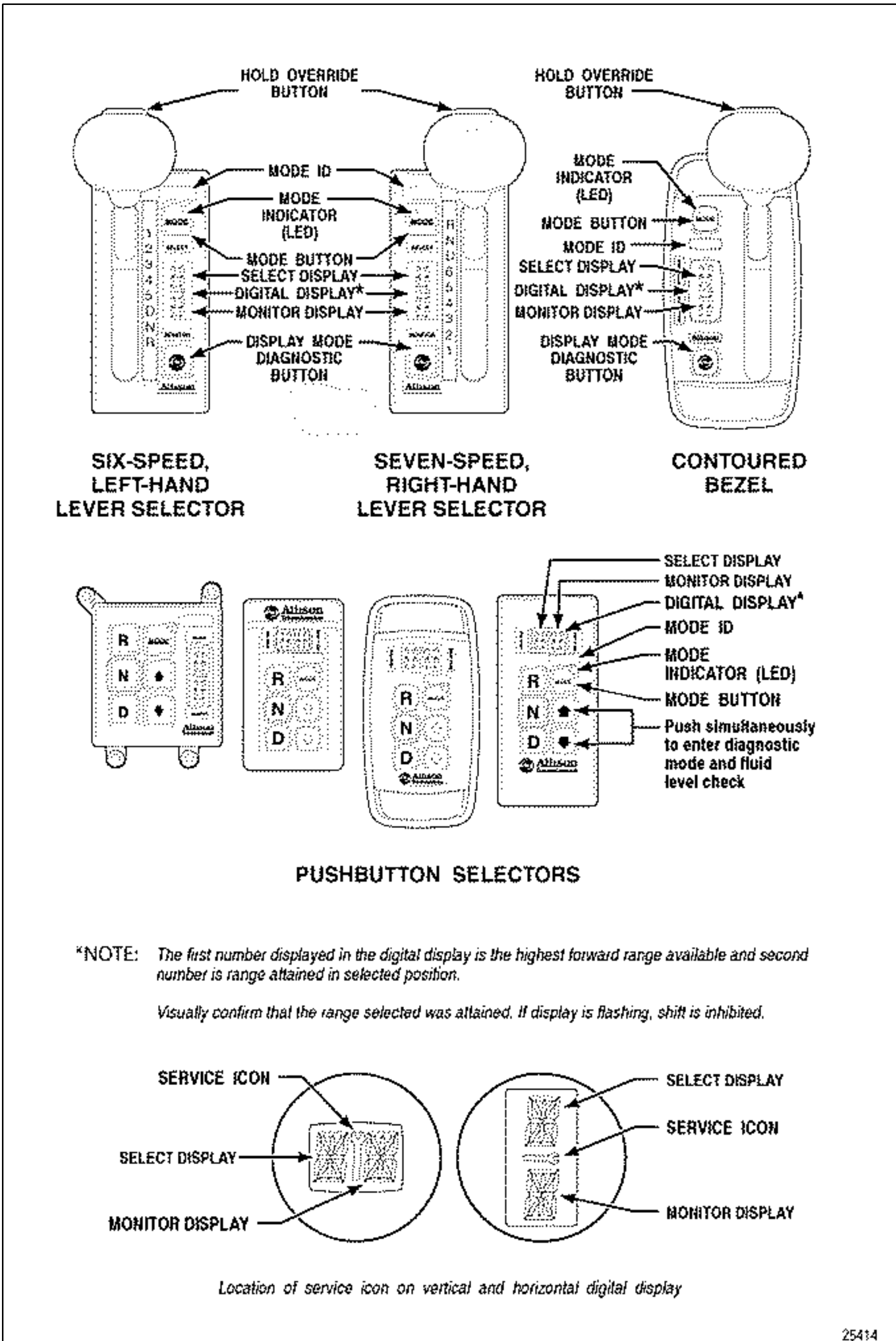


Figure 3–1. Typical Allison 4th Generation Prognostics Shift Selectors

3.3 COLD WEATHER STARTS

If the Transmission Fluid Temperature (TFT) sensor detects the transmission fluid is below -7°C (20°F), the transmission is programmed to start in 2nd gear.

If the transmission fluid temperature is below 10°C (50°F) follow these procedures when making directional shift changes:

- To shift from forward to reverse, select **N** (Neutral) and then **R** (Reverse).
- To shift from reverse to forward, select **N** (Neutral) and then **D** (Drive) or another forward range.

NOTE: During cold fluid conditions, always place the transmission in **N** (Neutral) prior to any direction changes.

NOTE: Failure to follow these procedures during cold fluid conditions, may cause the **CHECK TRANS** light to illuminate and the transmission to be restricted to **N** (Neutral).

Transmission operation at extremely cold ambient temperatures may require preheating or the use of a TES 295 transmission fluid. Refer to 3.3.1 PREHEATING REQUIREMENT.

3.3.1 PREHEATING REQUIREMENT. If ambient temperatures drop below the specified minimum levels for the fluid type, preheat the transmission fluid before beginning transmission operation. The minimum fluid temperatures at which the transmission may be safely operated without preheating are shown in Table 3–1.

Table 3–1. Fluid Type Specifications for Minimum Temperature

Fluid Type	Minimum Temperature	
	Celsius	Fahrenheit
TES 295	–35	–31
TES 389	–25	–13

Preheat the transmission fluid using one of the following methods:

- Use an auxiliary heat source such as a sump heater
- Operate the transmission in **N** (Neutral) with the engine running at idle for a minimum of 20 minutes before attempting range operation.

CAUTION: Transmission malfunction or damage may occur if you operate the transmission with the fluid temperature below the minimum fluid temperature specification limit.

3.4 HIGH FLUID TEMPERATURE

The transmission is considered to be overheated when any of the following temperatures are exceeded:

Sump fluid	121°C (250°F)
Fluid to cooler	149°C (300°F)
Retarder out fluid	165°C (330°F)

Typical continuous sump temperature is 93°C (200°F).

If the transmission overheats during normal operation, make sure the transmission fluid level is correct. Refer to 5.8 PERIODIC FLUID LEVEL CHECKS.

CAUTION: The engine should never be operated for more than 10 seconds at full throttle with the transmission in range and the output stalled. Prolonged operation of this type will cause the transmission fluid temperature to become excessively high and will cause severe overheat damage to the transmission.

If the engine temperature gauge indicates a high temperature, the transmission is probably overheated. Stop the vehicle and check the cooling system. If it appears to be functioning properly, run the engine at 1200–1500 rpm with the transmission in **N** (Neutral). This should reduce the transmission and engine temperatures to normal operating levels in 2 or 3 minutes.

If the transmission and engine temperatures do not decrease, reduce the engine rpm. If the engine temperature indicates a high temperature, an engine or radiator problem is indicated. If high temperature in either the engine or transmission persists, stop the engine and have the overheating condition investigated by maintenance personnel.

NOTE: Some shift schedules may be inhibited as a result of operating conditions, such as engine or transmission fluid temperature.

3.5 TURNING OFF THE VEHICLE

Always select **N** (Neutral) before turning the vehicle off.

3.6 PARKING BRAKE

WARNING: If you leave the vehicle and the engine is running, the vehicle can move unexpectedly and you or others could be injured. If you must leave the engine running, **DO NOT LEAVE** the vehicle until you have completed all of the following procedures:

- Put the transmission in **N** (Neutral).
- Be sure the engine is at low idle (500–800 rpm).
- Apply the parking and emergency brakes and make sure they are properly engaged.
- Chock the wheels and take other steps necessary to keep the vehicle from moving.

The parking brake is only intended to secure an unattended vehicle with the ignition **off**. Always maintain the vehicle parking brake system according to the manufacturer's specifications. The parking brake may not have sufficient capacity to restrain a vehicle with the engine running and the transmission in a forward or reverse range. When the vehicle is unattended and the engine is running, the transmission **must be in N** (Neutral) with the **brakes fully applied** and the **wheels chocked.**

WARNING: The vehicle service brakes, parking brake, or emergency brake must be applied whenever **N** (Neutral) is selected to prevent unexpected vehicle movement. Selecting **N** (Neutral) does not apply the vehicle brakes unless an auxiliary system to apply the parking brake is installed by the OEM.

3.7 DRIVING ON SNOW OR ICE

WARNING: Using the retarder on wet or slippery roads may cause loss of traction on the drive wheels—your vehicle may slide out of control. To help avoid injury or property damage, turn the retarder enable to OFF when driving on wet or slippery roads.

NOTE: The retarder is disabled automatically whenever the vehicle ABS is active. However, in the event the ABS malfunctions, it is recommended that the retarder enable switch, if equipped, be disabled.

If possible, reduce vehicle speed and select a lower range before losing traction. Select the range that will not exceed the speed expected to be maintained.

Accelerate or decelerate very gradually to prevent the loss of traction. It is very important to decelerate gradually when a lower range is selected. It is important that you reach the selected lower range before attempting to accelerate. This avoids an unexpected downshift during acceleration.

3.8 ROCKING OUT

WARNING: To help avoid injury or property damage caused by sudden movement of the vehicle, do not make shifts from **N** (Neutral) to **D** (Drive) or **R** (Reverse) when the throttle is open. The vehicle may lurch forward or rearward and the transmission can be damaged. Avoid this condition by making shifts from **N** (Neutral) to a forward range or **R** (Reverse) only when the throttle is closed and the service brakes are applied.

CAUTION: DO NOT make **N** (Neutral) to **D** (Drive) or directional shift changes when the engine rpm is above idle. Also, if the wheels are stuck and not turning, do not apply full power for more than 10 seconds in either **D** (Drive) or **R** (Reverse). Full power for more than 10 seconds under these conditions causes the transmission to overheat. If the transmission overheats, shift to **N** (Neutral) and operate the engine at 1200–1500 rpm until it cools (2–3 minutes).

If the vehicle is stuck in deep sand, snow, or mud, it may be possible to rock it out using the following procedure:

1. Shift to **D** (Drive) and apply a steady, light throttle (never full throttle). Refer to Figure 4–1 and Table 4–1 for additional information.
2. When the vehicle has rocked forward as far as it will go, apply and hold the vehicle service brakes.
3. When engine has returned to idle, select **R** (Reverse).

4. Release the vehicle service brakes and apply a steady, light throttle (never full throttle) allowing the vehicle to rock in **R** (Reverse) as far as it will go.
5. Apply and hold the vehicle service brakes and allow the engine to return to idle.

This procedure may be repeated in **D** (Drive) and **R** (Reverse) if each directional shift continues to move the vehicle a greater distance.

3.9 TOWING OR PUSHING

CAUTION: Failure to lift the drive wheels off the road, disconnect the driveline, or remove the axle shafts before pushing or towing can cause serious transmission damage.

When the engine cannot be started, it may become necessary to push or tow the vehicle. Before pushing or towing a vehicle do one of the following:

- Lift the drive wheels off the road
- Disconnect the driveline
- Remove the axle shafts

NOTE: When the axle shafts are removed, make sure the wheel openings are covered to prevent loss of lubricant and entry of dust and dirt.

An auxiliary air supply is usually required to actuate the vehicle brake system.

4.0 SELECTING RANGE AND SHIFT SCHEDULES

4.1 SELECTING RANGE

If your vehicle is equipped with an Allison Transmission 4th Generation Controls with Prognostics shift selector, a keypad pushbutton shift selector or a lever shift selector will be used. Examples of these shift selectors are shown in Figure 4–1. Some vehicle Original Equipment Manufacturers (OEMs) may choose to use their own shift selector. See the vehicle OEM for information about their selectors as needed. This Operator's Manual only provides information about Allison shift selectors.

NOTE: The transmission starts in 2nd gear if the Transmission Fluid Temperature (TFT) sensor detects the transmission fluid is below -7°C (20°F).

When a forward range, such as **D** (Drive), has been selected, the transmission starts in the lowest forward gear programmed in the Transmission Control Module (TCM) calibration. Usually that would be 1st range but some vehicles may be programmed for 2nd gear start instead. Refer to Table 4–1 for more information and driving tips for each range.

NOTE: Check the digital display window in the shift selector to verify the selected range whenever a button is pushed or the lever is moved to be sure the range selected is shown. A flashing or blank SELECT display indicates the range selected was not obtained due to an active inhibit or active DTC.

NOTE: If equipped with a HIGH IDLE switch, turn the HIGH IDLE off before shifting from **N** (Neutral) to **D** (Drive) or **R** (Reverse). The shift from **N** (Neutral) to **D** (Drive) or **R** (Reverse) is inhibited when engine speed is above idle.

WARNING: To help avoid unexpected vehicle movement that might cause death, serious injury, or property damage, always have your foot on the brake, the throttle released, and the engine at idle before making a **N** (Neutral) to **D** (Drive); **N** (Neutral) to **R** (Reverse); **D** (Drive) to **R** (Reverse); or **R** (Reverse) to **D** (Drive) selection.

NOTE: Before making any direction changes or shifting from **N** (Neutral) to any range, make sure the vehicle has come to a complete stop and the engine has returned to idle. Refer to 3.8 ROCKING OUT if the vehicle is stuck.

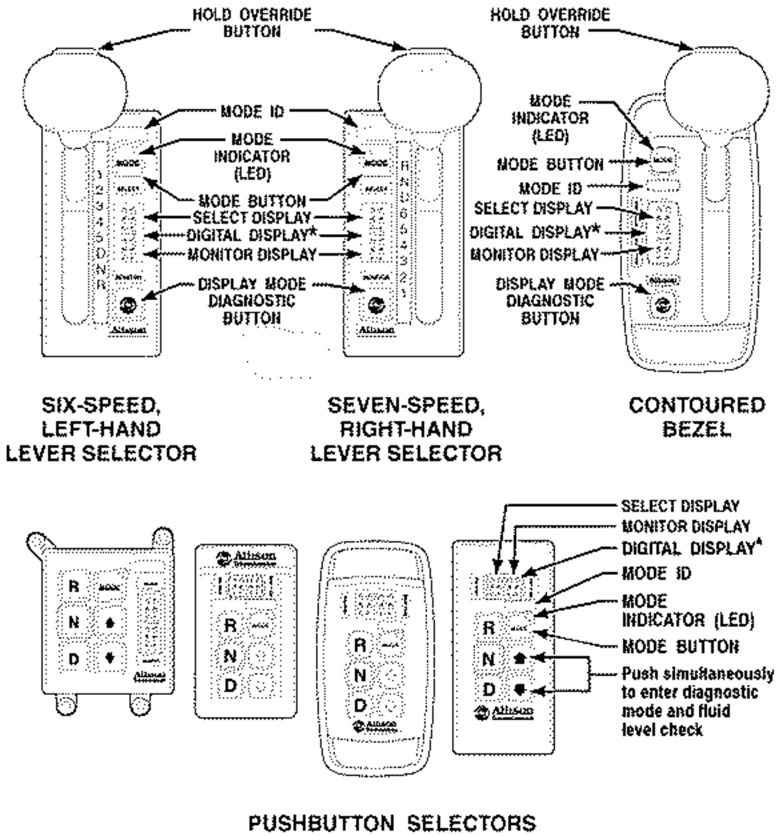
NOTE: Conditions responsible for illuminating the **CHECK TRANS** light will not allow any shift selector changes until the DTC related to the condition goes inactive. The MONITOR display shows the range the transmission has locked in because of an active DTC. The SELECT display goes blank when the **CHECK TRANS** light is on. Move the vehicle to a safe location before turning off the vehicle and seek qualified assistance if needed. Even if the transmission is not in Neutral, the operator is still able to view DTCs by simultaneously pressing the ↑ (Upshift) and ↓ (Downshift) arrows, if equipped with the keypad pushbutton shift selector, or by pressing the **DISPLAY MODE/DIAGNOSTIC** (DMD) button, if equipped with the lever shift selector.

Refer to 5.0 CARE AND MAINTENANCE, 6.0 DIAGNOSTICS, and 7.0 PROGNOSTICS SHIFT SELECTORS COMPONENTS AND FUNCTIONS for additional information about using the shift selectors to access, read, or clear transmission prognostic information and DTCs.

4.1.1 USING KEYPAD PUSHBUTTON SHIFT SELECTOR TO SELECT RANGE. If your vehicle is equipped with the keypad pushbutton shift selector, ranges are selected by pressing and releasing the button for the desired range. For example, press and release the N button to select **N** (Neutral), the D button to select **D** (Drive) and the R button to select **R** (Reverse). You may also manually select a lower forward gear below the (D) position by pushing the ↓ (Downshift) arrow after pressing **D** (Drive).

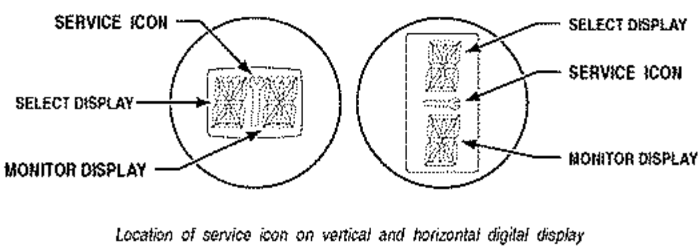
4.1.2 USING LEVER SHIFT SELECTOR TO SELECT RANGE. If your vehicle is equipped with the lever shift selector, make sure the vehicle is in **N** (Neutral) before starting the engine. The neutral start circuit will not allow the engine to start if the lever is not in **N** (Neutral). To go to range using a lever shift selector, press the hold override button to release the lever from its detent position and move the lever to the range you want. Refer to Figure 4–1.

You may manually select a lower forward gear below the (D) position by moving the lever to the lower range you would like to “range hold”.



*NOTE: *The first number displayed in the digital display is the highest forward range available and second number is range attained in selected position.*

Visually confirm that the range selected was attained. If display is flashing, shift is inhibited.



Location of service icon on vertical and horizontal digital display

25414

Figure 4–1. Typical Allison 4th Generation Prognostics Shift Selectors

4.1.3 SELECTOR DISPLAY FLASHING (INHIBITS) . When appropriate, the transmission control system automatically invokes an inhibit to protect against certain types of abusive operation, such as:

- **Engine speed inhibit:** prevents shift from neutral to either a forward range or reverse if the engine speed is above 900 rpm.
- **Direction change inhibit:** prevents shifting the transmission from forward-to-reverse or from reverse-to-forward if vehicle speed is more than the allowed speed threshold, or if the engine speed is above 900 rpm. Rocking out by shifting from **D** (Drive) to **R** (Reverse) and **R** (Reverse) to **D** (Drive) is still available to the operator provided the vehicle speed detected is below the limit allowed for rocking out the vehicle.

When shifts are inhibited, the TCM puts the transmission in **N** (Neutral) and the RANGE SELECT character flashes an R for reverse inhibit or the RANGE SELECT character flashes the highest forward range number for a drive inhibit. After a range inhibit has occurred the driver must re-select range to exit the inhibit after bringing the vehicle to stop and/or returning to engine idle.

Shifts from **N** (Neutral) to **D** (Drive) or **N** (Neutral) to **R** (Reverse) are also inhibited when the TCM has been programmed (by input/output function) to detect that auxiliary equipment is in operation and the shift should not be allowed.

Table 4–1. DESCRIPTION OF AVAILABLE RANGES

Description of Available Ranges (refer to Figure 4–1)	
	**WARNING:** If you leave the vehicle and the engine is running, the vehicle can move unexpectedly and you or others could be injured. If you must leave the engine running, do not leave the vehicle until you have completed all of the following procedures: 1. Put the transmission in **N** (Neutral). 2. Be sure the engine is at low idle (500–800 rpm). 3. Apply the parking brakes and emergency brake and make sure they are properly engaged. 4. Chock the wheels and take any other steps necessary to keep the vehicle from moving.

Table 4–1. DESCRIPTION OF AVAILABLE RANGES *(cont'd)*

Description of Available Ranges (refer to Figure 4–1)	
	WARNING: R (Reverse) may not be attained due to an active inhibitor. Always apply the service brakes when selecting **R** (Reverse) to prevent unexpected vehicle movement and because a service brake inhibit may be present. When **"R"** is flashing, it indicates the shift to **R** (Reverse) is inhibited. Determine if diagnostic codes are active if **R** (Reverse) is not attained. Refer to 7.6 SELECTOR DISPLAY DESCRIPTIONS FOR ACTIVE DTCs AND INHIBITS.
	CAUTION: Do not idle in **R** (Reverse) for more than five minutes. Extended idling in **R** (Reverse) can cause transmission overheating and damage. Always select **N** (Neutral) whenever time at idle exceeds five minutes.
	NOTE: Check the digital display window in the shift selector to verify the selected range whenever a button is pushed or the lever is moved to be sure the range selected is shown (i.e., if the **N** (Neutral) button is pressed, **N** should appear in the digital display). A flashing display indicates the range selected was not attained due to an active inhibit.
R	Completely stop the vehicle and let the engine return to idle before shifting from a forward range to **R** (Reverse) or from **R** (Reverse) to a forward range. The digital display will display **R** when **R** (Reverse) is selected.
	WARNING: When starting the engine, make sure the service brakes are applied. Failure to apply the service brakes can result in unexpected vehicle movement.
	WARNING: Vehicle service brakes, parking brake, or emergency brake must be applied whenever **N** (Neutral) is selected to prevent unexpected vehicle movement. Selecting **N** (Neutral) does not apply vehicle brakes, unless an auxiliary system to apply the parking brake is installed (refer to the Operator's Manual for the vehicle).
	WARNING: If you let the vehicle coast in **N** (Neutral), there is no engine braking and you could lose control. Coasting can also cause severe transmission damage. To help avoid injury and property damage, do not allow the vehicle to coast in **N** (Neutral).

Table 4–1. DESCRIPTION OF AVAILABLE RANGES *(cont'd)*

Description of Available Ranges (refer to Figure 4–1)	
N	Use **N** (Neutral) when starting the engine to check vehicle accessories and for extended periods of engine idle operation (longer than five minutes). For vehicles equipped with the pushbutton selector, **N** (Neutral) is selected by the TCM during start-up. For vehicles equipped with the lever selector, the vehicle will not start unless **N** (Neutral) has been selected. If the vehicle starts in any range other than **N** (Neutral), seek service immediately. **N** (Neutral) is also used during stationary operation of the Power Takeoff (PTO) (if the vehicle is equipped with a PTO). The digital display shows **N** when **N** (Neutral) is selected. Always select **N** (Neutral) before turning off the vehicle engine.
	WARNING: D (Drive) may not be attained due to an active inhibitor. Always apply the service brakes when selecting **D** (Drive) to prevent unexpected vehicle movement and because a service inhibit may be present. When **"D"** is flashing, it indicates the shift to **D** (Drive) is inhibited. Determine if diagnostic codes are active if **D** (Drive) is not attained. Refer to 7.6 SELECTOR DISPLAY DESCRIPTIONS FOR ACTIVE DTCs AND INHIBITS .
	CAUTION: Do not idle in **D** (Drive) for more than five minutes. Extended idling in **D** (Drive) may cause transmission overheating and damage. Always select **N** (Neutral) if time at idle exceeds five minutes.
	NOTE: If equipped with a HIGH IDLE switch, turn the HIGH IDLE switch off before shifting from **N** (Neutral) to **D** (Drive) or **R** (Reverse). **D** (Drive) or **R** (Reverse) will not be attained unless the shift is made with the engine at idle. Also, be aware of other interlocks that would prevent attaining **D** (Drive) or **R** (Reverse). Example: "service brakes not applied" (service brake interlock present).
D	The transmission initially attains first range when **D** (Drive) is selected (except for those units programmed to start in second-range). As vehicle speed increases, the transmission upshifts automatically through each range. As the vehicle or equipment slows down, the transmission automatically downshifts to the correct range. The digital display shows the highest range available in **D** (Drive).

Table 4–1. DESCRIPTION OF AVAILABLE RANGES *(cont’d)*

Description of Available Ranges (refer to Figure 4–1)	
	WARNING: To avoid loss of control, use a combination of downshifting, braking, and other retarding devices. Downshifting to a lower transmission range increases engine braking and can help you maintain control. The transmission has a feature to prevent automatic upshifting above the lower range selected. However, during downhill operation, if engine governed speed is exceeded in the lower range, the transmission will upshift to the next higher range to prevent engine damage. This will reduce engine braking and could cause a loss of control. Apply the vehicle brakes or other retarding device to prevent exceeding engine governed speed in the lower range selected.
6* **5*** **4*** **3** **2**	Lower ranges provide greater engine braking for going down grades (the lower the range, the greater the braking effect). Occasionally, it may be desirable to restrict automatic shifting to a lower range because of: • Road conditions • Load • Traffic conditions, etc. The pushbutton shift selector arrow buttons access individual forward ranges. Push the ↑ (Upshift) or ↓ (Downshift) arrows for the desired range. The digital display shows the range chosen. Even though a lower range is selected, the **transmission may not downshift** until vehicle speed is reduced (this prevents excessive engine speed in the lower range).
1	First-range provides the vehicle with its maximum driving torque and engine braking effect. Use first-range when: • Pulling through mud and deep snow. • Maneuvering in tight spaces. • Driving up or down steep grades. For vehicles equipped with the pushbutton selector, push the ↓ (Downshift) arrow until first-range appears in the select window.
* Actual ranges available depend on programming by vehicle manufacturer.	

4.2 SHIFT SCHEDULES AND AUTOMATIC RANGE SHIFTS

The transmission initially attains first range when **D** (Drive) is selected (except for those units programmed to start in 2nd range). As vehicle speed increases, the transmission automatically upshifts through each range. As the vehicle or equipment slows down, the transmission automatically downshifts to the correct range. The SELECT display shows the highest range available in **D** (Drive).

The points at which shifts occur depend upon predetermined speeds and other operating conditions. A transmission shift calibration includes several sets of shift points which may be used according to current or anticipated operating conditions for both upshift and downshift points.

NOTE: The vehicle OEM or bodybuilder is responsible for evaluating the driveability of shift schedules in the intended vehicle and duty cycle. For additional details regarding these shift schedules and/or other options for primary and secondary shift schedules, contact a qualified Allison Transmission service outlet for further information.

4.2.1 UPSHIFTING. As long as the Transmission Control Module (TCM) calculates there is enough vehicle power and vehicle acceleration available to grant and keep the next upshift then there are no other limitations imposed on upshifting until the vehicle attains its top range displayed in the SELECT display on the selector. Vehicle power and acceleration characteristics are monitored by the transmission controls to attempt to eliminate shift cycling. Shift cycling is an upshift followed closely by a downshift which is then followed by another upshift and so on.

NOTE: If shift cycling is noted use the alternate shift schedule by pressing the **MODE** button. The operator can also manually select the next lower range (using the shift selector) to hold that lower range until conditions are met to grant the upshift point again without shift cycling.

4.2.1.1 HOLD SCHEDULE FOR UPSHIFTS

As a standard feature of each shift calibration, the transmission controls incorporate a **"hold upshift"** shift schedule, which the operator may select if the transmission is not operating in its highest range. When this schedule is active, the shift points for upshifts are raised in order to hold the transmission in its current gear and inhibit upshifting beyond the current range. Holds are activated by selecting the current range or a lower range on the shift selector.

CAUTION: A typical use of the "hold" feature is to maximize engine braking when operating downhill. However, in order to prevent over-speeding the engine, the hold function is not infinite. It will permit shifts from the hold range to the next higher range at some speed above the shift calibration speed.

4.2.2 DOWNSHIFTING. Downshifts are allowed to occur as long as transmission output speed is low enough to keep from overspeeding the engine after completing the downshift. When a range downshift is manually selected by the operator, but the transmission output speed is determined to be above the limits, the transmission stays in the range it was in even though a lower range was requested by the operator. A shift to a lower range can occur when the operator applies the vehicle service brakes or a retarding device, such as an exhaust brake, engine brake, or retarder. This action reduces the transmission output speed which in turn lowers the vehicle speed, allowing the transmission to shift to the lower range.

4.2.2.1 PRESELECT SCHEDULE FOR DOWNSHIFTS

The preselect downshift schedule is similar to the hold feature. The operator may initiate the preselect downshift shift schedule by selecting any forward gear on the shift selector that is lower than the gear currently in use. When a range has been "preselected" in this manner, shifts to and from gears above the preselected gear range occur at higher than normal engine speeds. Shifts below the preselected range are not affected.

Preselect downshifting is beneficial in maintaining higher engine speed, resulting in increased engine braking or engine brake performance during downhill operation or vehicle deceleration cycles. However, preselect shifts are permitted only if an engine over-speed condition will not occur after completion of the downshift.

NOTE: Preselecting during normal operation may result in reduced fuel economy.

4.2.2.2 NON-ENGINE BRAKE OPERATION

Two choices of preselect shift schedules are available for governing preselected downshifts during normal transmission operation. One of the following choices is selected when the TCM is programmed by the vehicle OEM:

- **Standard Preselects** – downshifts occur so the engine speed after the shift is approximately 300 rpm above the engine governed speed

- **Low Preselects**– downshifts occur so the engine speed after the shift is approximately 150 rpm above the engine governed speed

4.2.2.3 ENGINE BRAKE OR EXHAUST BRAKE OPERATION

When the TCM detects the engine brake is enabled, it commands use of a preselect shift schedule in order to enhance engine brake performance. The default speeds for these shifts are known as the Alternate Engine Brake Preselects.

- **Alternate Engine Brake Preselects** – downshifts occur at engine speeds approximately midway between 1000 rpm and the Standard Preselects for your transmission model.

As an option, the preselect shift points during engine brake operation can be specified to be the same schedule selected when the TCM is programmed by the vehicle OEM for non-engine brake operation:

- **Standard Preselects** – downshifts occur so the engine speed after the shift is approximately 300 rpm above the engine governed speed
- **Low Preselects**– downshifts occur so the engine speed after the shift is approximately 150 rpm above the engine governed speed

---

NOTE: Specify Standard or Low Preselects when the TCM is programmed.

The preselect schedule chosen above will be activated for downshifts that occur while the engine brake is active and until operation in a specified gear is reached. This specified gear is the Engine Brake Preselect Range CMC that is programmable using Allison DOC® For PC-Service Tool. If this CMC is set to a value higher than 2nd gear, then downshifts from the Engine Brake Preselect Range to 2nd gear will be made as standard (non-engine brake) closed throttle downshifts. Additionally, if the TCM is programmed to make engine brake preselect downshifts at Standard Preselects or Low Preselects speeds, downshifts between the Engine Brake Preselected Range to an even lower gear can be specified to use the Alternate Engine Brake Preselect downshift speeds. The lowest gear to use this downshift schedule is also a CMC (Alternate Engine Brake Preselect Range). If this option is specified and the Alternate Engine Brake Preselect Range CMC is higher than 2nd gear, downshifts from the Alternate Engine Brake Preselect Range to 2nd gear uses normal (non-preselect) closed throttle shift speeds.

NOTE: If an exhaust brake or engine compression brake is installed on the engine, then they must be integrated to the transmission controls. Shift quality issues will arise if not properly integrated to the transmission controls.

4.2.2.4 RETARDER MODE SHIFT SCHEDULE

The retarder mode shift schedule is automatically activated when the retarder is switched on in order to raise closed throttle downshifts for additional cooling during retarder operation. Retarder closed throttle downshifts occur at speeds approximately halfway between the normal closed throttle downshift and the preselect downshift for each range. Refer to 4.3 USING THE HYDRAULIC RETARDER .

4.2.3 ACCELERATOR CONTROL. The position of the accelerator pedal influences when automatic shifting occurs. An electronic throttle position signal tells the TCM how much the operator has pressed the pedal. When the pedal is fully pressed, upshifts occur automatically at higher engine speeds. A partially pressed position of the pedal causes upshifts to occur at lower engine speeds.

4.2.3.1 KICKDOWN SHIFT SCHEDULE

Kickdown is an optional shift schedule which is activated when the kickdown input function is enabled. If shift schedule S2, S3, or S4 is in use and kickdown is active, all shifts revert to schedule S1, Wide Open Throttle (WOT) shift points. Similarly, if shift schedule S6, S7, or S8 is in use and kickdown is active, all shifts revert to schedule S5, WOT shift points.

4.2.4 PRIMARY AND SECONDARY SHIFT SCHEDULES. The primary shift schedule is normally used each time the vehicle is started and is specified in such a way to accommodate normal vehicle operation.

The secondary shift schedule is an alternate shift schedule the TCM only uses upon request. The request for this schedule can be a dedicated request from the operator or can be interlocked with the operation of another vehicle system.

Primary and secondary shift schedules may be changed using the **MODE** button but some applications may use a dash-mounted switch. The **MODE** indicator LED illuminates while in secondary shift schedule. The vehicle might also have a dash-mounted light that illuminates when the secondary mode schedule is active.

Frequently, either performance or economy shift points are selected for the primary shift schedule (reflecting the most commonly used state of the vehicle), and the other set of shift points are selected for the secondary shift schedule.

The primary and secondary shift schedules must be specified when the TCM is programmed. The vehicle OEM determines which primary/secondary shift schedule combination they would like the transmission to have when the vehicle is built.

4.2.5 PERFORMANCE/ECONOMY SHIFT SCHEDULES. Currently, Allison Transmission offers the following commonly available shift schedules to the OEM(s):

- **S1 & S5** - Performance: WOT upshifts near Full Load Governed Speed (FLGS)
- **S2 & S6** - Performance: WOT upshifts at a fixed (less than 100) percent of Full Load Governed Speed (FLGS)
- **S3 & S7** - Economy: Upshifts at speeds which pull engine down to a fixed rpm after the shift
- **S4 & S8** - Economy: Upshifts at speeds which pull engine down to a fixed rpm (and less than S3) after the shift
- **S9** - Economy: Upshifts and downshifts occur at speeds that are even lower than the S4 shift strategy

Schedules S1 through S4 are typically used with engines using all-speed governors. Schedules S5 through S8 are designed to provide the same WOT upshifts as the corresponding S1 through S4 schedules. However, the S5 through S8 part throttle shift schedules have been modified.

4.2.6 LOAD-BASED SHIFT SCHEDULING (LBSS). The LBSS shifting strategy option combines the advantages of both performance and economy shift schedules. LBSS is part of the standard Shift Energy Management (SEM) calibration for approved engines. The controls automatically select the economy shift schedule when an unloaded state of the vehicle is detected (based on capability of the vehicle to accelerate quickly), then automatically switch to performance shift points when the vehicle is loaded and its ability to accelerate is reduced. The resulting operation can continuously modify transmission shifting to keep the engine near its more efficient speeds, which can produce improved overall vehicle fuel economy while still enabling high productivity during loaded conditions.

Performance mode is commanded upon each initialization of the TCM. The switch to economy is commanded by the TCM only when it is determined the economy mode in LBSS is available based on the evaluation of the vehicle operating system. The mode is also reset to performance when any of the following are detected:

- Neutral has been commanded for more than 20 seconds
- Transmission has been in first range for more than 120 seconds
- An engine derate condition has been detected
- Loss of torque data from the engine

In addition to providing the capability to automatically switch between performance and economy schedules, the availability of economy mode in LBSS is selectable as a CMC, with Allison DOC® For PC-Service Tool, within the shift calibration as follows:

Table 4–2. LBSS ECONOMY MODE

CMC Setting	Selection	Description
1	Reserved 1	Reserved for future use
2	Reserved 2	Reserved for future use
3	Low	This setting keeps the vehicle in economy mode when lightly loaded or on low upgrades. The vehicle will always be in performance mode if carrying a load or when negotiating moderate grades.
4	Medium	This is the default value. This setting keeps the vehicle in economy mode more than the default setting. When the vehicle is empty, even on moderate grades, economy mode is normally in use. Likewise, economy mode also is used on nearly-level grades with moderate loads. Performance mode will be commanded when heavily loaded or with moderate loads on larger grades
5	High Grades	This setting keeps the vehicle in economy mode in most circumstances. Performance will typically be commanded only when negotiating severe when heavily loaded. This setting permits higher powered vehicles to be in economy mode for most operation except during the most demanding operating conditions

4.2.7 OVER-TEMPERATURE SHIFT SCHEDULE. Regardless of operator request, the TCM automatically limits transmission operation to 4th range or below during oil over-temperature conditions. If the transmission is above 4th range when over-temperature occurs, the preselect shift schedule is used for all downshifts until 4th range is reached.

4.2.8 CRUISE MODE SHIFT SCHEDULE. This shift schedule is activated when a J1587 or J1939 datalink message is received to indicate cruise control is active. Shift points for this operation are modified in order to reduce the frequency of upshifts and downshifts during cruise operation. This shift schedule is a standard feature of each shift calibration.

The vehicle cruise control features interact with retarder activation/deactivation and are determined by calibration and CMC(s). Refer to 4.3.2 RETARDER/ CRUISE CONTROL INTERACTIONS.

4.3 USING THE HYDRAULIC RETARDER

A hydraulic retarder is optional on all of the models covered in this manual. The purpose of the retarder is to assist in stopping the vehicle during stop-and-go driving and to control the downhill speed of the vehicle on a grade. For both of these uses, the retarder extends the life of the service brakes and enhances vehicle control. The retarder automatically disengages when the vehicle approaches a stop.

When the retarder enable switch is turned on to enable the retarder system, a special retarder mode shift schedule is activated. This shift schedule allows downshifts at higher than the normal road speeds. Increased coolant flow through the transmission cooler and engine radiator occurs due to the raised downshift points. Refer to 4.3.1 RETARDER CAPACITY REDUCTION.

NOTE: The transmission retarder is configured as either a low, medium, or high capacity retarder by TCM calibration. Allison Transmission requires written vehicle OEM approval before a service outlet increases the retarder capacity at a customer’s request. Existing vehicle drivelines, differentials, axles, and the cooling system must be designed for the additional retarder torque generated if a higher capacity retarder calibration is installed. The cost to modify retarder capacity is the responsibility of the customer.

The amount of Retarder Modulation Request (RMR) is controlled by the operator and depends on the type of retarder control used in the vehicle. Various hand, foot and automatic control techniques are used. Refer to Table 4–3. In Allison 4th Generation Controls with Prognostics, the TCM also activates or limits retarder operation in response to torque speed control or electronic retarder control messages received on the vehicle's J1939 Datalink. Contact your OEM to understand how the retarder controls have been integrated into your vehicle.

The presence of a retarder must be autodetected as part of Allison 4th Generation Controls with Prognostics.

NOTE: The retarder enable switch is used to turn the retarder off for slippery road conditions.

WARNING: DO NOT USE THE RETARDER DURING INCLEMENT WEATHER OR WHEN ROAD SURFACES ARE SLIPPERY.

Use of the hydraulic retarder during inclement weather or when road surfaces are slippery could result in death, serious injury, or property damage. On vehicles which have a primary retarder control based upon closed throttle position, brake pedal position, or brake apply pressure, always manually disable the retarder controls during inclement weather or slippery road conditions, using the OEM provided retarder enable switch if present.

If the transmission retarder does not apply, death, serious injury, or property damage may occur. Operator should be prepared to apply vehicle brakes or other retarder device if the transmission retarder does not apply.

If the transmission retarder does not function, death, serious injury, or property damage may occur. Be sure to test for proper retarder function periodically. If a retarder is present but is not detected by "autodetect," the retarder will not function. Whenever the retarder does not apply, seek service help immediately.

Regardless of the type of Allison retarder controls on your vehicle (refer to Table 4–3) the following safety features are common to each configuration:

- The retarder can be disabled when inclement weather or slippery road conditions are present
- Vehicle brake lights should always be on when the retarder is applied (periodically verify they are working)
- Anti-lock Brake System (ABS) sends a signal to the TCM to indicate the brake system is activated

NOTE: The retarder is automatically disabled and the lockup clutch is disengaged whenever the ABS is active. In the event the ABS malfunctions, it is recommended the retarder enable switch be disabled, if equipped.

NOTE: If your transmission has a retarder but it is not functioning, it may not have been autodetected during vehicle manufacture. Consult the nearest Allison Transmission service outlet to have autodetect reset or the retarder enabled using the Allison DOC® For PC–Service Tool.

NOTE: A common cause for retarder performance complaints is incorrect transmission fluid level. Fluid level must be set correctly for highest retarder effectiveness. As little as 2 liters (2 quarts) too high or too low can reduce retarder effectiveness and increase transmission temperature. Refer to 5.8 PERIODIC FLUID LEVEL CHECKS.

NOTE: The retarder requires about two seconds to reach full capacity. Be sure to anticipate this delay when using the retarder to prevent unnecessary service brake applications during non-emergency stops.

NOTE: When the transmission fluid or engine water temperature (engine water temperature is an OEM option) exceeds programmed limits, retarder capacity is automatically gradually reduced to minimize or avoid possible system overheating.

CAUTION: Observe the following cautions when driving a vehicle equipped with a retarder:

- THE RETARDER WORKS ONLY WHEN THE ENGINE IS AT CLOSED THROTTLE.
- OBSERVE TRANSMISSION AND ENGINE TEMPERATURE LIMITS AT ALL TIMES. Select the lowest possible transmission range to increase the cooling system capacity and total retardation available.
- In the event of OVERHEATING, DECREASE THE USE OF THE RETARDER; USE THE SERVICE BRAKES TO SLOW THE VEHICLE.
- OBSERVE THE RETARDER/SUMP “OVERTEMP” LIGHT to be sure it responds properly to retarder temperature.

Table 4–3. Types of Retarder Control

Type	Description	Amount of Application
Manual	Separate apply pedal	Zero to Full apply
	Hand lever*	Six levels based on lever position
Automatic	Auto “Full On”*	“Full On” when closed throttle sensed
Brake Pressure Apply**	Single pressure switch	Off or “Full On” (based on brake pressure)
	Three pressure switches	1/3, 2/3, or “Full On” (based on brake pressure)
Pedal Position**	Special brake pedal	1/3, 2/3, or “Full On” (based on brake pressure)
J1939 Data Link	Digital message from engine controller	Zero to Full Apply

Table 4–3. Types of Retarder Control *(cont'd)*

Type	Description	Amount of Application
Combinations of the above systems**	Auto "half-on" plus pressure switch*	Half capacity at closed throttle or "Full On" with brake pressure
	Auto "1/3 on" plus two pressure switches*	1/3, capacity at closed throttle or 2/3 and "Full On" with brake pressure
	Hand lever plus pressure switch*	6 levels of modulation with lever, or "Full On" with brake pressure
	Foot pedal plus pressure switch	Full modulation with separate pedal, or "Full On" with brake pressure
	Hand lever plus interface for special pedal*	6 levels of modulation with lever, or 3 levels of modulation based on pedal position

* These control systems may apply the retarder at high speed on grades when the vehicle has road speed limiting and the retarder is enabled.
** For retarder apply systems integrated with the service brake system, the retarder is most effective when applied with light brake pedal pressure for 1–2 seconds to allow the retarder to fully charge. Added pedal pressure can be applied when more aggressive braking is desired.

4.3.1 RETARDER CAPACITY REDUCTION.

NOTE: In the event of excessively high temperatures in the transmission fluid and/or engine coolant during retarder operation, the maximum available retarder capacity may be reduced, affecting vehicle operation.

Retarder capacity is reduced if the transmission retarder-out or transmission sump temperature exceeds specified limits, as detected by temperature sensors which are integral to the transmission. In addition, retarder capacity is reduced in the event of elevated engine water temperature based on:

- engine water temperature as communicated to the TCM with an engine coolant sensor or via an SAE J1939 or J1587 datalink, or
- detection by an engine water temperature sensor which provides an analog input signal to the TCM. This sensor is supplied and installed by the vehicle builder.

4.3.1.1 BASED ON RETARDER TEMPERATURE

If the retarder temperature exceeds 143ºC (290ºF), the TCM raises the closed throttle downshift points by activating the preselect downshift schedule. Use of the preselect downshift schedule forces downshifts to occur at higher than normal road speeds, increasing coolant flow through the transmission cooler and engine radiator.

If the retarder temperature exceeds 149ºC (300ºF), retarder capacity begins to reduce. Capacity reduction continues until it is reduced to approximately 27% of the maximum available retarder capacity.

NOTE: If the output speed increases 300 rpm above the speed at which capacity reduction starts, full retardation is restored.

If the retarder temperature exceeds 166ºC (330ºF), the retarder temperature indicator output activates. This illuminates a retarder over-temperature light that alerts the operator of excessive retarder temperature. The retarder temperature light deactivates when the retarder temperature drops below 159ºC (318ºF). If the retarder temperature remains above 166ºC (330ºF) for ten consecutive seconds, an active DTC P2740 (retarder oil temperature hot) is logged by the TCM. When the temperature drops and remains below 166ºC (330ºF) for ten consecutive seconds, the DTC becomes inactive and is stored in memory.

4.3.1.2 BASED ON TRANSMISSION SUMP TEMPERATURE

Independent of the retarder temperature, if the transmission sump temperature exceeds 117ºC (240ºF), retarder capacity will similarly be reduced as described above. The over-temperature indicator is activated and the over-temp DTC is logged if the sump temperature exceeds 121ºC (250ºF) for fifteen minutes, exceeds 128ºC (262ºF) for more than one minute, or instantaneously reaches 132ºC (270ºF).

4.3.1.3 BASED ON ENGINE WATER TEMPERATURE

If optional engine water capacity reduction and/or preselect downshifts are used, similar responses occur based on excessive engine water temperature. The capacity is reduced at the rate/slope programmed into the calibration and may continue to be reduced at this rate until:

- The retarder is operating at approximately 27.5% of its maximum capacity
- The retarder is deactivated by the operator or by vehicle operating conditions which eliminate the need for retardation
- Engine water temperature is returned to a level that does not invoke the capacity reduction

NOTE: Full retardation is restored if the output speed increases 300 rpm above the speed at which water capacity reduction starts.

4.3.2 RETARDER/CRUISE CONTROL INTERACTIONS. Two control features affect retarder operation when the vehicle is equipped with cruise control:

- Feature 1: Cruise Control Retarder Auto On Disable

This feature only applies to electronic engines that communicate with the transmission on either J1587 or J1939. The TCM calibration must specify this feature to be either on or off. If the feature is on in the calibration, the TCM prohibits retarder operation when cruise control is active but the throttle is closed, which implies downhill coasting operation. This feature is highly recommended if the retarder apply system automatically applies the retarder at high levels at closed throttle.

If the feature is off in the calibration or the engine is not electronic, the TCM commands retarder operation whenever the cruise control goes to zero throttle. This mode of operation is only acceptable if the subsequent level of retarder apply is less than 25%.

- Feature 2: Retarder Cancel Cruise Control

This feature provides for a short flash of the retarder indicator output whenever the requested retarder level is increased. The retarder indicator output must be wired to the engine cruise control to turn off cruise control when the level of retardation requested is changed. This operation emulates the effect of applying the service brakes. Feature 2 is an optional feature that must be specified for the controls calibration.

HIGHWAY SERIES

5.0 CARE AND MAINTENANCE

5.1 PERIODIC INSPECTIONS

NOTE: The terms fluid and oil are used interchangeably in this publication. Both terms refer to the fluid or oil in the transmission and nowhere else.

It is very important to continually monitor the fluid level and connections for the electronic and hydraulic circuits. Keep the transmission clean to make inspection easier. Make regular periodic inspections for:

- Proper transmission fluid fill. Refer to 5.8 PERIODIC FLUID LEVEL CHECKS.
- Transmission fluid that is discolored, has a strong odor, or exceeded oil analysis limits.
- Presence of engine coolant in the transmission fluid.

NOTE: Transmission overhaul is required when the transmission has been contaminated with engine coolant. Allison Transmission recommends all clutch friction plates, lockup clutch, solenoids, and rusted/damaged parts be replaced during the rebuild.

- Presence of transmission fluid in the engine cooling system.
- Leaking fluid around fittings or hydraulic lines.
- Dripping oil from the transmission or output seal area (refer to Figure 5–1 and Figure 5–2).
- Debris that is blocking the breather located on top of the torque converter housing (refer to Figure 5–1 and Figure 5–2).
- Loose bolts securing transmission to engine or vehicle components attached to the transmission.
- Loose engine and transmission mounts.

- Harnesses interfacing with transmission controls and vehicle function are still in good condition.

Report any abnormal condition to service management. Immediately correct any problems found during this inspection to prevent further vehicle and/or transmission damage.

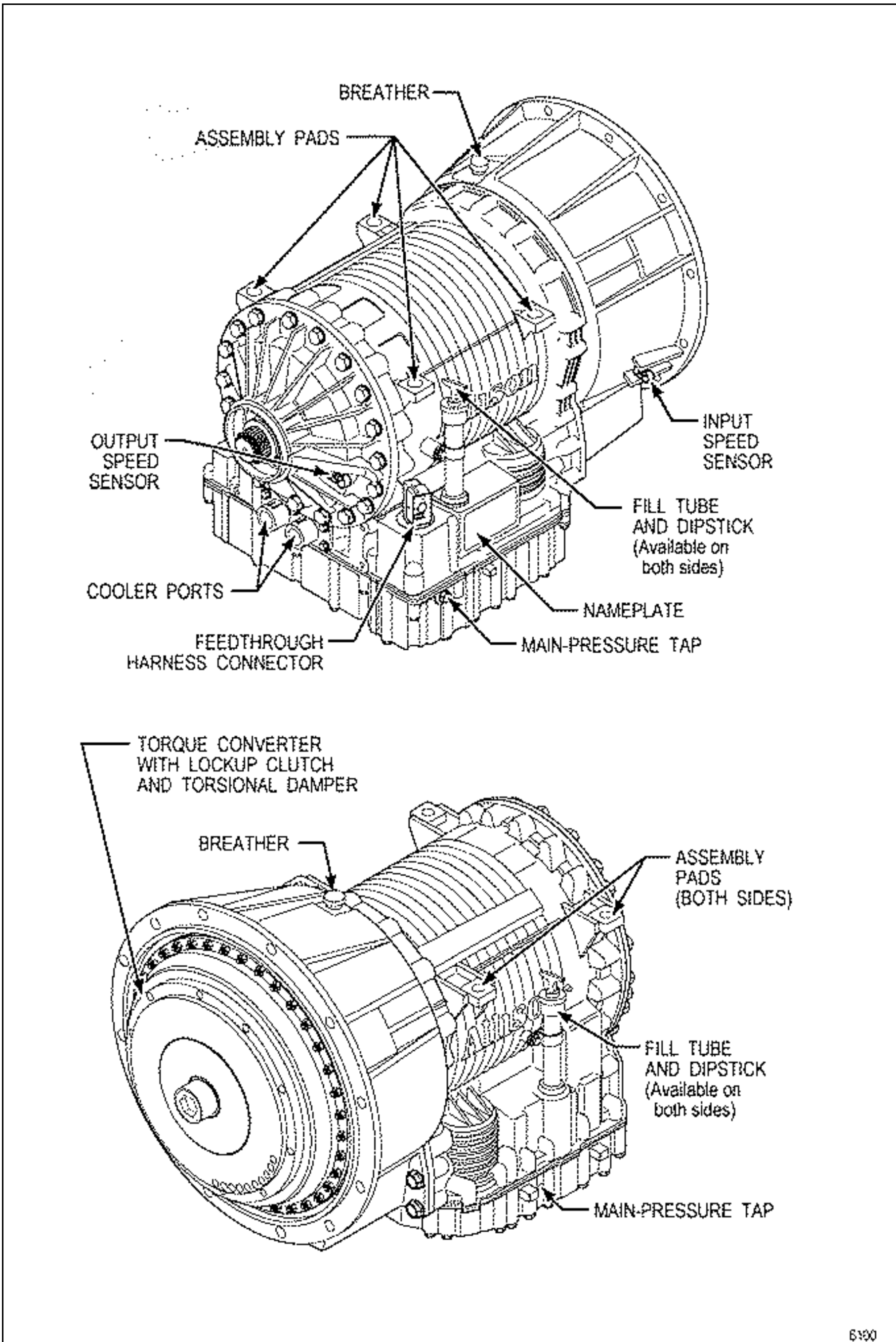


Figure 5–1. 3000 HS (Allison 4th Generation Controls)

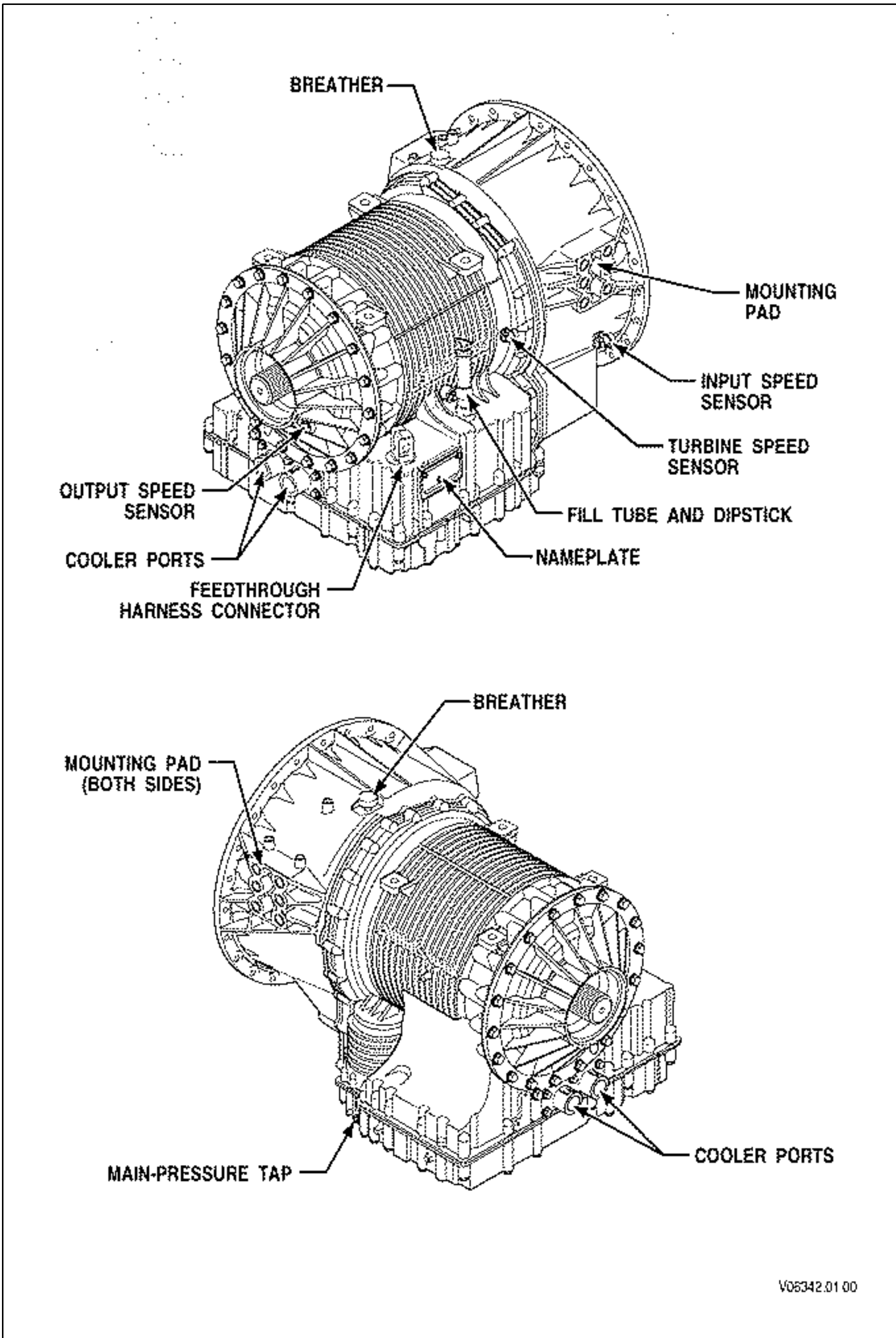


Figure 5–2. 4000 HS and 4500 HS (Allison 4th Generation Controls)

5.2 PREVENT MAJOR PROBLEMS

You can help keep minor problems from becoming major problems by contacting an Allison Transmission distributor or dealer when one of these conditions occur:

- A shift quality issue
- A driveability issue such as a vibration
- Transmission, hydraulic line or fitting is leaking fluid

NOTE: Dampness around the breather and output seal is normal. If there is a drip associated with the dampness at the breather, output seal, or elsewhere on the transmission then repair the cause of the leak.

- **CHECK TRANS** light illuminates

5.3 IMPORTANCE OF TRANSMISSION FLUIDS

Proper transmission fluid selection is important to transmission performance, reliability, and durability. The fluid used in the transmission does the following:

- Provides the working medium for the torque converter, controls, and clutch application
- Transfers heat from the transmission to the cooler
- Lubricates gears and bearings
- Carries rust inhibiting chemicals throughout the transmission
- Achieves optimum coefficient of friction for the clutch application
- Maintains clutch engagement
- Carries contaminants to the filters

5.4 RECOMMENDED AUTOMATIC TRANSMISSION FLUIDS

Only use fluids meeting Allison Transmission specification TES 295 or TES 389 in your transmission. For a list of currently approved transmission fluids, go to the Allison Transmission web site at: *www.allisontransmission.com*, select SERVICE, Fluids.

Allison Transmission recommends you take the following into consideration when selecting the appropriate fluid type for your transmission:

- Fluids meeting specification TES 295 are preferred over TES 389 fluids for use in all 3000 and 4000 Product Families transmission applications.

- TranSynd®, a TES 295 fluid, is available through Allison distributors and dealerships.
- TES 295 fluids are fully qualified for Severe Duty and Extended Drain intervals.
- A fluid meeting TES 295 specification is required in order to use Prognostics Features in A51, A52, A53 series TCMs calibrated prior to October 09, 2009 if Calibration Identification Number (CIN) starts with 4A.
  - The Prognostics packages available in A51, A52, A53 TCMs calibrated after October 09 2009 to a CIN starting with 4C allows a selectable fluid type between either TES 295 or TES 389 fluid.
- A TES 295 fluid allows you to operate at a lower ambient temperature than a TES 389 type fluid. Refer to Table 5–1.
- A TES 389 fluid is the minimum fluid requirement approved for use in 3000 and 4000 Product Families transmissions.
- To extend the TES 389 fluid drain intervals beyond the recommended mileage or hours change interval, use a fluid analysis program. Refer to 5.6 FLUID ANALYSIS.
- When choosing a fluid type to use, consider what the minimum fluid operating temperature of the fluid will be based on the ambient temperatures reached in the geographical location for the vehicle. Refer to 3.3.1 PREHEATING REQUIREMENT.

Table 5–1. Transmission Fluid Minimum Operating Temperature Requirements

Fluid Type	Minimum Operating Conditions	
	Celsius	Fahrenheit
TES 295	–35	–31
TES 389	–25	–13

5.5 KEEPING FLUID CLEAN

CAUTION: Containers or fillers that have had antifreeze solution or engine coolant in them must NEVER be used to hold transmission fluid. Antifreeze and coolant solutions contain ethylene glycol and water which, if put into the transmission, can cause damage.

Make sure that transmission fluid is clean, free of chemical contaminants, and within fluid specification limits. Refer to Table 5–2.

Handle transmission fluid in clean, residue-free containers and fillers to prevent any foreign material or chemical contamination of the transmission fluid.

5.6 FLUID ANALYSIS

Transmissions used in high cycle rate applications should use fluid analysis to make sure fluid is changed as soon as needed. Transmission protection and fluid change intervals may be optimized by monitoring fluid oxidation according to the tests and limits. Refer to Table 5–2. Consult your local telephone directory for firms in your area that provide a fluid analysis service. Use only one fluid analysis firm to ensure consistent and accurate fluid analysis. Refer to Technician's Guide for Automatic Transmission Fluid, GN2055EN, for additional information.

Table 5–2. Fluid Oxidation Measurement Limits

Test	Limit
Viscosity	±25 change from new fluid
Total Acid Number (TAN)	+3.0* change from new fluid
Solids	2 percent by volume

* mg of potassium hydroxide (KOH) to neutralize a gram of fluid.

5.7 TRANSMISSION FLUID REFILL

The fluid refill volume will be less than the volume listed for the initial fill due to some fluid remaining in the external circuits as well as in various transmission component cavities. After refill, verify the fluid level is correct. Refer to 5.8 PERIODIC FLUID LEVEL CHECKS.

NOTE: Quantities listed in Table 5–3 are approximate and do not include external lines and cooler hoses.

Table 5–3. Transmission Fluid Capacity

Transmission	Sump	Initial Refill		Refill	
		Liters	Quarts	Liters	Quarts
3000 Product Family	4 inch	27	29	18	19
	2 inch	25	26	16	17
4000 Product Family*	4 inch	48	51	40	42
	2 inch	41	43	33	35

* Subtract 2.8 Liters (3 Quarts) for transmissions without PTO.

5.8 PERIODIC FLUID LEVEL CHECKS

Even though transmission fluid is not consumed during transmission operation as engine oil might be, periodic fluid level checks should be made prior to placing the vehicle in service or just after returning from service. Periodic fluid level checks help prevent human error or mechanical failure of a vehicle or transmission component. Periodic checks also help to detect fluid leaks, cooler failure (contaminating the transmission fluid), fluid overfill, fluid underfill or the wrong kind of fluid used the last time the transmission was serviced.

Check the transmission fluid level by one of the following methods:

- Dipstick
- Using Allison 4th Generation shift selector to electronically check the Oil Level Sensor (OLS) located in the transmission control valve module
- Using Allison DOC® For PC-Service Tool to check the level with the OLS

The dipstick is marked with temperature bands for a COLD and HOT fluid level check. The fluid check marked COLD is designed to allow the fluid level to be checked from 16°C (61°F) to 60°C (140°F).

NOTE: Only use this check to confirm adequate fluid volume for a cold start-up and not to set fluid levels for continued operation.

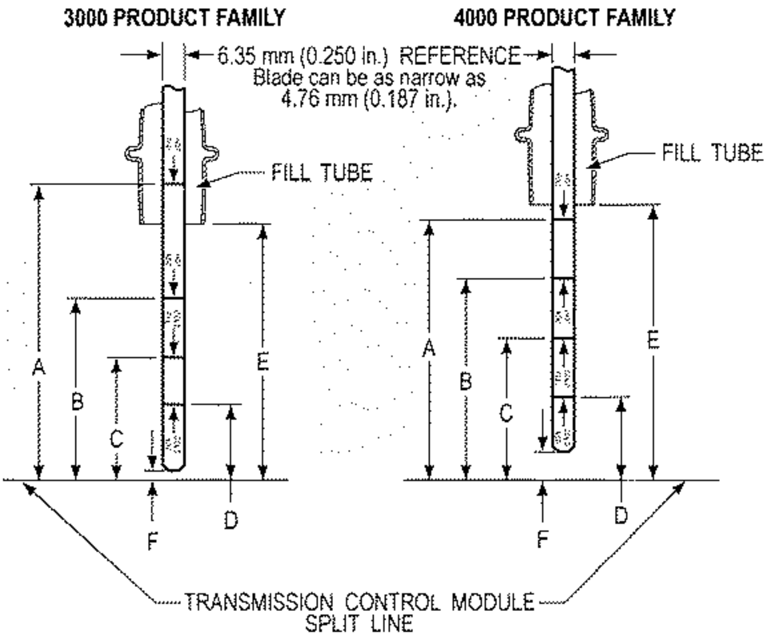
The OLS is designed to automatically compensate for fluid temperature fluctuations (thermal expansion) that is, within its operating band parameters for fluid temperature. Allison Transmission recommends using the Allison 4th Generation controls shift selector to check the OLS. This method is more accurate than the dipstick method.

Use the dipstick method if any of the following situations exist:

- If transmission fluid temperature is below the allowed temperature to check it electronically, conduct a COLD CHECK to determine whether there is enough fluid to start and move the vehicle.
- If the vehicle does not have an Allison 4th Generation shift selector, or the OEM has not integrated the electronic messages regarding oil level into their selector.
- If the OLS or vehicle wiring is defective, or the OLS was not auto detected, preventing electronic access to fluid level.

5.8.1 FLUID CHECK USING DIPSTICK.

There are two temperature bands marked on the dipstick to allow for transmission fluid expansion when the temperature increases. The lower band, referred to as COLD CHECK, is used when the transmission fluid is below operating temperature. The upper band, referred to as HOT CHECK, is used when the transmission fluid is at normal operating temperature. The OEM may refer to these as COLD FULL/COLD ADD (COLD CHECK) and HOT FULL/HOT ADD (HOT CHECK). Refer to Figure 5–3 for further information on dipstick markings.



OIL SUMP	TRANSMISSION/SUMP DESCRIPTION	DIMENSION A	DIMENSION B	DIMENSION C	DIMENSION D	DIMENSION E	DIMENSION F**
2.00 in. and 4.00 in.	4000 PRODUCT FAMILY	106.7 mm (4.20 in.)	76.2 mm (3.00 in.)	66.0 mm (2.60 in.)	*	132.6 mm (5.22 in.)	13.8 mm (0.54 in.)
2.00 in.	3000 PRODUCT FAMILY	101.6 mm (4.00 in.)	73.7 mm (2.90 in.)	50.8 mm (2.00 in.)	*	86.6 mm (3.41 in.)	5.9 mm (0.23 in.)
4.00 in.	3000 PRODUCT FAMILY	101.6 mm (4.00 in.)	63.5 mm (2.50 in.)	45.7 mm (1.80 in.)	*	86.6 mm (3.41 in.)	5.9 mm (0.23 in.)

NOTE: Calibrate level marking locations with respect to transmission control module split line and fill tube.
Scale none.
*Dimension determined by installation.
**Reference dimension only. Actual dimension to be determined by installation.

5864

Figure 5–3. Standard Transmission Dipstick Markings

COLD CHECK: The COLD CHECK band verifies the transmission has adequate fluid for start-up and operation until it can be checked at the operating (hot) temperature. Only use this check to confirm adequate fluid level for a cold start-up and not to set fluid levels for continued operation. Typically, the check is most accurate with fluid temperatures of 16-49°C (61-120°F).

NOTE: With engine off the fluid level should reach the hot run band or higher on the dipstick even at cold ambient temperatures. The cold check band is calibrated on the stick for the fluid level attained while the transmission is running and in **N** (Neutral). Do not move the vehicle until the fluid level reaches the cold full mark with engine running and transmission in **N** (Neutral).

HOT CHECK: The HOT CHECK band checks the fluid level at the normal operating temperature, 71-93°C (160-200°F). Fluid level checks at operating temperature offer the best assurance of maintaining the correct fluid level. Typically, the transmission is at operating temperature at the end of the shift or at the end of the day.

The fluid must be maintained above the COLD CHECK mark to assure the fluid is above the charging pump suction port inside the transmission. This prevents charging pump cavitation which causes aeration of the fluid and erratic operation of the transmission. If the fluid is above the HOT CHECK mark, it may contact the rotating parts of the transmission causing fluid aeration which results in erratic transmission operation, and may cause overheating and power loss.

CAUTION: Transmission damage can result from extended operation at low fluid level conditions.

NOTE: Do not overfill the transmission. Overheating, oil foaming out of the breather, and power loss may occur if driven while transmission is overfilled.

5.8.1.1 COLD CHECK PROCEDURE

NOTE: The correct fluid level cannot be determined unless the transmission is in a level position.

CAUTION: DO NOT start the engine until the presence of sufficient transmission fluid has been confirmed. Remove the transmission fluid dipstick and be sure the static fluid level is near the HOT FULL mark.

WARNING: If you leave the vehicle and the engine is running, the vehicle can move unexpectedly and you or others could be injured. If you must leave the engine running, do not leave the vehicle until you have completed all of the following procedures:

1. Put the transmission in **N** (Neutral).
2. Be sure the engine is at low idle (500–800 rpm).
3. Apply the parking brakes and emergency brake and make sure they are properly engaged.
4. Chock the wheels and take any other steps necessary to keep the vehicle from moving.

A COLD CHECK determines if the transmission has enough fluid to be operated safely until a HOT CHECK can be made. Complete a COLD CHECK after the presence of transmission fluid has been confirmed with the engine off. The transmission fluid temperature should be between 16-49°C (61-120°F).

NOTE: Always check fluid level with the dipstick in the unscrewed or loose position.

Complete a COLD CHECK procedure using the dipstick as follows:

1. Move the vehicle to a level surface, put the transmission in **N** (Neutral) and set the parking brake.
2. With the engine idling (500–800 rpm), shift to **D** (Drive) and then to **R** (Reverse) to clear air from the hydraulic circuits.
3. Run the engine at idle (500–800 rpm) in **N** (Neutral) for about one minute.
4. Clean debris from around the end of the fill tube before removing the dipstick.
5. Remove the dipstick and wipe it clean.
6. Insert the dipstick into the fill tube, pushing down until it stops, but still in its loose or unscrewed position.
7. Remove the dipstick and observe the fluid level. If the fluid on the dipstick is within the COLD CHECK band (refer to Figure 5–3), the fluid

level is satisfactory. If the fluid level is not within this band, add or drain (refer to 5.7 TRANSMISSION FLUID REFILL as necessary to bring the level within the COLD CHECK band.

8. Perform a HOT CHECK at the first opportunity after normal operating temperature (71-93°C (160-199°F)) is reached.

CAUTION: DO NOT operate the transmission for extended periods of time until a HOT CHECK has verified proper fluid level. Transmission damage can result from extended operation at improper fluid level conditions.

CAUTION: The fluid level rises as fluid temperature rises. DO NOT fill the transmission above the COLD CHECK band if the transmission fluid is below normal operating temperatures. During operation, an overfull transmission can become overheated, leading to transmission damage.

CAUTION: Obtain an accurate fluid level by imposing the following conditions:

- Engine is idling (500–800 rpm) in **N** (Neutral)
- Transmission fluid is at the normal operating temperature
- The vehicle is on a level surface
- Apply the parking brake and chock the wheels

5.8.1.2 HOT CHECK PROCEDURE

NOTE: Always check fluid level with the dipstick in the unscrewed or loose position.

To complete a HOT CHECK procedure using the dipstick do the following:

1. Be sure fluid has reached normal operating temperature of 71-93°C (160-200°F). If a transmission temperature gauge is not present, measure fluid level when the engine water temperature gauge has stabilized.
2. Park the vehicle on a level surface and shift to **N** (Neutral).
3. Apply the parking brake and allow the engine to idle (500–800 rpm).
4. Clean debris from around the end of the fill tube before removing the dipstick.

5. Remove the dipstick and wipe it clean.
6. Insert the dipstick into the fill tube, pushing down until it stops, but still in its loose or unscrewed position.
7. Remove the dipstick and observe the fluid level. The safe operating level is anywhere within the HOT RUN band on the dipstick. Refer to Figure 5–3.
8. If the level is not within the HOT RUN band, add or drain fluid as necessary to bring the level within the HOT RUN band. Refer to 5.7 TRANSMISSION FLUID REFILL.
9. Measure fluid level more than once. Be sure fluid level measurements are consistent. If readings are not consistent, be sure the transmission breather is clean and not clogged. Refer to Figure 2–1 and Figure 2–2 for the location of the fill tube and dipstick.
10. If readings are still not consistent, contact your nearest Allison distributor or dealer.

5.8.1.3 TRANSMISSION DIPSTICK MARKINGS ILLUSTRATION

Refer to Figure 5–3.

5.8.2 FLUID LEVEL CHECKS USING ALLISON 4TH GENERATION SHIFT SELECTORS.

The OLS is standard in your transmission. With the OLS and an Allison 4th Generation shift selector, you can get a more accurate electronic fluid level check than with a dipstick.

5.8.2.1 ELECTRONIC FLUID LEVEL CHECK PREREQUISITES

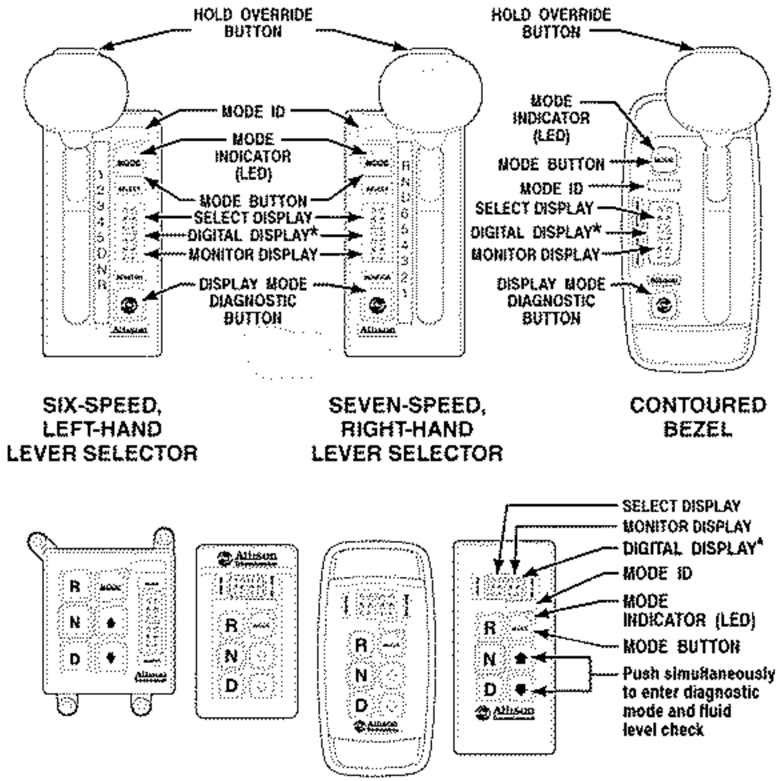
- OLS is functional and is auto-detected by the Transmission Control Module (TCM).
- Vehicle has an Allison 4th Generation shift selector.

5.8.2.2 ELECTRONIC FLUID LEVEL CHECK PROCEDURE

The OLS is designed to measure transmission fluid level. To check the fluid level electronically from the shift selector, do the following:

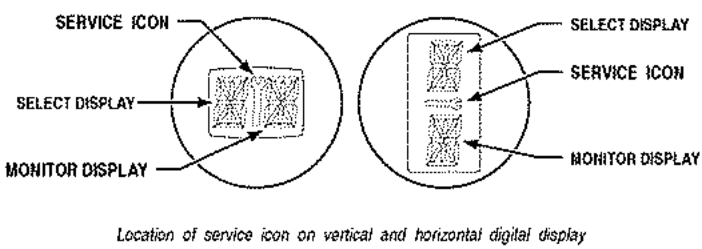
1. Be sure transmission fluid has reached the correct operating temperature band for the OLS:
   – A52, A53 TCMs calibrated after October 09 2009 to a CIN starting with 4C can be checked from 40-104°C (104- 219º F).
   – Any other TCM model or previous calibrations prior to October 09 2009 can be checked from 60-104° C (140- 219º F).

   - If a transmission temperature gauge is not present, measure fluid level when the engine water temperature gauge has stabilized.
2. Park the vehicle on a level surface and shift to **N** (Neutral)
3. Apply the parking brake and allow the engine to idle (500–800 rpm).
4. Make sure vehicle is stopped with transmission output at 0 rpm.
5. Allow a settling period of two minutes to facilitate oil drain back time. The TCM communicates status once fluid level request is initiated.
6. Fluid level measurement and readout may be initiated by pressing once on:
   - **DISPLAY MODE/DIAGNOSTIC** (DMD) button on the lever selector. Refer to Figure 5–4.
   - ↑ (Upshift) and ↓ (Downshift) arrows simultaneously on the keypad of the pushbutton selector. Refer to Figure 5–4.
7. To exit the fluid level display mode, press any range button on the pushbutton shift selector or press the **DISPLAY MODE/DIAGNOSTIC** (DMD) button on the lever shift selector



*NOTE: *The first number displayed in the digital display is the highest forward range available and second number is range attained in selected position.*

Visually confirm that the range selected was attained. If display is flashing, shift is inhibited.



Location of service icon on vertical and horizontal digital display

25414

Figure 5–4. TYPICAL ALLISON 4TH GENERATION SHIFT SELECTOR

5.8.2.3 FLUID RANGE DETECTED FOR OIL LEVEL SENSOR (OLS)

The OLS has a detection range of up to LO 4 to HI 3 that can display on the selectors. The actual oil level to add may be greater than 4 liters (4.22 quarts) if the transmission is more than 4 liters (4.22 quarts) low from the full mark. The actual fluid volume to drain may be more than 3 liters (3.17 quarts) if the transmission is overfull by more than 3 liters (3.17 quarts).

5.8.2.4 DISPLAY OF FLUID LEVEL AND FLUID LEVEL CODES

After obtaining the fluid level reading mode, the display provision of the transmission shifter indicates fluid level status to the operator by sequentially flashing the fluid level information two characters at a time to the SELECT and MONITOR digital displays. Refer to Figure 5–4.

A delayed fluid level check is indicated by a "—" in each of the digital displays (SELECT and MONITOR) followed by a numerical countdown. The countdown, from 8 to 1, indicates the time remaining in the two minute waiting (settling) period.

An alphanumeric code (other then "o, L") indicates either a fault code, unacceptable conditions to receive the fluid level information, or there is a system malfunction.

The following is an explanation of what will appear in the single digital display.

- **Correct Fluid Level—**"o, L" is displayed (represents Fluid (Oil) Level Check Mode), followed by "o, K". The "o, K" display indicates the fluid is within the correct fluid level zone. The sensor display and the transmission dipstick may not agree exactly because the OLS compensates for fluid temperature.
- **Low Fluid Level—**"o, L" is displayed (represents Fluid (Oil) Level Check Mode), followed by "Lo" (represents low fluid level) and the number of quarts the transmission is low. For example: "2" indicates 2 additional quarts will bring the fluid level within the middle of the "o, K" zone.
- **High Fluid Level—**"o, L" is displayed (represents Fluid (Oil) Level Check Mode), followed by "HI" (represents High Oil Level) and the number of quarts the transmission is overfilled. For example: "1" indicates 1 quart of fluid above the full transmission level.
- **Invalid For Display—**"o, L" (represents Fluid (Oil) Level Check Mode), followed by "—" and an alphanumeric which is a fault code and indicates conditions are not acceptable to receive the fluid level information, or there is a system malfunction.

The following is an explanation of what appears in the SELECT and MONITOR digital displays.

- **Correct Fluid Level**

SELECT	MONITOR	Description
“o”	“L”	Represents Fluid (oil) Level Check Mode
“o”	“K”	Fluid (oil) level is within the correct fluid level zone

- **Low Fluid Level**

SELECT	MONITOR	Description
“o”	“L”	Represents Fluid (oil) Level Check Mode
“L”	“o”	Represents Low Fluid (oil) Level
“0”	“2”	The number of quarts the transmission is low

- **High Fluid Level**

SELECT	MONITOR	Description
“o”	“L”	Represents Fluid (oil) Level Check Mode
“H”	“I”	Represents High Fluid (oil) Level
“0”	“1”	The number 1 indicates 1 quart of fluid above the full transmission level

- **Invalid for Display**

SELECT	MONITOR	Description
“o”	“L”	Represents Fluid (oil) Level Check Mode
“—”	“—”	The dashes are followed by a numerical display which is a fault code that indicates conditions are not proper to receive the fluid level information or there is a system malfunction.

The shift selector shows invalid for display codes two characters at a time. An invalid for display code is returned when the fluid level data is requested, but an operational condition has not been met. The invalid for display codes and their meaning are shown in Table 5–4.

Table 5–4. Invalid for Display Codes

Display (Former)	Display (MY08, Cal/Sfw or newer)	Interpretation of Display
oL — OX	oL — OX	Settling time too short*
oL — 50	oL — EL	Engine rpm too low
oL — 59	oL — EH	Engine rpm too high
oL — 65	oL — SN	**N** (Neutral) must be selected
oL — 70	oL — TL	Sump fluid temperature too low
oL — 79	oL — TH	Sump fluid temperature too high
oL — 89	oL — SH	Output shaft rotation
oL — 95	oL — FL	Sensor failure

*A number between 8 and 1 that flashes during the countdown period.

NOTE: A51, A52, A53 TCMs calibrated after October 09 2009 to a CIN starting with 4C may be electronically checked for oil level from 40-104°C (104- 219º F). Otherwise, perform the electronic oil level check from 60-104°C (140- 219º F) .

5.9 PROGNOSTICS FEATURES

The Prognostics package contains functions that maximize fluid and filter use, as well as a feature which provides an indication of when the clutch system wear is significant enough to warrant transmission repair. You can then schedule the repair at your convenience. Refer to Table 5–5 for Prognostics Function Description.

Table 5–5. Prognostics Function Description

Prognostics Function Name	Description
Oil Life Monitor (OM)	Displays the percentage of fluid life remaining

Table 5–5. Prognostics Function Description *(cont'd)*

Prognostics Function Name	Description
Filter Life Monitor (FM)	Notifies that main and lube filters need changed
Transmission Health Monitor (TM)	Notifies that one or more clutches, C1-C5, needs replaced

NOTE: The term **TRANS SERVICE** indicator refers to the lighted wrench icon in the shift selector.

Allison Transmission 4th Generation Controls with Prognostics has a **TRANS SERVICE** indicator, between the SELECT and MONITOR display window on all Allison 4th Generation Controls with Prognostics lever and keypad pushbutton shift selectors. Refer to Figure 4–1. The OEM may choose to use their own selector but provide the **TRANS SERVICE** indicator for Prognostics as a lamp or via a message on a display unit.

When a specified threshold is detected for any of the serviceable conditions, the **TRANS SERVICE** indicator is illuminated to alert the operator. Failure to attend to the service condition and reset the **TRANS SERVICE** indicator within a defined operating period results in illumination of the **CHECK TRANS** light, indicating the increased probability that the service condition will develop into a more serious condition. Refer to 6.2.1 CHECK TRANS LIGHT.

5.9.1 PROGNOSTICS PREREQUISITES. The following requirements must be met to use the Prognostics features and functions:

- Vehicle harness has a wire for the filter life indicator switch (wire 118).
- The OEM has ordered your calibration from Allison Transmission with Prognostics enabled.

NOTE: It is important to note that if Prognostics is **disabled**, it is not available at all in the calibration. This is different than the OEM ordering your calibration with Prognostics off. Defaulting Prognostics off means it could be enabled in the future without recalibrating to a different calibration provided the other conditions are met to use Prognostics.

- If the CIN starts with 4A, use TES 295 transmission fluid. If the CIN starts with 4C, TES 295 or TES 389 transmission fluid may be used
- Using Allison Transmission High Capacity Main and Lube Filters

- Using Allison 4th Generation Controls with Prognostics keypad pushbutton or lever shift selector. Refer to Figure 4–1.

NOTE: Allison Transmission may approve some OEM selectors for Prognostics, provided the **TRANS SERVICE** indicator or message display is integrated by the OEM. At the time of this publication there are no capable OEM selectors for Prognostics.

5.9.2 PROGNOSTICS FEATURES AVAILABILITY. The vehicle manufacturer specifies whether they want Allison Prognostics Feature Package to be made available in the calibration and in what configuration, for example defaulted on or off. The Oil Life Monitor (OM), Filter Life Monitor (FM), and Transmission Health Monitor (TM) are the individual functions included in the Allison Prognostics Feature Package. These individual functions cannot be turned on or off separately within the Allison Prognostics Feature Package.

The transmission calibration can be made for the vehicle manufacturer (or the customer) so the Prognostics Feature is in one of the following states:

- Available and the Prognostics Features are defaulted on and therefore monitoring Oil Life Monitor (OM), Filter Life Monitor (FM), and Transmission Health Monitor (TM) presently.
- Available and the function is defaulted off and therefore available but not monitoring Oil Life Monitor (OM), Filter Life Monitor (FM), and Transmission Health Monitor (TM) presently.
- Disabled and therefore not available within this Transmission Control Module (TCM) calibration.

Methods to turn the Prognostics Package Features on or off (provided all other requirements are met), include the following:

- Through the shift selector (if allowed by TCM programming). Refer to 5.9.3 PROCEDURE TO TURN PROGNOSTICS ON AND OFF.
- Using the Allison DOC® For PC-Service Tool, Customer Modifiable Constant (CMC) can be toggled to enabled or disabled for the Allison Prognostics Feature Package provided the OEM ordered a calibration that has the Allison Prognostics Feature Package as a programmable feature.
- Recalibrate the TCM provided wire 118 is in the harness. This can be done at an authorized Allison distributor or dealer.

NOTE: Prognostics should not be turned on after recalibration of the TCM until all other requirements for the fluid filters, selector, and harness are met. If wire 118 is not in the vehicle harness, DTC P0848, Pressure Switch 2 (PS2) Circuit High, will be active. If the selector is not a Prognostics capable selector (there is no wrench icon in the selector) then DTC U0304, Software Incompatible with Gear Shift Control Module 1, is active.

The OEM initially specifies how they want the calibration configured for operator access regarding reset for Prognostics functions through the selector. The vehicle owner may then have the CMC toggled to either enabled or disabled to allow or disallow the Prognostics Package reset from the shift selector via programming features in Allison DOC® For PC-Service Tool.

Reset methods for the Prognostics Package and reset of individual features in the package include the following: (Refer to 5.9.3 PROCEDURE TO TURN PROGNOSTICS ON AND OFF).

- Oil Life Monitor (OM) and Filter Life Monitor (FM) may be reset through the selector by different shift pattern sequences.
- Oil Life Monitor (OM) and Filter Life Monitor (FM) may be reset by SAE J1939 datalink messages.
- Oil Life Monitor (OM), Filter Life Monitor (FM), and Transmission Health Monitor (TM) may be reset individually with Allison DOC® For PC-Service Tool.
- Transmission Health Monitor (TM) is always manually reset with Allison DOC® For PC-Service Tool and cannot be manually reset through the selector. Individual clutch reset is allowed with Allison DOC® For PC–Service Tool.
- The Prognostics CMC can be set to restrict Prognostic Package resets to the Allison DOC® For PC-Service Tool only. Individual functions, such as the Oil Life Monitor (OM), Filter Life Monitor (FM), and Transmission Health Monitor (TM) may not be restricted individually for reset by the service tool. Restriction to reset by the service tool only affects the whole Prognostics Package, which is handled by a single Prognostics CMC.
- Filter Life Monitor (FM) and Transmission Health Monitor (TM) automatically reset themselves if monitored conditions allow.

NOTE: An Allison service outlet can assist with programming and recalibration to enable Prognostics, at customer expense, as long as all Allison Transmission requirements are met prior to the enabled feature being turned on.

NOTE: The three Prognostics functions, Oil Life Monitor (OM), Filter Life Monitor (FM), and Transmission Health Monitor (TM), are enabled or disabled as a group and cannot be enabled or disabled individually.

CAUTION: Prognostics requires the use of Allison approved TES 295 or TES 389 fluids and Allison High Capacity Filters if turned ON. If any other fluids or filters are used, the Prognostics feature MUST BE turned OFF. Prognostics information will not be accurate with any other transmission fluids and could result in missed maintenance activities resulting in transmission damage. If Prognostics functions are not programmed or are turned OFF, refer to 5.0 CARE AND MAINTENANCE and review the miles/hours/months fluid and filter change interval charts or visit *www.allisontransmission.com*, click Service, Fluid/Filter Change Interval, then Fluids, and read the current revision of Service Tips 1099 for details.

5.9.3 PROCEDURE TO TURN PROGNOSTICS ON AND OFF.

WARNING: To help avoid unexpected vehicle movement that might cause death, serious injury, or property damage, always have your foot on the brake, the throttle released, and the engine at idle before making a **N** (Neutral) to **D** (Drive); **N** (Neutral) to **R** (Reverse); **D** (Drive) to **R** (Reverse); or **R** (Reverse) to **D** (Drive) selection.

The Prognostics feature can be turned on with the Allison DOC® For PC-Service Tool or, if the specific calibration allows it, the operator can do the following:

1. Set the vehicle brakes to prevent movement of the vehicle.
2. With engine off, turn the ignition on (do not start the engine). Wait for initialization to complete (wait for N N to display in the selector).
3. Move the shift selector (for a lever) or press the keypad (for a pushbutton) through the following sequence of range positions,

pausing no more than three (3) seconds between consecutive shifts: **N-D-N-R-N-D-N-R-N-D-N-R-N**.

4. Watch for the wrench icon between the SELECT and MONITOR display to illuminate and then turn off. That tells the operator they have successfully enabled the Allison Prognostics Feature Package, consisting of the Oil Life Monitor (OM), Filter Life Monitor (FM), and Transmission Health Monitor (TM).

If another **TRANS SERVICE** indicator is installed in the dash or incorporated in an OEM message display, it too should also briefly illuminate in similar fashion as the wrench icon.

Disabling the Prognostics feature can be done with Allison DOC® For PC-Service Tool or, if the specific calibration allows it, the operator can do the following:

1. Set the vehicle brakes to prevent movement of the vehicle.
2. With engine off, turn the ignition on (do not start the engine). Wait for initialization to complete (wait for N N to display in the selector).
3. Move the shift selector (for a lever) or press the keypad (for a pushbutton) through the following sequence of range positions, pausing no more than three (3) seconds between consecutive shifts: **N-D-N-R-N-D-N-R-N-D-N-R-N**.
4. Watch for the wrench icon to illuminate and then turn off. That tells the operator they have successfully disabled the Allison Prognostics Feature Package, consisting of the Oil Life Monitor (OM), Filter Life Monitor (FM), and Transmission Health Monitor (TM).

If another **TRANS SERVICE** indicator is installed in the dash or incorporated in an OEM message display, it too should also briefly illuminate in similar fashion as the wrench icon.

5.9.4 NORMAL PROGNOSTICS INDICATION AT ENGINE START. Once Prognostics is monitoring the system, normal operation at engine start is as follows:

1. A system bulb check illuminates the wrench icon between the SELECT and MONITOR display of the selector for approximately 0.5 seconds.
2. If Prognostics features are enabled, the wrench icon illuminates again for 3 seconds after the bulb check.
   - If Prognostics features are disabled, the wrench icon does not illuminate again after the bulb check.
   - The **TRANS SERVICE** indicator, if installed, should behave the same way as described for the wrench icon in Step 2.

NOTE: If the shift calibration permits a maximum allowable gear in primary mode that is different than the maximum allowable gear in secondary mode, Prognostics enabling/disabling is only permitted in the shift mode with the highest maximum allowable range. If you have a higher range set of gears in secondary mode than in primary mode to enable Prognostics, push the **MODE** button so the mode light is illuminated first.

NOTE: The three Prognostics functions, Oil Life Monitor (OM), Filter Life Monitor (FM), and Transmission Health Monitor (TM), are enabled or disabled as a package and cannot be enabled or disabled individually.

5.9.5 SETTING FLUID TYPE FOR PROGNOSTICS. To select transmission fluid type do the following:

- With the engine off and the ignition on, perform the following sequence on the selector, **N-R-N-D-N-R-N-D-N-R-N-D-N**.

The wrench icon flashes if TES 389 is the current setting and illuminates solidly if TES 295 is the current setting. To change the transmission fluid type, wait 5 seconds after entering transmission fluid type mode and perform one of the following sequences to select the proper transmission fluid type:

- **N** (Neutral) **R** (Reverse) **N** (Neutral) to select TES 295 (the wrench icon illuminates solidly showing TES 295 has been selected).
- **N** (Neutral) **D** (Drive) **N** (Neutral) to select TES 389 (the wrench icon begins to flash showing TES 389 has been selected).

The selector exits 30 seconds after entering transmission fluid type mode or the ignition may be turned off to exit earlier. Only one transmission fluid type selection may be made after entering transmission fluid type mode. All other attempts will be ignored. Transmission fluid type mode needs to be entered again if the wrong type of transmission fluid is selected.

5.9.6 OIL LIFE MONITOR (OM). Based on the vehicle's duty cycle, this feature determines fluid life and alerts you when a fluid change is required. Not only does it help you get maximum fluid life while providing the maximum protection for the transmission, the OM also saves you money by preventing unnecessary fluid changes.

Oil life is calculated based on hours of engine and transmission operation. Miles are approximated from the hours and calibrated information. The number of shifts per mile (shift density) determines the duty cycle of the transmission and the oil life limits are based on the observed duty cycle. Hours are accumulated when the engine is running, including when the vehicle is stationary for Power Takeoff (PTO) operation, or for extended idle time.

NOTE: Oil life is continuously calculated on the following cumulative effects:

- Operating hours
- Output revolutions
- Shift density (shifts per mile)
- Retarder accumulator applies (if equipped)

5.9.6.1 FLUID CHANGE NOTIFICATION

The wrench icon illuminates when remaining fluid life reaches 1%. Afterwards, every time the vehicle is started and **D** (Drive) is selected the wrench icon illuminates again and stays on for two minutes to remind the operator a fluid change is needed. This occurs until service is performed and the OM is reset.

NOTE: If the OM mode has been accessed via the shift selector, a number between 0 and 99 is displayed indicating the percentage of fluid life remaining before a change is required.

Calendar based fluid requirements still apply with OM (refer to 5.0 CARE AND MAINTENANCE). If the OM has not indicated the need for a fluid change before 60 months for TES 295 fluid, or 24 months for TES 389 fluid, it is necessary to change the fluid and filters per calendar requirements and then reset the OM. Calendar requirements are not required if a fluid analysis program is in place. Refer to 5.6 FLUID ANALYSIS.

5.9.6.2 READ AND RESET OIL LIFE MONITOR (OM) FROM SELECTOR

READ OM. With engine off and ignition on, push the **DISPLAY MODE/DIAGNOSTIC** (DMD) button twice on the lever selector to enter OM mode. With engine off and ignition on, push the ↑ (Upshift) and ↓ (Downshift) arrows simultaneously twice on the keypad pushbutton selector to enter OM mode. The oil life left is displayed as a percentage between 0 and 99 in the shift selector display window.

RESET OM. The OM may be reset back to 99% by either of these methods:

- Display the OM information and press and hold the **DISPLAY MODE/DIAGNOSTIC** (DMD) button for 10 seconds.

- With the ignition on and the engine off, shift between **N-D-N-D-N-R-N** to reset the value displayed to 99 pausing no more than 3 seconds between consecutive shifts.

The wrench icon illuminates briefly following a reset to acknowledge the reset was successful.

RESET with Allison DOC® For PC-Service Tool. If the value displayed remains unchanged, then it is possible the reset may be restricted to Allison DOC® For PC-Service Tool only.

HISTORY. Allison DOC® For PC–Service Tool may also be used to review reset history and the mileage recorded at the time of reset. Fluid life remaining will be displayed from 100% down to –100% when viewing records in the service tool. A negative % indicates how far past due it is on the oil change. A historical record of the last six resets, including mileage at the time of each reset, may also be viewed using the Allison DOC® For PC-Service Tool Diagnostics Program.

DTC P0897 . If transmission maintenance continues to be unattended, the **CHECK TRANS** light illuminates and DTC P0897, Transmission Fluid at Limit, sets.

CAUTION: Transmission fluid and filter change frequency is determined by the severity of transmission service. To help avoid transmission damage, more frequent changes may be necessary than recommended in the general guidelines due to operating conditions and duty cycle.

For the appropriate recommended change interval guidelines for your specific transmission configuration, refer to Table 5–6, Table 5–7 or Table 5–8.

5.9.7 FILTER LIFE MONITOR (FM). This feature provides an alert when the transmission's fluid filters need to be replaced. It helps extend filter change intervals to reduce routine maintenance downtime and saves you money in the long run, all while providing maximum protection for the transmission. The Filter Life Indicator (FLI) pressure switch signals the TCM when fluid exiting the main filter drops below a pre-determined pressure. Both the main and lube filters **must be** changed when the wrench icon in the selector display indicates the main filter should be changed. The differential pressure limit is verified for a period of time to be sure there is no false indication of the need to change filters.

5.9.7.1 FILTER CHANGE NOTIFICATION

The wrench icon flashes on and off for 2 minutes after **D** (Drive) is selected. Once the Filter Life Monitor (FM) mode has been accessed via the shift selector, The “oK” or “Lo” message is displayed in the selector display window. “oK” means the filters do not need to be changed, and “Lo” means the filters need to be changed.

DTC P088A, Deteriorated Filter, sets along with the wrench icon illuminating for filter restriction but this DTC does not illuminate the **CHECK TRANS** light.

DTC P088B, Very Deteriorated Filter, illuminates the **CHECK TRANS** light if filter service is not performed within a certain period of time of the wrench icon illuminating.

5.9.7.2 READ AND RESET FILTER LIFE MONITOR (FM) FROM SELECTOR

Read FM. With engine off and ignition on, push the **DISPLAY MODE/DIAGNOSTIC** (DMD) button three times on the lever selector to enter FM mode. With engine off and ignition on, push the ↑ (Upshift) and ↓ (Downshift) arrows simultaneously three times on the keypad pushbutton selector to enter FM mode.

The message “oK” or “Lo” is displayed in the selector display window. The message “oK” means the filters do not need to be changed, and “Lo” means the filters need to be changed.

Reset FM. The FM automatically resets once the new filters have been installed and the Filter Life Indicator (FLI) pressure switch no longer detects low pressure at the filter.

The FM can also be reset manually by either of these methods:

- Press and hold the **MODE** button for 10 seconds while in FM mode.
- With ignition on and engine off, shift between **N-R-N-R-N-D-N** to reset the FM, pausing no more than 3 seconds between consecutive shifts.

The wrench icon illuminates briefly following a reset to acknowledge the reset was successful.

If the value displayed remains unchanged, it is possible the reset may be restricted to Allison DOC® For PC-Service Tool only. The FM still resets automatically even if restricted from manual reset through the selector.

History. Allison DOC® For PC-Service Tool Diagnostics Program may be used to display the amount of transmission operation from the initial service indication until the filter reset occurred. Allison DOC® For PC-Service Tool indicates the FM as -- Expired “YES“ or “NO”.

CAUTION: Transmission fluid and filter change frequency is determined by the severity of transmission service. To help avoid transmission damage, more frequent changes may be necessary than recommended in the general guidelines due to operating conditions and duty cycle.

For the appropriate recommended change interval guidelines for your specific transmission configuration, refer to Table 5–6, Table 5–7 or Table 5–8.

5.9.8 TRANSMISSION HEALTH MONITOR (TM). This prognostic feature determines clutch life status of the transmission's clutches and alerts you when clutch maintenance is required. It helps avoid costly repairs and downtime by taking the guesswork out of scheduling routine transmission maintenance, and it ensures your transmission is operating at its maximum performance level. The clutch life status is determined by monitoring the cumulative changes and the calculated running clearance of the transmission clutches.

5.9.8.1 CLUTCH MAINTENANCE NOTIFICATION

The TM feature determines when clutch maintenance is needed. If any of the clutches (except lockup) reaches a remaining life of approximately 10% or if any of the clutch running clearances (except lockup) exceeds a maximum value, then the wrench icon in the selector is steadily illuminated from just after ignition on until ignition is turned off. If TM mode has been accessed via the shift selector, an "oK" or "Lo" is displayed. The "oK" message means no clutch maintenance is needed, and the "Lo" message means an unacceptable clutch life status exists and clutch maintenance is required.

DTC P2789, Clutch Adaptive Learning at Limit, sets if multiple warnings have occurred due to the TM actively detecting issues with the clutch system and illuminating the **CHECK TRANS** light.

5.9.8.2 READ AND RESET TM FROM SELECTOR

Read TM. With engine off and ignition on, push the **DISPLAY MODE/DIAGNOSTIC** (DMD) button four times on the lever selector to enter TM mode. With engine off and ignition on, push the ↑ (Upshift) and ↓ (Downshift) arrows simultaneously four times on the keypad pushbutton selector to enter TM mode.

The message "oK" or "Lo" is displayed in the selector display window. The message "oK" means clutch system maintenance is not required at this time. The message of "Lo" means clutch system maintenance is required.

Reset. The TM feature automatically resets when appropriate conditions are detected. TM can only be manually reset using Allison DOC® For PC-Service

Tool. When resetting TM with the service tool, individual clutches or all clutches can be reset. Operator reset through the shift selector is not allowed.

History. The Allison DOC® For PC–Service Tool may be used to display the amount of transmission operation from the initial service indication until the service reset. The Allison DOC® For PC-Service Tool also displays "OK" or "Not OK" for each clutch.

5.9.9 FLUID AND FILTER CHANGE INTERVAL RECOMMENDATIONS .

CAUTION: Transmission fluid and filter change frequency is determined by the severity of transmission service. To help avoid transmission damage, more frequent changes may be necessary than recommended in the general guidelines due to operating conditions and duty cycle.

For the appropriate recommended change interval guidelines for your specific transmission configuration, refer to Table 5–6, Table 5–7 or Table 5–8.

CAUTION: Transmission fluid and filters **must be changed** whenever there is evidence of dirt or high temperature conditions. A high temperature condition is indicated when the transmission fluid is discolored, has a strong odor, or has exceeded oil analysis limits.

There are three methods recommended by Allison Transmission to help you determine when to change the fluid and filters in your Allison transmission. The methods are as follows:

- When a Prognostics indicator becomes active (shown by illuminating the wrench icon between the SELECT and MONITOR display in all Allison Transmission 4th Generation with Prognostics keypad pushbutton and lever selectors).
- When recommendations listed in the Fluid and Filter Change Interval Tables are met. Refer to Table 5–6, Table 5–7, or Table 5–8.
- When a fluid analysis program indicates a fluid change is necessary. Filter changes must still occur based on either of the events occurring above.

5.9.9.1 FLUID AND FILTER CHANGE INTERVAL SCHEDULES WITH PROGNOSTICS TURNED ON

NOTE: Calendar based change intervals must still be adhered to for both fluid and filter changes even if Prognostics has not indicated to the operator for either fluid or filter maintenance yet, unless fluid analysis is used. If maintenance is done because the fluid or filters reached the calendar based change interval, the OM and FM should be manually reset at that time. Refer to 5.9.6 OIL LIFE MONITOR (OM) and 5.9.7 FILTER LIFE MONITOR (FM).

NOTE: Allison Transmission High Capacity filters are required in order to use Filter Life Monitor (FM) feature with Prognostics on maintenance schedule as shown in Table 5–6.

NOTE: Either TES 295 or TES 389 fluid types are required to use the OM feature with Prognostics on. A mixture of TES 389 and TES 295 fluid must continue to use the TES 389 fluid change intervals until two fluid changes with only TES 295 fluid have occurred, at which time the TES 295 schedule may be used.

NOTE: Look at OM % left and/or fluid condition at the time of filter change to determine if it is in the best interest of the customer to change the fluid.

Table 5–6. Prognostics On Fluid and Filter Change Intervals

	Fluid Change Intervals	High Capacity[**] Main and Lube Filter Change Intervals	Suction Filter Assembly Change Interval
TES 295 Fluids[*] (includes TranSynd®)	Whichever is first of the following: • If the wrench icon in the selector is illuminated steady for 2 minutes after **D** (Drive) is selected • 60 calendar months[**] **NOTE:** Always replace main and lube filters with the fluid change[**].	Whichever is first of the following: • If the wrench icon in the selector is flashing on and off for 2 minutes after **D** (Drive) selected • Any time the fluid is changed • 60 calendar months[**]	At time of transmission overhaul
TES 389 Fluids[*]	Whichever is first of the following: • If the wrench icon in the selector is illuminated steady for 2 minutes after **D** (Drive) is selected • 24 calendar months[**] **NOTE:** Always replace main and lube filters with the fluid change[**].	Whichever is first of the following: • If the wrench icon in the selector is flashing on and off for 2 minutes after **D** (Drive) selected • Any time the fluid is changed • 24 calendar months[**]	At time of transmission overhaul

NOTE: TES 389 fluid type choice for prognostics is available only if TCM has a 4C or later CIN; all 4A CINs must use TES 295 fluid only if prognostics is enabled and ON.

[*] Either TES 295 or TES 389 fluid types are required to use the Oil Life Monitor (OM) feature with Prognostics on as shown in this table. A mixture of TES 389 and TES 295 fluid must continue to use the TES 389 schedule shown in this table until two fluid changes with only TES 295 fluid have occurred, at which time the TES 295 schedule may be used.
[**] Allison Transmission High Capacity filters are required in order to use the Filter Life Monitor (FM) feature with Prognostics as shown in this table.

5.9.9.2 FLUID AND FILTER CHANGE INTERVAL SCHEDULES WITH PROGNOSTICS DISABLED OR TURNED OFF

NOTE: A mixture of TES 389 and TES 295 fluid must continue to use the TES 389 fluid change intervals until two fluid changes with only TES 295 fluid have occurred, at which time the TES 295 schedule may be used.

CAUTION: Transmission fluid and filter change frequency is determined by the severity of transmission service. To help avoid transmission damage, more frequent changes may be necessary than recommended in the general guidelines due to operating conditions and duty cycle.

For the appropriate recommended change interval guidelines for your specific transmission configuration, refer to Table 5–6, Table 5–7 or Table 5–8.

NOTE: Change fluid/filters at or before recommended mileage, months, or hours have elapsed, whichever occurs first. For vehicles that average less than 40 km/h (25 mph), operating hours represent a more reliable measure of fluid life; therefore, fluid change intervals should not be based on mileage only.

Table 5–7. Prognostics Disabled or Turned Off Fluid and Filter Change Intervals

General Vocation* Refer to Table 5–8 for additional information on severe vocations.			
	Fluid Change Intervals	**High Capacity Main*** and Lube Filter Change Intervals**	**Suction Filter Assembly Change Interval**
TES 295 Fluids** (includes TranSynd®)	Whichever is first of the following: • 480 000 km (300,000 miles) • 6000 hours of operation • 48 calendar months **NOTE:** Always replace main and lube filters with the fluid change***.	Whichever is first of the following: • Any time the fluid is changed • 120 000 km (75,000 miles) • 3000 hours of operation • 36 calendar months	At time of transmission overhaul
TES 389 Fluids**	Whichever is first of following: • 40 000 km (25,000 miles) • 1000 hours of operation • 12 calendar months **NOTE:** Always replace main and lube filters with the fluid change***.	Whichever is first of the following: • Any time the fluid is changed • 40 000 km (25,000 miles) • 1000 hours of operation • 12 calendar months	At time of transmission overhaul

* General Vocation includes all non-retarder transmissions not identified as severe, and intercity coaches with duty cycles of less than one stop per mile.
** A mixture of TES 389 and TES 295 fluid must continue to use the TES 389 schedule shown in this table until two fluid changes with only TES 295 fluid have occurred, at which time the TES 295 schedule may be used.
*** This information is based on using Allison Transmission High Capacity filters and a TES 389 or TES 295 fluid type with Prognostics Features not available or turned off.

Table 5–8. Prognostics Disabled or Turned Off Fluid and Filter Change Intervals

Severe Vocation*			
	Fluid Change Intervals	**High Capacity **Main and Lube Filter Change Intervals**	**Suction Filter Assembly Change Interval**
TES 295 Fluids*** (includes TranSynd®)	Whichever is first of the following: • 240 000 km (150,00 miles) • 6000 hours of operation • 48 calendar months **NOTE:** Always replace main and lube filters with the fluid change**.	Whichever is first of the following: • Any time the fluid is changed • 120 000 km (75,000 miles) • 3000 hours of operation • 36 calendar months	At time of transmission overhaul
TES 389 Fluids***	Whichever is first of the following: • 20 000 km (12,000 miles) • 500 hours of operation • 6 calendar months **NOTE:** Always replace main and lube filters with the fluid change **.	Whichever is first of the following: • Any time the fluid is changed • 20 000 km (12,000 miles) • 500 hours of operation • 6 calendar months	At time of transmission overhaul

* Severe Vocation includes all retarder equipped transmissions, or vocations for On/Off Highway, Refuse, Transit, and Intercity Coach with duty cycle greater than one (1) stop per mile.

** This information is based on using Allison Transmission High Capacity filters and a TES 389 or TES 295 fluid type with Prognostics Features not available or turned off.

*** A mixture of TES 389 and TES 295 fluid must continue to use the TES 389 schedule shown in this table until two fluid changes with only TES 295 fluid have occurred, at which time the TES 295 schedule may be used.

5.9.9.3 FLUID AND FILTER CHANGE PROCEDURE

NOTE: Do not drain the transmission fluid if only filters are being replaced.

WARNING: Avoid contact with the hot fluid or the sump when draining transmission fluid. Direct contact with the hot fluid or the hot sump may result in bodily injury.

Drain Fluid

1. Drain the fluid when the transmission is at operating temperature of 71–93°C (160–200°F). Hot fluid flows quicker and drains more completely.
2. Remove the drain plug from the control module and allow the fluid to drain into a suitable container.
3. Examine the fluid for contamination.

NOTE: At each fluid change, examine the drained fluid for evidence of dirt or water. A normal amount of condensation appears in the fluid during operation.

Replace Filters (Refer to Figure 5–5).

1. Remove 12 bolts (1), two filter covers (2), two gaskets (3), two O-rings (4), two O-rings (5), and two filters (6) from the bottom of the control module.
2. When reinstalling parts, lubricate and install new O-rings (4) and (5) on each cover (2). Lubricate O-ring inside filter (6) and push filter onto cover (2). Install new gaskets (3) on cover (2) and align holes in gaskets with holes in cover.

CAUTION: Do not use the bolts to draw the filter covers to the control module. Do not use an impact wrench to tighten the bolts. Using an impact wrench to tighten the bolts may cause stripped threads and expensive parts replacement. Use a torque wrench to tighten the bolts.

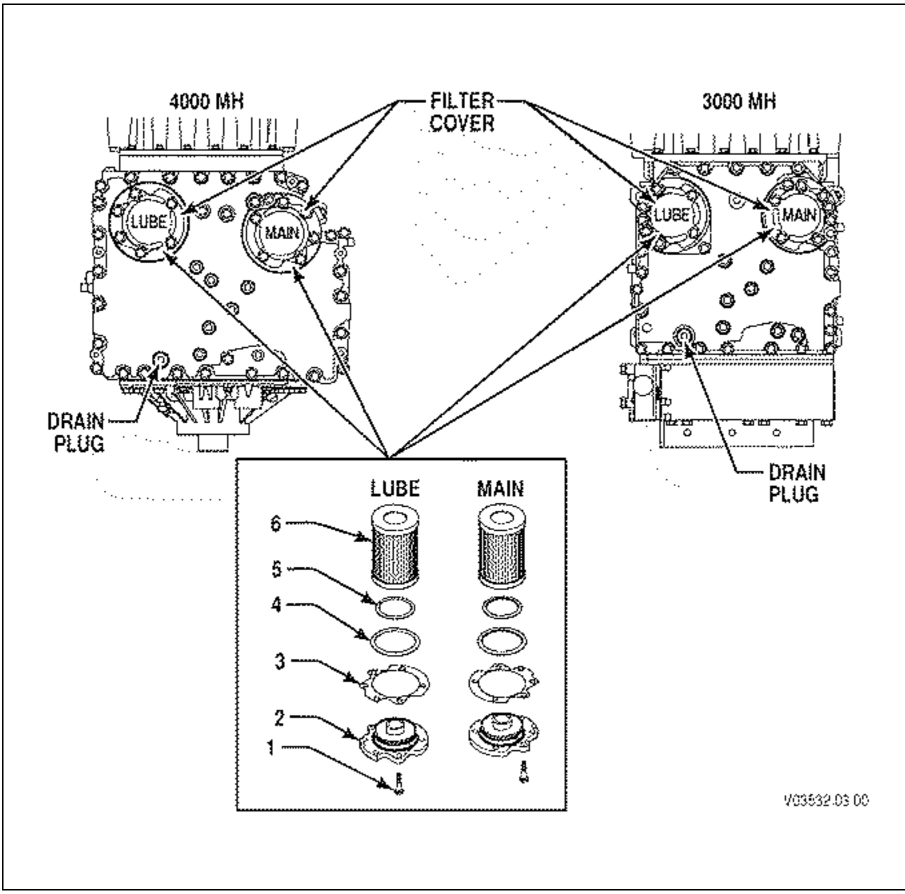


Figure 5–5. Location of Filters for Service

3. Install filter and cover assemblies into the filter compartment. Align each filter/cover assembly with the holes in the channel plate/sump. Push the cover assemblies in by hand to seat the seals.
4. Install 12 bolts into cover and tighten to 51–61 N•m (38–45 lb ft).
5. Replace the drain plug O-ring. Install the plug and tighten to 25–32 N•m (18–24 lb ft).

5.9.9.4 REFILL TRANSMISSION

Refer to 5.7 TRANSMISSION FLUID REFILL.

HIGHWAY SERIES

6.0 DIAGNOSTICS

6.1 OVERVIEW

Diagnostic features are provided with the transmission control system to assist in troubleshooting of malfunctions and/or the monitoring of specific operating parameters. When a control system malfunction is detected, a series of Diagnostic Trouble Codes (DTCs) are used to identify and clarify the nature of the malfunction. These DTCs are each named by a 5 character alphanumeric string that refers to a diagnostic algorithm running pass/fail tests to help identify a malfunction in the transmission or vehicle operation. Most DTCs have some kind of diagnostic response that the operator notices, such as an illuminated **CHECK TRANS** light, selector display change, lock in range, or inhibit shifts condition.

DTCs are logged in the Transmission Control Module (TCM) memory by severity and by their active/inactive status with the most severe and active codes listed first. A maximum of five DTCs (numbered d1–d5) from most recent to oldest may be read from the shift selector. As DTCs are added, the oldest inactive DTC (historic) is dropped from the list. If all DTCs are active, the DTC with the lowest priority is dropped from the list.

An active code is any code that is current in the TCM decision-making process and has failed the DTC test(s) associated with that specific diagnostic algorithm. Historical codes, which are by definition inactive, are codes that are no longer failing their algorithm but are retained in the TCM in order to help the technician analyze possible causes and provide them direction if the vehicle is brought in before they are cleared from the queue.

DTCs can be cleared manually by the operator or they clear automatically from last (d5) to first (d1) in the queue after a number of engine starts, without becoming active again.

6.2 DIAGNOSTIC TROUBLE CODE RESPONSE

The electronic control system is programmed to inform the operator of a problem with the transmission system via the **CHECK TRANS** light and shift selector display while it automatically takes action to protect the operator, vehicle, and transmission. When the Transmission Control Module (TCM) flags a Diagnostic Trouble Code (DTC) as active, the TCM may take a combination of diagnostic responses as listed in the table below. Refer to Table 6–1.

Table 6–1. Diagnostic Trouble Code (DTC) Response

Category of Response	Actions Taken
Do Not Shift (DNS)	Release lockup (LU) clutch and inhibit LU operation
	Inhibit shifts from the current attained range
	Turn on the **CHECK TRANS** light
	Display the current attained range in the MONITOR window of the shift selector
	Blank the SELECT window of the shift selector
	Disable ability for shift selectors to respond to any range change request from the operator using the shift selector(s).
Solenoids OFF (SOL OFF)	All solenoids are commanded off resulting in hydraulic default operation of the transmission - PCS1 and PCS2 are on hydraulically when off electrically.
Return to Previous Range (RPR)	When speed sensor ratio or PS1 tests do not pass, the TCM commands the same range as commanded before the shift.
Neutral No Clutches (NNC)	When certain speed sensor ratio or PS1 tests do not pass, the TCM commands a neutral condition with no clutches applied.
Do Not Adapt (DNA)	The TCM stops adaptive shift control while the code is active.

6.2.1 CHECK TRANS LIGHT. Each time the engine is started, the **CHECK TRANS** light illuminates briefly for a bulb check. After a few seconds it should turn off. If the **CHECK TRANS** light does not illuminate briefly after the ignition is turned on, or if the **CHECK TRANS** light remains steadily on after ignition and engine start, have the vehicle and transmission system checked by a qualified Allison Transmission technician.

If the **CHECK TRANS** light is steadily illuminated due to an active DTC, the shift selector blanks the SELECT and only shows a range the transmission has locked into in the MONITOR window of the selector, seek immediate attention from a qualified Allison Transmission technician. Perform service as soon as possible in order to minimize the potential for damage to the transmission or vehicle. The transmission can be operated for a short time in the current attained range in order to get the vehicle to a safe location for service assistance. If the vehicle engine is turned off, prepare for the possibility that at engine restart the transmission may be locked in **N** (Neutral) and will not accept operator requests to change range if a DTC that causes a **CHECK TRANS** light is active at time of engine restart.

NOTE: Some DTCs may be logged without the TCM activating the **CHECK TRANS** light. Contact your Allison Transmission authorized service outlet whenever there is a transmission-related concern. They have the equipment to access and troubleshoot DTCs.

6.3 USING SHIFT SELECTOR FOR ACCESSING DIAGNOSTICS INFORMATION

6.3.1 INTERPRETING DTC MESSAGE SEQUENCE ACROSS SELECTOR DISPLAYS. Up to five DTCs may be displayed from the selector once the diagnostic display mode has been initiated by the operator (refer to 6.3.3 READ/CLEAR DIAGNOSTIC TROUBLE CODES (DTCs) USING LEVER SHIFT SELECTOR, and 6.3.4 READ/CLEAR DIAGNOSTIC TROUBLE CODES (DTCs) USING KEYPAD PUSHBUTTON SHIFT SELECTOR).

DTCs are seven characters in length and are displayed in four character strings. Three of the four character strings consist of two characters. The first position in the character string is one character in length and it is the code type, designated by a P or U.

Each character string displays for 1-2 seconds in a sequential pattern in the selector display until the DTC completes the message cycle. The message continues to repeat itself until the operator presses the **MODE** button to read the next DTC in the queue (if any) or requests to exit diagnostics mode (refer to 6.3.3.4 EXITING DIAGNOSTIC MODE USING LEVER SHIFT SELECTOR and 6.3.4.4 EXITING DIAGNOSTIC MODE USING KEYPAD PUSHBUTTON SHIFT SELECTOR). The diagnostics mode times out and returns the selector to normal operating mode after approximately 10 minutes of operator inactivity.

The first two characters in the first string displays the position of the DTC in the queue, d1 (newest) through d5 (oldest). The next five characters that display in the selector define the DTC.

The following example illustrates the method for displaying any DTC stored in the queue. In this example we have the newest code, d1, as it would appear in the selector display for DTC P2534:

Table 6–2. Displaying DTC P2534 Stored in the Queue

RANGE SELECT WINDOW	RANGE MONITOR WINDOW
d*	1*
(blank display)	P**
2***	5***
3****	4****

* d1 Code list position (Note: d1=newest code, d5=oldest code in memory)
** Code type
*** Main code
**** Sub code

- **d1; P; 25; 34** repeats until the next DTC (d2) is accessed by pressing the **MODE** button or when the operator exits diagnostic display mode.

NOTE: The **MODE** indicator on the selector, (refer to Figure 4–1), will be illuminated simultaneously with the display of the DTC. If the DTC is currently active, the **MODE** indicator is not illuminated then the DTC is inactive (historic). Inactive DTCs will not inhibit or limit transmission performance. Only active DTCs limit transmission performance. The inactive codes kept in the queue for reference to assist with troubleshooting an intermittent problem.

The next example shows the display of DTC U0115 which is next in the queue (d2), after the operator pressed the **MODE** button.

Table 6–3. Displaying DTC U0115 Stored in the Queue

RANGE SELECT WINDOW	RANGE MONITOR WINDOW
d*	2*
(blank display)	U**
0***	1***
1****	5****

* d2 Code list position (Note: d1=newest code, d5=oldest code in memory)
** Code type
*** Main code
**** Sub code

- **d2; U; 01; 15** repeats until the next DTC (d3) is accessed by pressing the **MODE** button or when the operator exits diagnostic display mode. Refer to 6.3.4.4 EXITING DIAGNOSTIC MODE USING KEYPAD PUSHBUTTON SHIFT SELECTOR.

6.3.2 MEANING OF MODE INDICATOR IN DIAGNOSTIC MODE. If the **MODE** indicator is illuminated (refer to Figure 4–1), while reading DTCs out of the selector display, the displayed DTC is active. If the **MODE** indicator is not illuminated, the displayed DTC is inactive (historic).

NOTE: An illuminated **MODE** indicator while driving the vehicle does not mean there is an active DTC, this means a secondary shift schedule, typically an economy shift schedule, is active.

6.3.3 READ/CLEAR DIAGNOSTIC TROUBLE CODES (DTCs) USING LEVER SHIFT SELECTOR.

6.3.3.1 READING DTCs WITH PROGNOSTICS ON USING LEVER SHIFT SELECTOR

- To read DTCs with prognostics on using the lever shift selector, press the **DISPLAY MODE/DIAGNOSTIC** (DMD) button five times to enter diagnostic mode.
- Press the **MODE** button to read the next DTC in the queue, if any.

6.3.3.2 READING DTCs WITH PROGNOSTICS OFF USING LEVER SHIFT SELECTOR

- To read DTCs with prognostics off using the lever shift selector, press the **DISPLAY MODE/DIAGNOSTIC** (DMD) button two times to enter diagnostic mode.
- Press the **MODE** button to read the next DTC in the queue, if any.

NOTE: Be sure to record all displayed DTCs before they are cleared. This is essential for troubleshooting.

6.3.3.3 CLEARING DTCs USING LEVER SHIFT SELECTOR

While in diagnostic mode, clear all active DTCs by pressing and holding the **MODE** button for approximately three seconds until the **MODE** indicator flashes. Release the **MODE** button. The **MODE** indicator should not remain illuminated if the active DTC shown in the display has cleared.

To clear all stored DTCs that are stored in TCM history, press and hold the **MODE** button for ten seconds. The **MODE** indicator flashes a second time indicating all codes are cleared from the queue.

NOTE: Any codes that cause the **CHECK TRANS** light to illuminate are considered severe enough to warrant immediate attention from a qualified repair facility. Schedule repair as soon as possible.

NOTE: If an active DTC is cleared while the transmission is locked in range because of the diagnostic response to an active DTC, the transmission remains in that locked range even after clearing the active DTC. **N** (Neutral) must be manually selected or the ignition must be cycled.

NOTE: Some codes will self-clear once the conditions that caused the active code are not present, they will still be stored as inactive in the DTC queue. Some DTCs require an ignition cycle before they can be cleared from active status.

NOTE: If the condition(s) that caused the active code are still present, the code becomes active again.

6.3.3.4 EXITING DIAGNOSTIC MODE USING LEVER SHIFT SELECTOR

The operator can request to exit the diagnostic mode by one of the following methods:

- Momentarily press the **MODE** button once
- Moving the lever shift selector to any range
- Automatically leaves diagnostic mode after approximately ten minutes of operator inactivity at the lever shift selector, returning the lever shift selector back to a normal operating mode

6.3.4 READ/CLEAR DIAGNOSTIC TROUBLE CODES (DTCs) USING KEYPAD PUSHBUTTON SHIFT SELECTOR.

6.3.4.1 READING DTCs WITH PROGNOSTICS ON USING KEYPAD PUSHBUTTON SHIFT SELECTOR

- To read DTCs with prognostics on using the keypad pushbutton shift selector, simultaneously press the ↑ (Upshift) and ↓ (Downshift) arrows five times to enter diagnostic mode.
- Press the **MODE** button to read the next code in the queue, if any.

6.3.4.2 READING DTCs WITH PROGNOSTICS OFF USING KEYPAD PUSHBUTTON SHIFT SELECTOR

- To read DTCs with prognostics off using the keypad pushbutton shift selector, simultaneously press the ↑ (Upshift) and ↓ (Downshift) arrows two times to enter diagnostic mode.
- Press the **MODE** button to read the next code in the queue, if any.

NOTE: Be sure to record all DTCs displayed before they are cleared. This is essential for troubleshooting.

6.3.4.3 CLEARING DTCs USING KEYPAD PUSHBUTTON SHIFT SELECTOR

While in diagnostic mode, clear all active codes by pressing and holding the **MODE** button for approximately three seconds until the **MODE** indicator flashes. Release the **MODE** button. The **MODE** indicator should not remain illuminated if the active DTC shown in the display has cleared.

To clear all stored DTCs press and hold the **MODE** button for ten seconds. The **MODE** indicator flashes a second time indicating all codes are cleared from the queue.

NOTE: Any codes that cause the **CHECK TRANS** light are considered severe enough to warrant immediate attention from a qualified repair facility. Schedule repair as soon as possible.

NOTE: If an active indicator is cleared while the transmission is locked in range because of the diagnostic response to an active DTC, the transmission remains in that locked range even after clearing the active indicator. **N** (Neutral) must be manually selected or the ignition must be cycled.

NOTE: Some codes will self-clear once the conditions that caused the active code are not present, they will still be stored as inactive in the DTC queue. Some DTCs require an ignition cycle before they can be cleared from active status.

NOTE: If the condition(s) that caused the active code are still present, the code becomes active again.

6.3.4.4 EXITING DIAGNOSTIC MODE USING KEYPAD PUSHBUTTON SHIFT SELECTOR

The operator can request to exit the diagnostic mode by one of the following methods:

- Momentarily press the ↑ (Upshift) and ↓ (Downshift) arrows once
- Press any range button, **D** (Drive), **N** (Neutral), **R** (Reverse)
- Automatically exits diagnostic mode and returns to normal operating mode after approximately 10 minutes of operator inactivity at the pushbutton shift selector.

6.3.4.5 DIAGNOSTIC TROUBLE CODE (DTC) LIST AND DESCRIPTION

Table 6–4. Diagnostic Troubleshooting Codes (DTC) and Descriptions

DTC	Description	CHECK TRANS Light	Inhibited Operation Description
C1312	Retarder Request Sensor Failed Low	No	May inhibit retarder operation if not using J1939 datalink
C1313	Retarder Request Sensor Failed High	No	May inhibit retarder operation if not using J1939 datalink
P0122	Pedal Position Sensor Low Voltage	No	Use default throttle values. Freezes shift adapts.
P0123	Pedal Position Sensor High Voltage	No	Use default throttle values. Freezes shift adapts.
P0128	Transmission Fluid Over Temperature	No	Use hot mode shift schedule. Holds fourth range. TCM is inhibited. Freezes shift adapts.
P0602	TCMNot Programmed	Yes	Lock in Neutral
P0610	TCM Vehicle Options (TransID) Error	Yes	Use TID A calibration
P0613	TCM Processor	No	All solenoids off
P0614	Torque Control Data Mismatch—ECM/TCM	Yes	Allows operation only in reverse and second range
P0634	TCM Internal Temperature Too High	Yes	SOL OFF (hydraulic default)

Table 6–4. Diagnostic Troubleshooting Codes (DTC) and Descriptions *(cont'd)*

DTC	Description	CHECK TRANS Light	Inhibited Operation Description
P063E	Auto Configuration Throttle Input Not Present	Yes	Use default throttle values
P063F	Auto Configuration Engine Coolant Temp Input Not Present	No	None
P0658	Actuator Supply Voltage 1 (HSD1) Low	Yes	DNS, SOL OFF (hydraulic default)
P0659	Actuator Supply Voltage 1 (HSD1) High	Yes	DNS, SOL OFF (hydraulic default)
P0702	Transmission Control System Electrical (TransID)	Yes	Uses TID A calibration
P0703	Brake Switch Circuit Malfunction	No	No Neutral to Drive shifts for refuse packer. TCM inhibits retarder operation if a TPS code is also active.
P0708	Transmission Range Sensor Circuit High Input	Yes	Ignore defective strip selector inputs
P070C	Transmission Fluid Level Sensor Circuit—Low Input	No	None
P070D	Transmission Fluid Level Sensor Circuit—High Input	No	None
P0711	Transmission Fluid Temperature Sensor Circuit Performance	Yes	Use default sump temp
P0712	Transmission Fluid Temperature Sensor Circuit Low Input	Yes	Use default sump temp
P0713	Transmission Fluid Temperature Sensor Circuit High Input	Yes	Use default sump temp
P0716	Turbine Speed Sensor Circuit Performance	Yes	DNS, Lock in current range

Table 6–4. Diagnostic Troubleshooting Codes (DTC) and Descriptions *(cont'd)*

DTC	Description	CHECK TRANS Light	Inhibited Operation Description
P0717	Turbine Speed Sensor Circuit No Signal	Yes	DNS, Lock in current range
P0719	Brake Switch ABS Input Low	No	TCM assumes ABS is OFF
P071A	RELS Input Failed On	Yes	Inhibit RELS operation
P071D	General Purpose Input Fault	Yes	None
P0721	Output Speed Sensor Circuit Performance	Yes	DNS, Lock in current range
P0722	Output Speed Sensor Circuit No Signal	Yes	DNS, Lock in current range
P0726	Engine Speed Sensor Circuit Performance	No	Default to turbine speed
P0727	Engine Speed Sensor Circuit No Signal	No	Default to turbine speed
P0729	Incorrect 6th Gear Ratio	Yes	DNS, Attempt 5th, then 3rd
P0731	Incorrect 1st Gear Ratio	Yes	DNS, Attempt 2nd, then 5th
P0732	Incorrect 2nd Gear Ratio	Yes	DNS, Attempt 3rd, then 5th
P0733	Incorrect 3rd Gear Ratio	Yes	DNS, Attempt 4th, then 6th
P0734	Incorrect 4th Gear Ratio	Yes	DNS, Attempt 5th, then 3rd
P0735	Incorrect 5th Gear Ratio	Yes	DNS, Attempt 6th, then 3rd, then 2nd
P0736	Incorrect Reverse Gear Ratio	Yes	DNS, Lock in Neutral
P0741	Torque Converter Clutch System Stuck Off	Yes	None
P0776	Pressure Control Solenoid 2 Stuck Off	Yes	DNS, RPR
P0777	Pressure Control Solenoid 2 Stuck On	Yes	DNS, RPR

Table 6–4. Diagnostic Troubleshooting Codes (DTC) and Descriptions *(cont'd)*

DTC	Description	CHECK TRANS Light	Inhibited Operation Description
P0796	Pressure Control Solenoid 3 Stuck Off	Yes	DNS, RPR
P0797	Pressure Control Solenoid 3 Stuck On	Yes	DNS, RPR
P0842	Transmission Pressure Switch 1 Circuit Low	Yes	DNS, Lock in current range
P0843	Transmission Pressure Switch 1 Circuit High	Yes	DNS, Lock in current range
P0880	TCM Power Input Signal	No	None
P0881	TCM Power Input Signal Performance	No	None
P0882	TCM Power Input Signal Low	Yes	DNS, SOL OFF (hydraulic default)
P0883	TCM Power Input Signal High	No	None
P0894	Transmission Component Slipping	Yes	DNS, Lock in first
P0960	Pressure Control Solenoid Main Mod Control Circuit Open	Yes	None
P0962	Pressure Control Solenoid Main Mod Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P0963	Pressure Control Solenoid Main Mod Control Circuit High	Yes	None
P0964	Pressure Control Solenoid 2 (PCS2) Control Circuit Open	Yes	DNS, SOL OFF (hydraulic default)
P0966	Pressure Control Solenoid 2 (PCS2) Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)

Table 6–4. Diagnostic Troubleshooting Codes (DTC) and Descriptions *(cont'd)*

DTC	Description	CHECK TRANS Light	Inhibited Operation Description
P0967	Pressure Control Solenoid 2 (PCS2) Control Circuit High	Yes	DNS, SOL OFF (hydraulic default)
P0968	Pressure Control Solenoid 3 (PCS3) Control Circuit Open	Yes	DNS, SOL OFF (hydraulic default)
P0970	Pressure Control Solenoid 3 (PCS3) Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P0971	Pressure Control Solenoid 3 (PCS3) Control Circuit High	Yes	DNS, SOL OFF (hydraulic default)
P0973	Shift Solenoid 1 (SS1) Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P0974	Shift Solenoid 1 (SS1) Control Circuit High	Yes	DNS, SOL OFF (hydraulic default)
P0975	Shift Solenoid 2 (SS2) Control Circuit Open	Yes	7-speed: Allow 2 through 6, N, R
P0976	Shift Solenoid 2 (SS2) Control Circuit Low	Yes	7-speed: Allow 2 through 6, N, R. Inhibit TCM operation
P0977	Shift Solenoid 2 (SS2) Control Circuit High	Yes	7-speed: Allow 2 through 6, N, R
P0989	Retarder Pressure Sensor Failed Low	No	None
P0990	Retarder Pressure Sensor Failed High	No	None
P1739	Incorrect Low Gear Ratio	Yes	Command 2nd and allow shifts 2 through 6, N, R
P1891	Throttle Position Sensor PWM Signal Low Input	No	Use default throttle values
P1892	Throttle Position Sensor PWM Signal High Input	No	Use default throttle values

Table 6–4. Diagnostic Troubleshooting Codes (DTC) and Descriptions *(cont'd)*

DTC	Description	CHECK TRANS Light	Inhibited Operation Description
P2814	Engine Coolant Temperature Sensor Circuit Low Input	No	Use default engine coolant values
P2815	Engine Coolant Temperature Sensor Circuit High Input	No	Use default engine coolant values
P2637	Torque Management Feedback Signal (SEM)	Yes	Inhibit SEM
P2641	Torque Management Feedback Signal (LRTP)	Yes	Inhibit LRTP
P2670	Actuator Supply Voltage 2 (HSD2) Low	Yes	DNS, SOL OFF (hydraulic default)
P2671	Actuator Supply Voltage 2 (HSD2) High	Yes	DNS, SOL OFF (hydraulic default)
P2685	Actuator Supply Voltage 3 (HSD3) Low	Yes	DNS, SOL OFF (hydraulic default)
P2686	Actuator Supply Voltage 3 (HSD3) High	Yes	DNS, SOL OFF (hydraulic default)
P2714	Pressure Control Solenoid 4 (PCS4) Stuck Off	Yes	DNS, RPR
P2715	Pressure Control Solenoid 4 (PCS4) Stuck On	Yes	DNS, SOL OFF (hydraulic default)
P2718	Pressure Control Solenoid 4 (PCS4) Control Circuit Open	Yes	DNS, SOL OFF (hydraulic default)
P2720	Pressure Control Solenoid 4 (PCS4) Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P2721	Pressure Control Solenoid 4 (PCS4) Control Circuit High	Yes	DNS, SOL OFF (hydraulic default)

Table 6–4. Diagnostic Troubleshooting Codes (DTC) and Descriptions *(cont'd)*

DTC	Description	CHECK TRANS Light	Inhibited Operation Description
P2723	Pressure Control Solenoid 1 (PCS1) Stuck Off	Yes	DNS, RPR
P2724	Pressure Control Solenoid 1 (PCS1) Stuck On	Yes	DNS, RPR
P2727	Pressure Control Solenoid 1 (PCS1) Control Circuit Open	Yes	DNS, SOL OFF (hydraulic default)
P2729	Pressure Control Solenoid 1 (PCS1) Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P2730	Pressure Control Solenoid 1 (PCS1) Control Circuit High	Yes	DNS, SOL OFF (hydraulic default)
P2736	Pressure Control Solenoid 5 (PCS5) Control Circuit Open	Yes	Inhibit retarder operation
P2738	Pressure Control Solenoid 5 (PCS5) Control Circuit Low	Yes	Allow 2 through 6, N, R. Inhibit retarder and TCM operation
P2739	Pressure Control Solenoid 5 (PCS5) Control Circuit High	Yes	Inhibit retarder operation
P2740	Retarder Oil Temperature Hot	No	None
P2742	Retarder Oil Temperature Sensor Circuit—Low Input	No	Use default retarder temp values
P2743	Retarder Oil Temperature Sensor Circuit—High Input	No	Use default retarder temp values
P2761	TCC PCS Control Circuit Open	Yes	Inhibit TCM operation

Table 6–4. Diagnostic Troubleshooting Codes (DTC) and Descriptions *(cont'd)*

DTC	Description	CHECK TRANS Light	Inhibited Operation Description
P2763	TCM PCS Control Circuit High	Yes	Inhibit TCM operation
P2764	TCM PCS Control Circuit Low	Yes	7-speed: allow 2 through 6, N, R. Inhibit TCM operation
P278A	Kickdown Input Failed ON	No	Inhibit kickdown operation
P2793	Gear Shift Direction Circuit	Yes	Ignores PWM input from shift selector
P2808	Pressure Control Solenoid 6 (PCS6) Stuck Off	Yes	DNS, RPR
P2809	Pressure Control Solenoid 6 (PCS6) Stuck On	Yes	DNS, RPR
P2812	Pressure Control Solenoid 6 (PCS6) Control Circuit Open	Yes	DNS, SOL OFF (hydraulic default)
P2814	Pressure Control Solenoid 6 (PCS6) Control Circuit Low	Yes	DNS, SOL OFF (hydraulic default)
P2815	Pressure Control Solenoid 6 (PCS6) Control Circuit High	Yes	DNS, SOL OFF (hydraulic default)
U0001	Hi Speed CAN Bus Reset Counter Overrun (IESCAN)	No	Use default values, inhibit SEM
U0010	CAN BUS Reset Counter Overrun	No	Use default values, inhibit SEM
U0100	Lost Communications with ECM/PCM (J1587)	Yes	Use default values
U0103	Lost Communication With Gear Shift Module (Shift Selector) 1	Yes	Maintain range selected, observe gear shift direction circuit
U0115	Lost Communication With ECM	Yes	Use default values

Table 6–4. Diagnostic Troubleshooting Codes (DTC) and Descriptions *(cont'd)*

DTC	Description	CHECK TRANS Light	Inhibited Operation Description
U0291	Lost Communication With Gear Shift Module (Shift Selector) 2	Yes	Maintain range selected, observe gear shift direction circuit
U0304	Incompatible Gear Shift Module 1 (Shift Selector) ID	Yes	Ignore shift selector inputs
U0333	Incompatible Gear Shift Module 2 (Shift Selector) ID	Yes	Ignore shift selector inputs
U0404	Invalid Data Received From Gear Shift Module (Shift Selector) 1	Yes	Maintain range selected, observe gear shift direction circuit
U0592	Invalid Data Received From Gear Shift Module (Shift Selector) 2	Yes	Maintain range selected, observe gear shift direction circuit

HIGHWAY SERIES

7.0 PROGNOSTICS SHIFT SELECTORS COMPONENTS AND FUNCTIONS

7.1 SELECT/MONITOR DISPLAY

A two-character vacuum fluorescent blue-green display is included on the face of each lever and keypad pushbutton shift selector. The left character, called the SELECT display appropriately designates **N** (Neutral), **R** (Reverse), or the highest gear available of the selected forward range. The right character of the display, called the MONITOR display, designates the actual gear being commanded by the TCM. The display of any other character in the SELECT or MONITOR display denotes a non-standard operating condition.

7.2 BACKLIGHTING

During normal vehicle operation, backlighting is provided for the range legend strip on the lever shift selector and for all six keypad buttons of the pushbutton shift selector.

The digital (range) display, the **MODE** and **RANGE** buttons are illuminated on the keypad pushbutton and lever shift selectors. The brightness of both is adjusted automatically, depending upon the brightness setting of the dash dimmer switch.

NOTE: The shift selector microprocessor, which controls the selector backlighting, is initialized by an ignition signal and not by power in the headlight circuit. Therefore, the shift selector backlighting and dimmer are functional only when both the headlights **and** the ignition are turned on.

When the headlights and dimmer are turned off, daylight conditions are assumed and the selector lighting is restored to full brightness.

If the selector is not wired into the dimmer circuit, the Digital Range Display is always at full brightness (as if the dash lights are off), but there is no backlighting for the **MODE** and **RANGE** buttons. When illuminated, the

TRANS SERVICE (shown as a wrench icon) indicator on the shift selector is at full brightness.

7.3 MODE BUTTON

The **MODE** button is located on the bezel face of the lever or keypad pushbutton shift selector. The button can be pressed anytime after engine start to activate the alternate shift schedule or special function.

The **MODE** button preforms the following functions:

- Activates a special function programmed into the TCM, which is typically an alternate ECONOMY or PERFORMANCE shift schedule
- Toggles to the next DTC while in DTC display mode
- Clears (erases) active and inactive DTCs from TCM memory.

NOTE: DTCs cannot be cleared individually. All active DTCs clear first, followed by the inactive (historic) DTCs, provided the **MODE** button is pressed long enough while in the DTC display mode. Refer to 6.0 DIAGNOSTICS for information and the procedure on reading and clearing (erasing) DTCs.

A MODE ID is located near the **MODE** button to identify the purpose associated with the **MODE** button selection. Refer to Figure 7–1 for the location of the **MODE** button and MODE ID on a lever shift selector. These items are located in similar positions on all keypad pushbutton shift selectors.

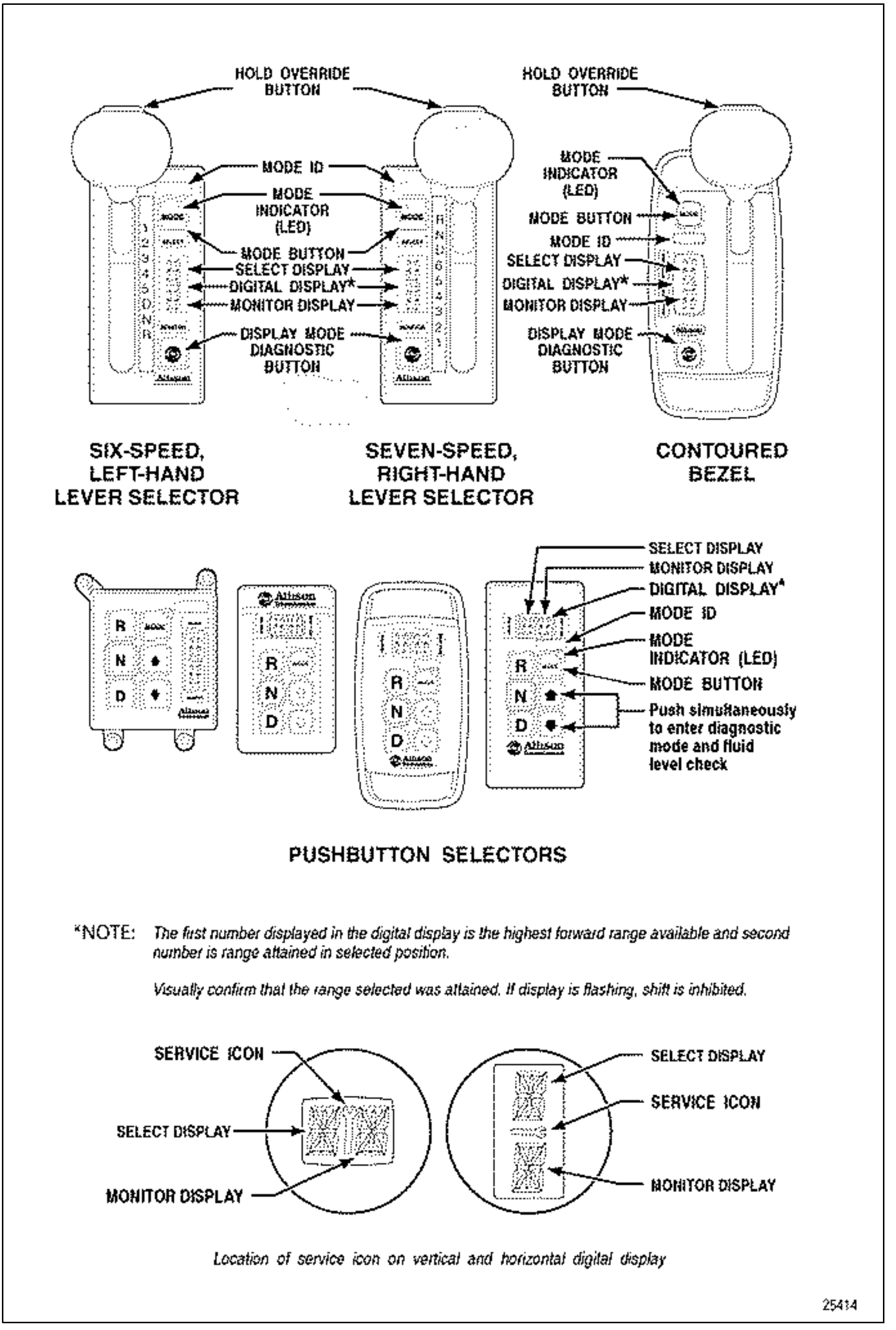


Figure 7–1. Typical Allison 4th Generation Prognostics Shift Selectors

7.4 MODE INDICATOR (LED)

A small red Light Emitting Diode (LED) located near the **MODE** button illuminates when an alternate shift schedule, such as ECONOMY or other programmed function, is activated.

This LED also illuminates while reading all active DTCs. Inactive (historic) DTCs do not light the **MODE** indicator when they are shown in the selector display window.

NOTE: Do not confuse the mode indicator lamp (red LED) with the **MODE** button. The **MODE** indicator displays mode function, active shift schedules or active, stored DTCs. Pushing on the indicator lamp thinking it is the **MODE** button may damage the LED.

7.5 TRANS SERVICE INDICATOR (WRENCH ICON)

The **TRANS SERVICE** (wrench icon) indicator illuminates in the event a service condition relating to a transmission clutch, fluid or filter life occurs. The **TRANS SERVICE** indicator is located between the SELECT and MONITOR displays on the shift selector display. Refer to Figure 7–2.

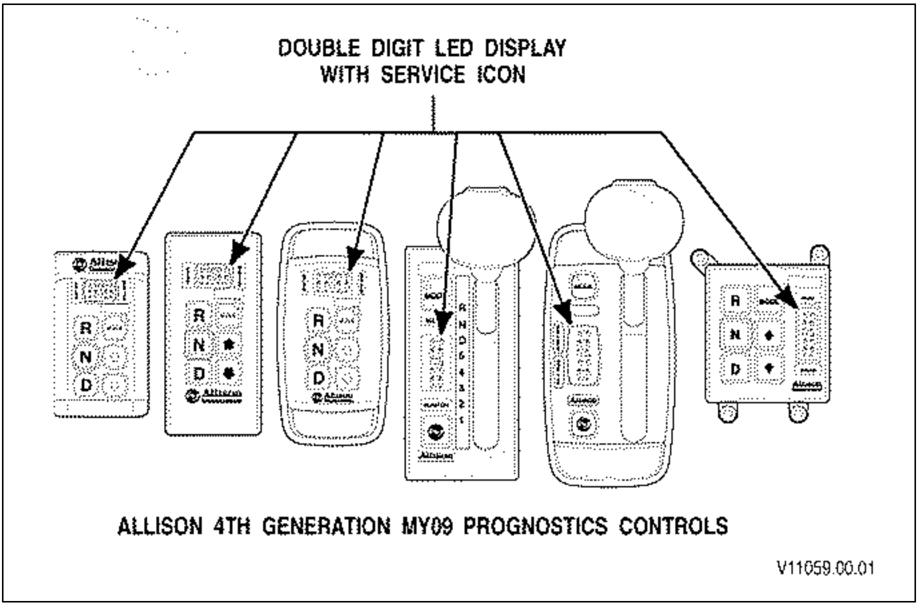


Figure 7–2. Typical Allison 4th Generation Prognostics Controls Shift Selectors with SELECT, MONITOR Digital Displays and Trans Service Indicator

For additional information regarding these conditions, refer to 5.9.6 OIL LIFE MONITOR (OM), or 5.9.7 FILTER LIFE MONITOR (FM), or 5.9.8 TRANSMISSION HEALTH MONITOR (TM).

7.6 SELECTOR DISPLAY DESCRIPTIONS FOR ACTIVE DTCs AND INHIBITS

RANGE SELECT Blank: With an active DTC, the SELECT display on the shift selector is blank. The MONITOR display indicates the range in which the transmission is locked. The **CHECK TRANS** light is also activated. Refer to 6.0 DIAGNOSTICS.

RANGE SELECT Flashing: The flashing display indicates a requested shift is either temporarily or permanently inhibited. The inhibit may clear if the cause of the inhibit clears within 3 seconds of the shift request. Otherwise, the operator must re-select the desired range. Refer to 7.6 SELECTOR DISPLAY DESCRIPTIONS FOR ACTIVE DTCs AND INHIBITS.

Wrench Icon Illuminated: This indicator is only functional if prognostics are enabled in the TCM controls calibration. This indicator is illuminated upon the detection of a service issue relating to clutch, filter, or fluid life. The appearance of the indicator (lit steadily or flashing) varies for each of the conditions monitored by the system. Refer to 7.5 TRANS SERVICE INDICATOR (WRENCH ICON).

All Segments Illuminated: If all segments of the display are on for more than 12 seconds, the TCM has not completed initialization. A DTC is associated with this condition. It is normal for all segments to illuminate for a brief time during initialization of the selector and controls.

SELECT/MONITOR BOTH BLANK: This condition indicates either a lack of power to the selector or the J1939 communication datalink has failed. Continuous blank indicates loss of power to the selector. If the blank display changes to a single or double cat-eye display, other conditions exist. Refer to cat-eye discussions below.

(|) Single Cat-Eye: This display indicates a selector fault other than loss of power and is always accompanied by a selector-related DTC. The single cat-eye is displayed in the SELECT location immediately after the fault is detected.

(|) (|) Double Cat-Eyes: This display indicates a failure of the J1939 communication link and is always accompanied by a DTC. The cat-eyes are illuminated in both the SELECT and MONITOR locations after approximately 12 seconds of blank display.

WARNING: Without the J1939 communication datalink, the shift selector cannot display the selected transmission range. Vehicle operation will be affected.

7.7 SELECTOR DISPLAY IS INOPERATIVE

In the event communication with the J1939 datalink is lost, limited communication between the TCM and the Allison keypad pushbutton and lever shift selectors continues through direction signal wire 134. This limited communication allows the operator to select **D** (Drive), **N** (Neutral), or **R** (Reverse) in order to get the vehicle to a service location. Operator requests for range upshifts and downshifts will not be recognized, and the shift selector display will not display the selected transmission range due to the lack of a J1939 datalink signal.

WARNING: Assuming proper installation of direction signal wire 134, most Allison shift selectors may still be used to command transmission direction changes in these circumstances. Due to the failure of the J1939 datalink communication, however, the shift selector cannot display the selected range. When this condition exists, it is advisable to slowly and carefully apply the throttle each time a change of direction has been selected in order to verify the direction of operation before accelerating the vehicle. This feature is not available with "strip pushbutton" shift selector models.

7.8 LEVER SHIFT SELECTOR

The Allison lever shift selector (refer to Figure 4–1) is an electromechanical control that has three locked positions to prevent accidentally selecting **R** (Reverse), **N** (Neutral), or **D** (Drive).

Lever shift selector positions are:

- **R** (Reverse)
- **N** (Neutral)
- **D** (Drive)
- Some number of lower forward range positions

The lever shift selector positions should agree with the number of ranges programmed in the Transmission Control Module (TCM).

In addition to the features listed in 7.0 PROGNOSTICS SHIFT SELECTORS COMPONENTS AND FUNCTIONS, the lever shift selector also includes the following features:

- **HOLD OVERRIDE**: The **HOLD OVERRIDE** button is a finger-controlled button integrated into the top and front side of the lever shift selector knob. This button uses a detent feature with three locked positions to prevent accidental range selection. Press the **HOLD OVERRIDE** button to release the detent and move the lever from the locked position. Once **D** (Drive) is selected, lower forward range positions may be selected without pressing the **HOLD OVERRIDE** button.
- **DISPLAY MODE/DIAGNOSTIC** (DMD): The DMD button, when pressed, allows access to fluid level information, prognostics information, and DTC information, depending on how many times it was pressed. Refer to Figure 4–1 and Table 4–1.

7.9 KEYPAD PUSHBUTTON SHIFT SELECTOR

The Allison keypad pushbutton shift selector (refer to Figure 4–1 and Table 4–1) has six buttons on the keypad that cause the following transmission operations to occur:

- **R**: Press to select reverse
- **N**: Press to select neutral
- **D**: Press to select drive
- ↑ (Upshift) arrow: Press to select the next higher forward range
- ↓ (Downshift) arrow: Press to select the next lower forward range
- **MODE**: Multi-functional use. Refer to 7.3 MODE BUTTON

The ↑ (Upshift) and ↓ (Downshift) arrows are only functional while in a forward range, and not in **N** (Neutral) or **R** (Reverse).

Pressing both the ↑ (Upshift) and ↓ (Downshift) arrows simultaneously when the transmission is in Neutral invokes requests for reading oil level, prognostics information or DTCs. Refer to 7.0 PROGNOSTICS SHIFT SELECTORS COMPONENTS AND FUNCTIONS and 7.9 KEYPAD PUSHBUTTON SHIFT SELECTOR . If the transmission is locked in range due to an active DTC, the system still allows the operator to review the DTC in the selector with simultaneous button presses on the ↑ (Upshift) and ↓ (Downshift) arrows even though the transmission is not in **N** (Neutral).

Conditions which illuminate the **CHECK TRANS** light disable the shift selector. The SELECT display is blank and the MONITOR display shows the range actually attained. For a detailed explanation, refer to 6.2.1 CHECK TRANS LIGHT.

8.0 CUSTOMIZING CONTROLS AND TCM PROGRAMMING

8.1 VEHICLE AND TRANSMISSION SIGNAL INTERFACE OVERVIEW

This section describes the vehicle interface connections to the transmission controls and transmission signals. The vehicle interfaces discussed in this section may be provided through a SAE J1939 vehicle communications interface and include:

- **CHECK TRANS** indicator
- Wrench Icon. Used for Prognostics features for needed scheduled transmission maintenance
- **RANGE INHIBITED** or **RANGE INHIBIT** indicator
- Neutral Start
- Speedometer signal
- Reverse Warning
- Anti-Lock Brake System (ABS) status
- Service Brake status
- Retarder Modulation signals (if equipped)
- Engine Water Temperature signal
- Range Request signals
- Other miscellaneous Transmission Input/Output (I/O) signals that control Auxiliary Vehicle functions by using either discrete electrical signals, J1939 messages, or a combination of both

8.2 INPUT AND OUTPUT FUNCTIONS OVERVIEW

Input and Output (I/O) functions are built into each transmission control system to allow additional functional controls of specialized transmissions and/or auxiliary vehicle operations that are tailored for the expected vocation of the vehicle.

Control signals are generally needed by each I/O function to work. These control signals, known as inputs, may be a combination of the following:

- Discrete analog switched signal voltages or switched-to-ground signals that control the on/off state of the needed input(s) that in turn allow the enabled I/O function to switch to on or off. Each input(s) must be wired to the correct vehicle circuits and the correct TCM pins through the correct OEM supplied switches, relays, connectors, and other components as needed.
- Various vehicle controller datalink messages from various controllers on the vehicle communications datalink such as, SAE J1939, and/or SAE J1708/J1587.
- Use of monitored vehicle and/or transmission data such as, temperatures, various speeds, and specific range attained that are then compared with program limits and CMC parameters within the TCM to turn the I/O function on and off.

Various combinations of these I/O functions are assembled into I/O packages. One or many I/O packages may exist in any specific I/O group. The I/O group is contained in your TCM as part of its calibration and software for the exact vocation of your vehicle. This strategy allows the vehicle OEM(s) maximum flexibility for choosing which I/O functions and discrete input circuits, labeled by wire number and TCM pin assignments, they want to control the I/O functions on your vehicle. To provide flexibility to the OEM(s) and customer, specific discrete input circuits to specific TCM pins vary between vocations and I/O packages and groups, even when the packages are contained within the same I/O group.

The calibration of each TCM, which also contains the programming of how your I/O is configured by the group and package, was selected for your vehicle by your vehicle OEM. To fit a customers exact I/O requirement for their vehicle it may be necessary for the TCM to have individual I/O functions or packages re-programmed, or possibly recalibrate theTCM, for a different I/O group. Most often reprogramming I/O with the Allison DOC® For PC–Service Tool is all that is needed. However, you will have to take your vehicle to a qualified technician if you need to determine what I/O has been enabled or disabled by your OEM, body builder, or service location. A qualified Allison or OEM technician can download and review your calibration information within the “I/O Wires Report” Section that is part of “Diagnostic Reports” contained in the Allison DOC® For PC-Service Tool. Your vehicle I/O or body builder should be consulted as well for information such as wiring diagrams, regarding how individual I/O functions were integrated in your vehicle.

Allison Transmission I/O information is also available as a separate publication in Fourth Generation Electronic Controls I/O Group and Package Info Sheets, The publication number is IO4105EN. This publication discusses various groups, packages, and wire numbers associated with specific vocations and related I/O functions. Purchase information is included for you at the Publications menu of *www.allisontransmission.com*. Browse by keyword or publication number or it may be ordered from an Allison service outlet.

Additionally, you may consult the Vocational Model Guide, SA3748, for more I/O information. This publication is available for free download from the Publications menu of *www.allisontransmission.com*. Browse by keyword or publication number.

NOTE: At the customer's request, and usually at the customer's expense, an Allison Service Outlet can:

- Run a report showing the present vehicle I/O configuration
- Enable/disable different I/O features and set the related CMC(s)
- Calibrate the TCM in order to get a new group with different I/O packages

Proper chassis wiring and connectors, switches, relays, lamps, indicators, datalink messages, and CMC(s) must all be integrated into the vehicle and verified to be working properly before a newly programmed I/O feature or function works. If components for I/O functions are not integrated correctly in the vehicle, some of the enabled I/O features can inhibit the transmission from going to range or cause active DTCs.

NOTE: All feature-related components must be integrated in the vehicle build prior to enabling the I/O feature. Features listed as "Not Enabled" must be enabled by Allison reprogramming-certified personnel.

8.3 CONTROLS SYSTEM OVERVIEW

The Allison 4th Generation Controls system provides the functional control for Allison transmissions. The transmission control system consists of the components shown in Figure 8–1 for the 3000 and 4000 Product Families.

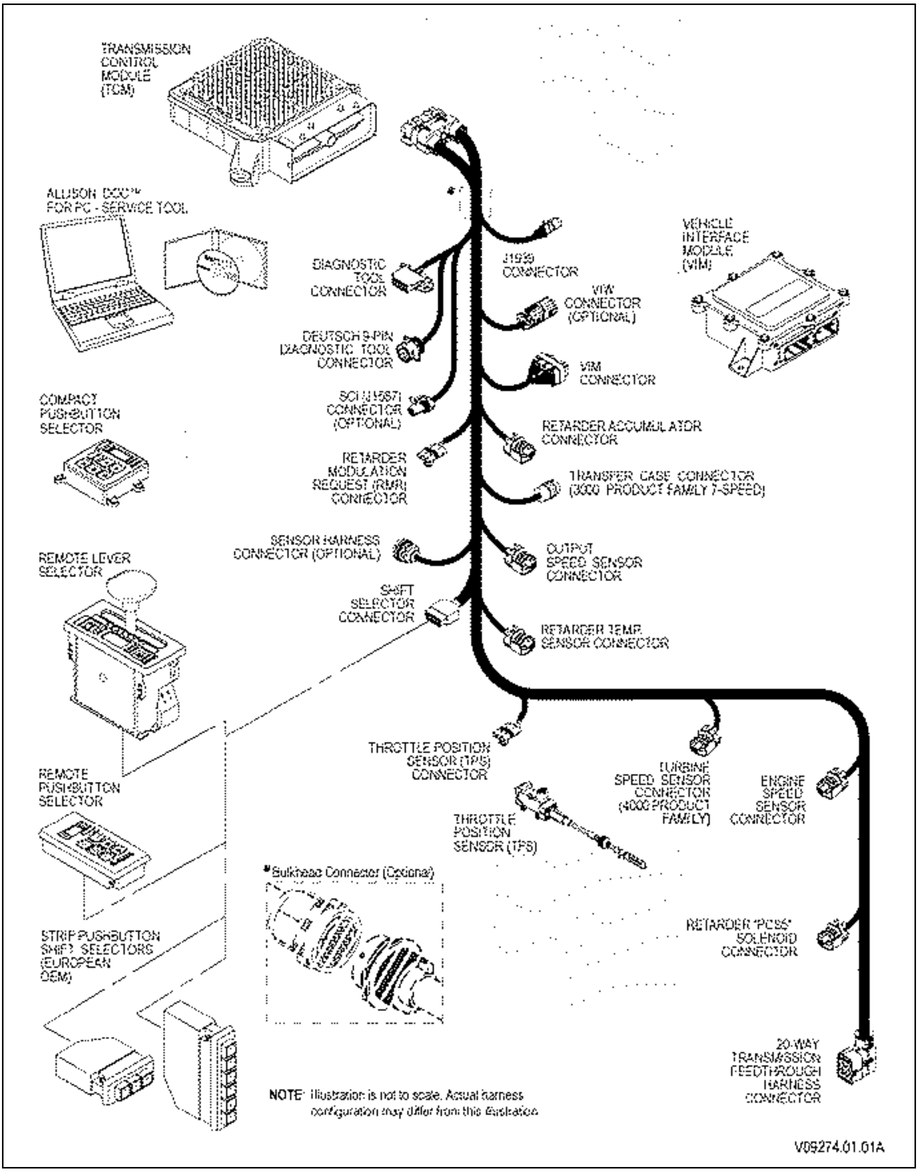


Figure 8–1. Typical Allison 4th Generation Controls Components

8.4 TRANSMISSION CONTROL MODULE (TCM) HARDWARE DESCRIPTION

Harness Connector- the TCM interfaces to your vehicle harness with one connector and uses an 80–pin connector interfaced to the vehicle harness. Refer to Figure 8–1.

TCM Power Requirements- TCM models A51, A52 and A53 are offered to the OEM(s) for the 3000 and 4000 Product Families transmissions. All A51 and A52 TCM configurations are compatible with 12-volt vehicle electrical systems. However, the A53 Max-Feature TCM is also compatible with a 24-volt vehicle electrical systems. See your vehicle dealer if you need assistance in determining which TCM is installed in your vehicle.

NOTE: Allison electronic controls are designed and manufactured to comply with all FCC and other guidelines regarding radio frequency interference/electromagnetic interference (RFI/EMI) for transportation electronics. Manufacturers, assemblers, and installers of radio-telephone or two-way communication radios have the sole responsibility to correctly install and integrate those devices into Allison transmission-equipped vehicles to the customer's satisfaction.

8.5 TRANSMISSION CONTROL MODULE (TCM) PROGRAM AND CALIBRATION OVERVIEW

The TCM program includes the basic logic and algorithms which command all of the various elements of transmission operation. The program is an integral element of the TCM structure and is defined as having a specific software level.

The TCM calibration includes all of the variables pertaining to the specific vehicle in which the TCM will be installed. Each calibration is based on input from the vehicle manufacturer and, once compiled, must be downloaded into the TCM to make it operational. Refer to 4.2 SHIFT SCHEDULES AND AUTOMATIC RANGE SHIFTS , for additional information regarding the shift calibration.

Functional control of the transmission results from the integration of the calibration data sets with the elements of the software program, in conjunction with the following:

- Matching TCM software to transmission hardware (Trans ID). Refer to 8.6 TRANSMISSION IDENTIFICATION (TID) WIRE.
- Automatic detection of other features (Autodetect). Refer to 8.7 AUTODETECT .

- Adaptive shifting. Refer to 8.8 ADAPTIVE SHIFTING.
- Transmission and controls diagnostics. Refer to 6.0 DIAGNOSTICS.
- Transmission prognostics. Refer to 7.0 PROGNOSTICS SHIFT SELECTORS COMPONENTS AND FUNCTIONS.
- Communication via vehicle datalinks. Refer to 7.6 SELECTOR DISPLAY DESCRIPTIONS FOR ACTIVE DTCs AND INHIBITS.
- Shift inhibits. Refer to 4.1.3 SELECTOR DISPLAY FLASHING (INHIBITS) .
- Control of the retarder. Refer to 4.3 USING THE HYDRAULIC RETARDER .

8.6 TRANSMISSION IDENTIFICATION (TID) WIRE

Using data transmitted over wire 176, the Trans ID feature assists the Transmission Control Module (TCM) in identifying the build generation of the transmission and subsequent selection of a shift calibration appropriate for that level of transmission hardware. Generally, TCM(s) with newer versions of the software may be matched with transmission hardware originally released with an earlier version of the software, as long as both are in the Allison 4th Generation Controls family. Trans ID will not permit an Allison 4th Generation TCM to control a transmission configured for an earlier-generation control system; nor will a controller from an earlier-generation control system function with transmission hardware configured for Allison 4th Generation Controls. If a calibration for the identified level of transmission hardware does not exist in the TCM, a DTC is set.

8.7 AUTODETECT

The Autodetect software feature automatically detects the presence of transmission components or input signals, thus permitting the use of different features or input signals with a common TCM. Autodetect checks for the presence of a valid input signal denoting the presence of each of the features listed. Diagnostic functions relating to each of these items are executed if the feature is detected and used. Refer to Table 8–1 for the presence of the following transmission components or data inputs.

Table 8–1. Transmission Components or Data Inputs.

Retarder	Present, Not Present
Oil Level Sensor (OLS)	Present, Not Present

Table 8–1. Transmission Components or Data Inputs. *(cont'd)*

Throttle[a]	Analog, J1587, J1939
Engine Coolant Temperature	Analog, J1587, J1939

[a] A pulse width modulated (PWM) throttle source is not "autodetected." This source requires a unique calibration or can be manually selected using Allison DOC® For PC–Service Tool.

8.8 ADAPTIVE SHIFTING

Adaptive shifting is a basic design feature of the shift controls which optimizes shift quality. This is accomplished by frequent monitoring of critical characteristics in the clutch engagement process and making continuous adjustments to certain characteristics which improve subsequent shifts.

The transmission shift calibration is based on several different types of shifts, such as full throttle, part throttle, closed throttle, upshifts, and downshifts. Each shift is associated with specific speed and throttle position parameters. To optimize each type of shift for normal driving, it is necessary for the shift controls to have experienced operation and shifting in a wide variety of operating conditions. A drive-in period under various driving conditions is required before the adaptive controls can be expected to optimize each and every shift. You should begin to see shift quality converge to the adapted level after five shifts of a particular shift type.

8.9 COMMUNICATION THROUGH VEHICLE DATALINKS

All Transmission Control Modules (TCMs) are capable of communicating with other vehicle systems over an SAE J1939 datalink. Some TCM models are also capable of communication using an SAE J1587 datalink or an International Standard Organization (ISO) 9141 communication link protocol. If the engine is electronically controlled, throttle position data may be communicated from the engine controls to all TCM models over the SAE J1939 datalink. TCM models A52 and A53 are also capable of communication using the SAE J1587 protocol.

SAE J1587 capability is only available with 3000 and 4000 Product Families transmission using TCM models A52 and A53. SAE J1587 does not support the display of prognostics information. Check with your vehicle OEM or Allison Transmission distributor or dealer for the capabilities of the TCM in your vehicle or if you need assistance in determining the datalink types available for your vehicle.

8.10 INFORMATION DISPLAYS

The OEM may supply and install a remote display for use in displaying transmission status and service information broadcast over the vehicle datalink. Such information may include the transmission range selected, transmission range attained, sump temperature indicator, prognostic information, and DTCs. If the display is reading on the J1587 datalink, the display of transmission prognostics information is not supported. Refer to 7.6 SELECTOR DISPLAY DESCRIPTIONS FOR ACTIVE DTCs AND INHIBITS.

8.11 SHIFT INHIBITS

When necessary, the transmission control system automatically activates an inhibit to protect against certain types of abusive operation. For example:

- **Engine speed inhibit:** prevents an attempt to shift the transmission from **N** (Neutral) to either a forward range or reverse if the engine speed is above 1260 rpm.

NOTE: There is no shift inhibit detection of high output speed/high throttle position for EVS calibrations.

9.0 EXTERNAL WIRE HARNESSES, VEHICLE INTERFACE MODULE, AND RETARDER CONTROLS

9.1 WIRE HARNESSES

NOTE: The external harness connecting transmission controls is part of the vehicle chassis harness and typically will not have an Allison Transmission part number. The harness parts are usually only available through the vehicle manufacturer and their vendors. Check with the OEM or dealer first to determine their wire harness service parts availability. Any Allison distributor or dealer can assist with determining serviceability of the external harness as well. The internal transmission harness inside the transmission is an Allison part and only available from an Allison distributor or dealer.

The transmission controls require the use of wiring harnesses to connect the various system components, including:

- Transmission Control Module (TCM)
- Main connector on the transmission
- Engine speed sensor on the transmission
- Turbine speed sensor on the transmission (4000 Product Families)
- Transmission output speed sensor on the transmission
- Serial communication datalink
- Shift selector
- Diagnostic connector
- Retarder controls (if equipped)
- Vehicle interface wiring
- Throttle Position Sensor (TPS) (only with mechanically controlled engines)

- Optional Vehicle Interface Module (VIM)

All wiring harnesses and connectors which mate to Allison connectors/components are typically supplied and installed by the vehicle manufacturer. Harnesses may consist of a single piece, or may be divided into multiple segments joined by bulkhead connectors.

9.2 VEHICLE INTERFACE MODULE (VIM)

The VIM contains relays and fuses necessary to interface the transmission controls with the vehicle wiring system. When ordering the VIM, specify 12 or 24 volts to properly match the vehicle electrical system.

In some cases, the OEM or body builder may choose not to use the Allison VIM. In these cases, the OEM must specify and install components which provide a proper interface between vehicle wiring and the transmission control system.

9.3 RETARDER CONTROLS

In order to meet the needs of operators in a wide variety of applications, vocations, and vehicle configurations, several retarder apply systems are offered for transmission models in the Allison 3000 and 4000 Product Families.

Certain types of apply systems may not be recommended for specific vocations. For example, factors such as retarder performance that may not be appropriate for the class or vehicle type or difficulty in installation. However, there are typically two or more apply types available for most vehicles.

In addition to the standard analog controls approach, the possible integration of the retarder with numerous other vehicle systems through a common SAE J1939-based vehicle controller creates additional design flexibility when determining methods of potential operator control of the transmission retarder.

The Transmission Control Module (TCM) must be calibrated to the proper method to ensure desired retarder operation. Operator controls of the retarder can be accomplished by either of the following methods:

- **Both Analog and J1939.** Input is based on a Retarder Enable switch for activation, plus one or more Allison Retarder Modulation Request (RMR) components to select the desired level of retardation. In addition, retardation is requested or limited based on messages from an SAE J1939-based vehicle controller.
- **J1939 Only.** Retardation is requested or limited based on messages from an SAE J1939-based vehicle controller.

The analog components that can be used with the 3000 and 4000 Product Families retarder are available from Allison Transmission. These components provide control over retarder operation and include various types of retarder operator and vehicle interface controls. Some of the available operator controls, known also as Retarder Modulation Request (RMR) devices include:

- Foot pedal
- Hand lever
- Automatic apply at closed throttle
- Apply integrated with service brakes
- One-step, two-step or three-step applies

Refer to Table 4–3 for the various types of retarder controls available.

The retarder apply system does not actuate the retarder directly. The driver uses the retarder operator controls to request a desired level of retardation, ranging from none, up to the maximum available from the specific retarder/transmission configuration in use. The TCM processes the request in conjunction with other input data which defines the current operating status of the transmission and vehicle. The TCM turns the retarder on at the requested level when conditions are appropriate for retarder operation.

Refer to 4.3 USING THE HYDRAULIC RETARDER for additional information about the retarder controls, retarder performance, and retarder usage.

HIGHWAY SERIES

10.0 TRANSMISSION COMPONENTS

10.1 TORQUE CONVERTER

The torque converter multiplies engine torque and transfers smooth, uninterrupted power to the wheels quickly. The torque converter consists of these four components:

- Pump–input element driven directly by the engine
- Turbine–output element hydraulically driven by the pump
- Stator–reaction (torque multiplying) element
- Lockup Clutch–mechanically couples the pump and turbine when commanded by the Transmission Control Module (TCM).

When the pump turns faster than the turbine and the stator is stationary, the torque converter is multiplying torque. When the turbine approaches the speed of the pump, the stator starts to rotate with the pump and turbine. When this occurs, torque multiplication stops and the torque converter functions as a fluid coupling. The lockup clutch is located inside the torque converter and consists of the following components:

- Piston and backplate–driven by the engine
- Clutch plate/damper (located between the piston and the backplate)–splined to the converter turbine

The lockup clutch/torsional damper is engaged and released in response to electronic signals from the TCM. Lockup clutch engagement provides a direct drive from the engine to the transmission input. This eliminates converter slippage and maximizes fuel economy and vehicle speed. The lockup clutch releases at lower speeds or when the TCM detects conditions requiring it to be released.

The torsional damper tries to absorb engine torsional vibration in an attempt to prevent transmitting engine torsional vibration on through to transmission components (clutches, etc), or items bolted to the transmission.

10.2 PLANETARY GEARS AND CLUTCHES

A series of three helical, constant mesh planetary gear sets and shafts provides the mechanical gear ratios and direction of travel for the vehicle. The planetary gear sets are controlled by five multi-plate clutches that work in pairs to produce up to six forward speeds and one reverse speed. The clutches are applied and released hydraulically in response to electronic signals from the Transmission Control Module (TCM) to the appropriate solenoids.

10.3 COOLER CIRCUIT

The transmission fluid is cooled by an integral (transmission-mounted) or remote-mounted oil cooler. Connections to the cooling circuit are located at the front or rear of the transmission to facilitate installation of remote cooler lines. On retarder models, only the rear cooler ports may be used. The integral cooler is mounted on the lower rear portion of the transmission, replacing the remote cooler manifold. Integral cooler oil ports are internal requiring coolant to be routed to and from the cooler.

10.4 RETARDER

The self-contained retarder is at the output of the transmission and consists of a vaned rotor which rotates in a vaned cavity. The rotor is splined to and driven by the output shaft. When the retarder is activated, the fluid in the accumulator is displaced into the retarder cavity. The pressurized fluid in the cavity acting against the rotating and stationary vanes causes the retarder rotor and output shaft to reduce speed, slowing the vehicle or limiting speed on a downhill grade. Refer to 4.3 USING THE HYDRAULIC RETARDER for additional information. When the retarder is deactivated, the retarder cavity is evacuated and the accumulator is recharged with fluid.

The retarder housing also allows the addition of either a remote or integral cooler for transmission sump fluid in addition to retarder out fluid. A bypass cover is placed over the sump cooling ports when the provision is not used. The sump cooler ports are located on the lower right rear face of the retarder housing. Refer to Figure 2–1 and Figure 2–2.

10.5 CONTROL VALVE MODULE

The 3000 and 4000 Product Family Transmission control valve module is bolted to the transmission main housing, and contain the main and lube filters. The control valve module also contains a main valve body assembly and solenoid valve body assembly. The Transmission Control Module (TCM) issues commands that actuate the range clutch solenoids to govern fluid flow to the commanded range clutches and lockup clutch contained in the torque converter.

The control valve module contains the following components:

- Various valves and valve bodies controlling and routing hydraulic pressure to the rest of the transmission
- Range clutch and lockup clutch solenoids
- Diagnostic valve, valve body, and diagnostic pressure switch
- Main filter life indicator valve, valve body, and filter life pressure switch
- Turbine speed sensor (3000 Product Family only)
- Sump temperature sensor

10.6 TRANSMISSION SPEED SENSORS

Three speed sensors are integral to the transmission assembly. The speed sensors provide the transmission input speed, converter turbine speed, and transmission output speed signals to the Transmission Control Module (TCM). For the specific location of the speed sensors, refer to Figure 2–1 and Figure 2–2.

The transmission input speed sensor is located on the converter housing and the transmission output speed sensor is located on the output housing. Both speed sensors require connection to the wiring harness.

The mounting provision for the turbine speed sensor differs between the transmission model families:

- For transmission models in the 3000 Product Families, the turbine speed sensor is internal to the transmission and does not require an external connection
- For transmission models in the 4000 Product Families, the turbine speed sensor is external to the transmission and requires connection to the wiring harness

11.0 GENERAL GUIDELINES

11.1 WELDING ON VEHICLE

Observe the following precautions when welding on the vehicle:

- Disconnect the wiring harnesses from the Transmission Control Module (TCM).
- Disconnect the TCM power and ground circuits from the battery, and any electronic control ground wires connected to the frame or chassis.
- Do not connect welding cables to electronic control components.
- Do not weld on electronic control components.
- Cover electronic control components and wiring to protect them from hot sparks, heat, etc.

11.2 PAINTING ON VEHICLE

11.2.1 ELECTROSTATIC PAINTING. If the vehicle chassis or body is painted using an electrostatic painting process, electrical voltage must not be discharged through the Transmission Control Module (TCM). To prevent this possibility, Allison recommends installing the TCM after the electrostatic paint process is complete. If the TCM is installed prior to electrostatic painting, make sure:

- the TCM is not painted.
- the elements being painted are properly and continuously grounded during the entire painting process.

NOTE: Allison Transmission is not responsible for TCM damage resulting from improper grounding during electrostatic painting of the vehicle.

During electrostatic painting, the paint droplets receive an electrostatic charge attracting them to be grounded surfaces. Voltages at the spray gun can exceed several thousand volts. The charge which builds up on an improperly grounded chassis or body can be discharged through the TCM, resulting in damage to the TCM.

11.2.2 PAINTING OF TRANSMISSION CONTROL COMPONENTS. While it may be desirable to paint chassis-mounted components in order to enhance the overall vehicle appearance and/or provide corrosion protection, the transmission control components **must not** be painted. Painting transmission control components can:

- compromise the integrity of connectors and connector seals.
- reduce thermal conductivity from inside the TCM to ambient air.
- cover labels or other identification, hindering the process to service these components.

11.3 ENVIRONMENT

Allison Transmission designed the Allison controls and components to operate in normal vehicle cab and chassis environments. The Allison controls and components can withstand moisture, direct light, heat, and shock loads. The Transmission Control Module (TCM), Allison shift selectors and their connectors are sealed, but are not considered immersible. Installation of the Allison controls and components must meet the environmental requirements in Allison 4^{th} Generation Controls Data. In addition, mount the Allison controls and components away from direct exposure to road hazards and weather. In order to meet the temperature limits listed in Allison 4^{th} Generation Controls Data, allow for free air movement around each component. The air movement dissipates heat away from the components. Exceeding the temperature limits reduces the life of the components.

11.4 COMPONENT ACCESS REQUIREMENTS

Access to service the controls and components is necessary throughout the life of the vehicle. Consider service access to transmission components when installing auxiliary vehicle controls and components, including the effort required to remove covers, body parts, or chassis members to gain access to the transmission component(s) being serviced.

12.0 CUSTOMER SERVICE

12.1 ORDERING PARTS

12.1.1 TRANSMISSION NAMEPLATE. The nameplate (refer to Figure 12–1) is located on the right side of the transmission and is imprinted with the following:

- Transmission model (for Specialty Series vocation models)
- Serial number
- Date code
- TransID number
- Engineering groups (for Specialty Series vocation models)

Use all of these numbers when ordering replacement parts or requesting service information.

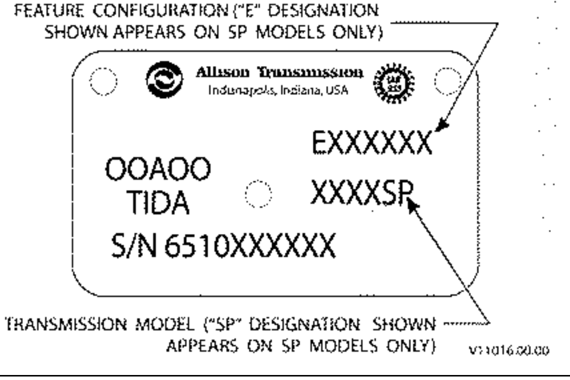


Figure 12–1. Transmission Nameplate

12.1.2 GENUINE PARTS. Allison Transmission recommends that only Allison genuine parts be used in an Allison transmission. Order all replacement parts from an authorized distributor or dealer. Service outlets can be located on the Allison Transmission web site at *www.allisontransmission.com*. Additionally, distributors and dealers are listed in the yellow pages under Transmission - Truck, Tractor, Etc.".

12.2 OWNER ASSISTANCE

The satisfaction and goodwill of the owners of Allison transmissions are of primary concern to Allison Transmission, its distributors, and their dealers.

As an owner of an Allison transmission, you have service locations throughout the world that are eager to meet your parts and service needs with:

- Expert service by trained personnel.
- Emergency service 24 hours a day in many areas.
- Complete parts support.
- Sales teams to help determine your transmission requirements.
- Product information and literature.

Normally, any situation that arises in connection with the sale, operation, or service of your transmission will be handled by the distributor or dealer in your area. Check the telephone directory for the Allison Transmission service outlet nearest you or use Allison Transmission's Sales and Service Locator tool on the Allison Transmission web site at *www.allisontransmission.com*. You may also refer to Allison Transmission's Worldwide Sales and Service Directory (SA2229EN).

We recognize, however, that despite the best intentions of everyone concerned, misunderstandings may occur. To further assure your complete satisfaction, we have developed the following three-step procedure to be followed in the event a problem has not been handled satisfactorily.

Step One—Discuss your problem with a member of management from the distributorship or dealership. Frequently, complaints are the result of a breakdown in communication and can be resolved quickly by a member of management. If you have already discussed the problem with the Sales or Service Manager, contact the General Manager. All Allison Transmission dealers are associated with an Allison Transmission distributor. If the problem originates with a dealer, explain the matter to a management member of the distributorship with whom the dealer has his service agreement. The dealer will provide his Allison Transmission distributor's name, address, and telephone number on request.

Step Two—When it appears the problem cannot be readily resolved at the distributor level without additional assistance, **contact the Allison Technical Assistance Center at 800-252-5283.** They will place you in contact with the Regional Customer Support Manager for your area.

For prompt assistance, please have the following information available:

- Name and location of authorized distributor or dealer.
- Type and make of vehicle/equipment.
- Transmission model number, serial number, and assembly number (if equipped with electronic controls, also provide the Transmission Control Module (TCM) assembly number).
- Transmission delivery date and accumulated miles and/or hours of operation.
- Nature of problem.
- Chronological summary of your transmission's history.

Step Three—If you are still not satisfied after contacting the Regional Customer Support Manager, **present the entire matter to the Home Office by writing to the following address:**

Allison Transmission
Manager, Warranty Administration
PO Box 894, Mail Code PF9
Indianapolis, IN 46206-0894

The inclusion of all pertinent information will assist the Home Office in expediting the matter.

When contacting the Home Office, please keep in mind that ultimately the problem will likely be resolved at the distributorship or dealership using their facilities, equipment, and personnel. Therefore, it is suggested that **Step One** be followed when experiencing a problem.

Your purchase of an Allison Transmission product is greatly appreciated, and it is our sincere desire to assure complete satisfaction.

12.3 SERVICE LITERATURE

Additional service literature is available. Allison service literature provides fully illustrated instructions for the operation, maintenance, service, overhaul, and parts support of your transmission. To be sure that you get maximum performance and service life from your unit, you may order publications from an Allison Transmission distributor or *www.allisontransmission.com/publications/*
.

12.4 ALLISON TRANSMISSION DISTRIBUTORS

NOTE: For a complete and up-to-date listing of Allison Transmission Service Centers, go to *www.allisontransmission.com/locator/*

EASTERN REGION

Atlantic Detroit Diesel-Allison, LLC
19 C Chapin Road
Pine Brook, NJ 07058
973-575-0309

Covington Power Services
8015 Piedmont Triad Parkway
Greensboro, NC 27409
336-292-9240

Detroit Diesel-Allison Canada East
Attn: Div. of Integrated Power Systems Corp.
2997 Avenue (rue) Watt
Quebec, Quebec G1X 3W1
418-651-5371

Florida Detroit Diesel-Allison, Inc.
2277 N.W. 14th Street
Miami, FL 33125-0068
305-638-5300

Harper Power Products, Inc
10 Diesel Drive
Toronto, Ontario M8W 2T8
416-259-3281

Johnson & Towers, Inc.
2021 Briggs Road
Mount Laurel, NJ 08054
856-234-6990

New England Detroit Diesel-Allison, Inc.
90 Bay State Road
Wakefield, MA 01880-1095
781-246-1810

Penn Detroit Diesel-Allison, LLC
8330 State Road
Philadelphia, PA 19136-2986
215-335-0500

Western Branch Diesel, Inc.
3504 Shipwright Street
Portsmouth, VA 23703
757-673-7000

W.W. Williams S.E., Inc.
3077 Moreland Avenue
Conley, GA 30288
404-366-1070

CENTRAL REGION

Central Power Systems & Services, Inc.
9200 Liberty Drive
Liberty, MO 64068
816-781-8070

Clarke Power Services, Inc.
3133 East Kemper Road
Cincinnati, OH 45241
513-771-2200

Inland Power Group, Inc.
13015 West Custer Avenue
Butler, WI 53007-0916
262-781-7100

Interstate PowerSystems, Inc.
2501 American Boulevard, East
Minneapolis, MN 55425
952-854-5511

Stewart & Stevenson Power Products, LLC
1000 Louisiana, Suite 5900
Houston, TX 77002
713-751–2600

United Engines, LLC
5555 West Reno Street
Oklahoma City, OK 73127
405-947-3321

Waterous Power Systems (A Division of Integrated Power Systems Corp.)
10025 – 51 Avenue
Edmonton, Alberta T6E OA8
780-437-8200

W.W. Williams M.W., Inc.
1176 Industrial Parkway, North
Brunswick, OH 44212-2342
330-225-7751

MEXICO REGION

Detroit Diesel-Allison de Mexico S.A.de C.V.
Av. Santa Rosa No. 58 Col.
Ampliacion Norte
San Juan Ixtacala, Tlalnepantla C.P.
54160, Estado de Mexico
525-5-5333-1800

WESTERN REGION

ABC Transmissions, Ltd
9357 – 193rd Street
Surrey, British Columbia V4N 4E7
604-888-1211

Allison West
14775 Wicks Boulevard
San Leandro, CA 94577–6779
510–351–6101

Pacific Power Products Company
7215 South 228th Street
Kent, WA 98032
253-854-0505

Smith Power Products, Inc.
3065 West California Avenue
Salt Lake City, UT 84104
801-415-5000

Stewart & Stevenson Power Products, LLC
5170 E 58th Place
Commerce City, CO 80022
303-287-7441

Valley Power Systems, Inc
425 South Hacienda Boulevard
City of Industry, CA 91745-1123
626-333-1243

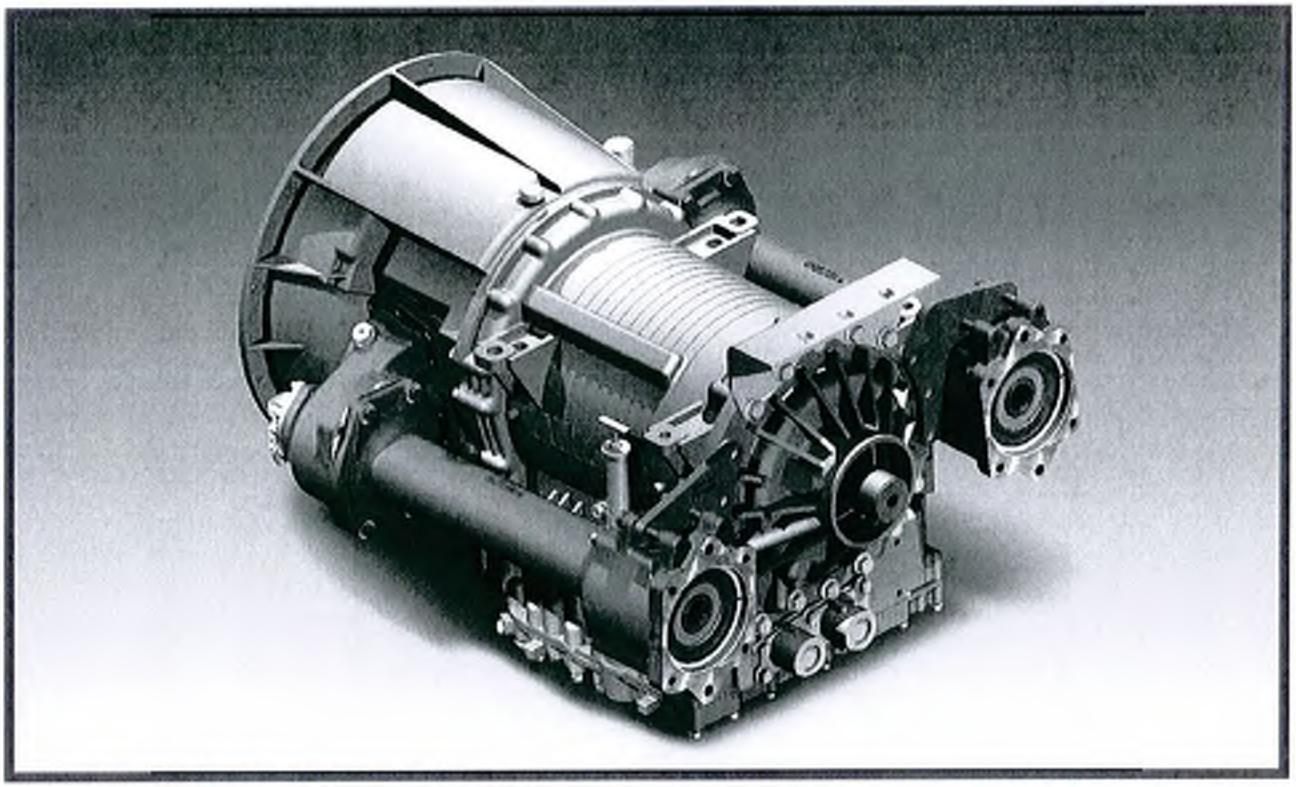
W.W. Williams S.W., Inc.
2602 S. 19th Avenue
Phoenix, AZ 85009
602-257-0561

CHELSEA®

Bulletin HY25-1890-M1/US

Owner's Manual
Power Take-Offs

Effective: March 2011
Supercedes: HY25-1890-M1/US June 2010



890 Series
892 Series
897 Series
899 Series

WARNING — User Responsibility

FAILURE OR IMPROPER SELECTION OR IMPROPER USE OF THE PRODUCTS DESCRIBED HEREIN OR RELATED ITEMS CAN CAUSE DEATH, PERSONAL INJURY AND PROPERTY DAMAGE.

This document and other information from Parker-Hannifin Corporation, its subsidiaries and authorized distributors provide product or system options for further investigation by users having technical expertise.

The user, through its own analysis and testing, is solely responsible for making the final selection of the system and components and assuring that all performance, endurance, maintenance, safety and warning requirements of the application are met. The user must analyze all aspects of the application, follow applicable industry standards, and follow the information concerning the product in the current product catalog and in any other materials provided from Parker or its subsidiaries or authorized distributors.

To the extent that Parker or its subsidiaries or authorized distributors provide component or system options based upon data or specifications provided by the user, the user is responsible for determining that such data and specifications are suitable and sufficient for all applications and reasonably foreseeable uses of the components or systems.

Offer of Sale

The items described in this document are hereby offered for sale by Parker Hannifin Corporation, its subsidiaries or its authorized distributors. This offer and its acceptance are governed by the provisions stated in the "Offer of Sale".

Patent Information

The Chelsea® Power Take Off or its components shipped with this owner's manual may be manufactured under one or more of the following U.S. patents:
4610175 5228355 4597301 5645363 6151975 6142274 6260682 7159701 B2 7510084 US7690450 B2
Other patents pending

Contents

Safety Information

These instructions are for your safety and the safety of the end user. Read them carefully until you understand them.

General Safety Information

To prevent injury to yourself and/or damage to the equipment:

- Read carefully all owner's manuals, service manuals, and/or other instructions.
- Always follow proper procedures, and use proper tools and safety equipment.
- Be sure to receive proper training.
- Never work alone while under a vehicle or while repairing or maintaining equipment.
- Always use proper components in applications for which they are approved.
- Be sure to assemble components properly.
- Never use worn out or damaged components.
- Always block any raised or moving device that may injure a person working on or under a vehicle.
- Never operate the controls of the Power Take-Off or other driven equipment from any position that could result in getting caught in the moving machinery.

Proper Matching of P.T.O.

⚠ **WARNING:** A Power Take-Off must be properly matched to the vehicle transmission and to the auxiliary equipment being powered. An improperly matched Power Take-Off could cause severe damage to the vehicle transmission, the auxiliary driveshaft, and/or to the auxiliary equipment being powered. **Damaged components or equipment could malfunction causing serious personal injury to the vehicle operator or to others nearby.**

To avoid personal injury and/or equipment damage:

- Always refer to Chelsea catalogs, literature, and owner's manuals. Follow Chelsea recommendations when selecting, installing, repairing, or operating a Power Take-Off.
- Never attempt to use a Power Take-Off not specifically recommended by Chelsea for the vehicle transmission.
- Always match the Power Take-Off's specified output capabilities to the requirements of the equipment to be powered.
- Never use a Power Take-Off whose range of speed could exceed the maximum.

Cold Weather Operation of Powershift P.T.O.

⚠ **WARNING:** During extreme cold weather operation [32°F (0°C) and lower], a disengaged Powershift Power Take-Off can momentarily transmit high torque that will cause unexpected output shaft rotation. This is caused by the high viscosity of the transmission oil when it is extremely cold. As slippage occurs between the Power Take-Off clutch plates, the oil will rapidly heat up and the viscous drag will quickly decrease.

The Power Take-Off output shaft rotation could cause unexpected movement of the driven equipment resulting in serious personal injury, death, or equipment damage.

To avoid personal injury or equipment damage:

- Driven equipment must have separate controls.
- The driven equipment must be left in the disengaged position when not in operation.
- Do not operate the driven equipment until the vehicle is allowed to warm up.

⚠ **This symbol warns of possible personal injury.**

Safety Information (Continued)

Rotating Auxiliary Driveshafts

WARNING: 

- Rotating auxiliary driveshafts are dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.
- Do not go under the vehicle when the engine is running.
- Do not work on or near an exposed shaft when the engine is running.
- Shut off the engine before working on the Power Take-Off or driven equipment.
- Exposed rotating driveshafts must be guarded.

Guarding Auxiliary Driveshafts

WARNING: We strongly recommend that a Power Take-Off and a directly mounted pump be used to eliminate the auxiliary driveshaft whenever possible. If an auxiliary driveshaft is used and remains exposed after installation, it is the responsibility of the vehicle designer and P.T.O. installer to install a guard.

Using Set Screws

WARNING: Auxiliary driveshafts may be installed with either recessed or protruding set screws. If you choose a square head set screw, you should be aware that it will protrude above the hub of the yoke and may be a point where clothes, skin, hair, hands, etc. could be snagged. A socket head set screw, which may not protrude above the hub of the yoke, does not permit the same amount of torquing as does a square head set screw. Also, a square head set screw, if used with a lock wire, will prevent loosening of the screw caused by vibration. Regardless of the choice made with respect to a set screw, an exposed rotating auxiliary driveshaft must be guarded.

Important: Safety Information and Owner's Manual

Chelsea Power Take-Offs are packaged with safety information decals, instructions, and an owner's manual. These items are located in the envelope with the P.T.O. mounting gaskets. Also, safety information and installation instructions are packaged with some individual parts and kits. **Be sure to read the owner's manual before installing or operating the P.T.O.** Always install the safety information decals according to the instructions provided. Place the owner's manual in the vehicle glove compartment.

WARNING: Operating the P.T.O. with the Vehicle in Motion

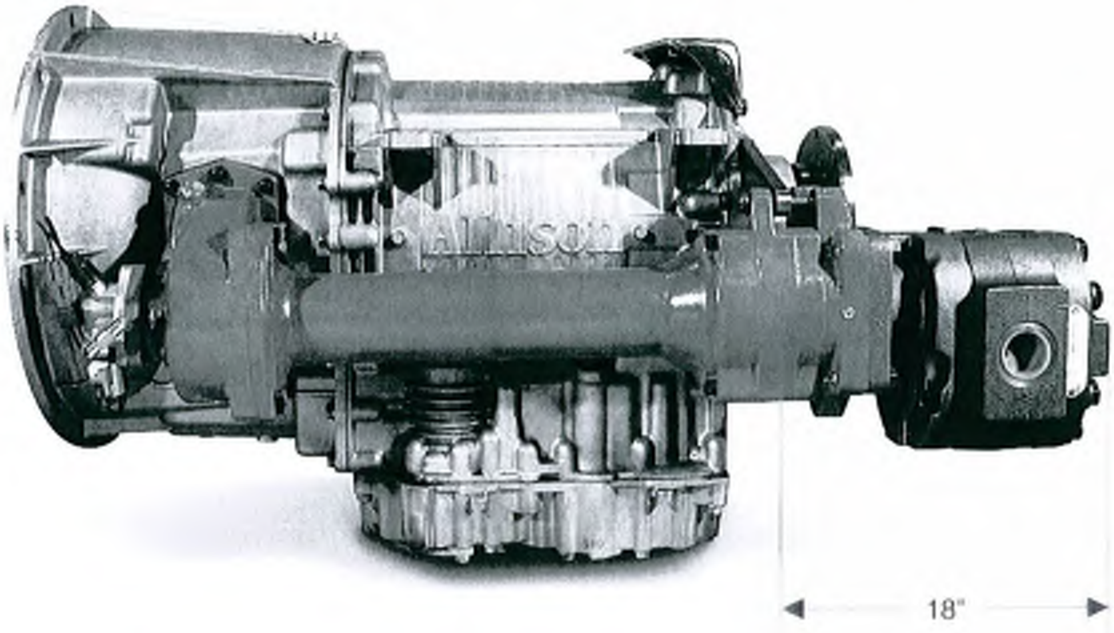
Some Power Take-Offs may be operated when the vehicle is in motion. To do so, the P.T.O. must have been properly selected to operate at highway speeds and correctly matched to the vehicle transmission and the requirements of the driven equipment.

If in doubt about the P.T.O. specifications and capabilities, avoid operating the P.T.O. when the vehicle is in motion. Improper application and/or operation can cause serious personal injury or premature failure of the vehicle, the driven equipment, and/or the P.T.O.

Always remember to disengage the P.T.O. when the driven equipment is not in operation.

This symbol warns of possible personal injury.

Direct Mount Pump Recommendations



Use caution to ensure that bracket does not pre-load pump/P.T.O. mounting

Chelsea strongly recommends the use of pump supports (Support Brackets) in all applications. P.T.O. warranty will be void if a pump bracket is not used when:

1) The combined weight of pump, fittings and hose exceed **120 pounds [54.43 kg]**.
2) The combined length of the P.T.O. and pump is **18 inches [45.72 cm]** or more from the P.T.O. centerline to the end of the pump.

Foreword

This booklet will provide you with information on correct installation of Chelsea® Power Take-Offs (P.T.O.'s). Proper installation and set up procedures will help you get additional and more profitable miles from your truck equipment and components.

It is important that you be sure that you are getting the right transmission/P.T.O. combination when you order a new truck. An inadequate transmission will overwork any P.T.O. in a short period of time. In addition, a mismatched transmission and P.T.O. combination can result in unsatisfactory performance of your auxiliary power system from the start.

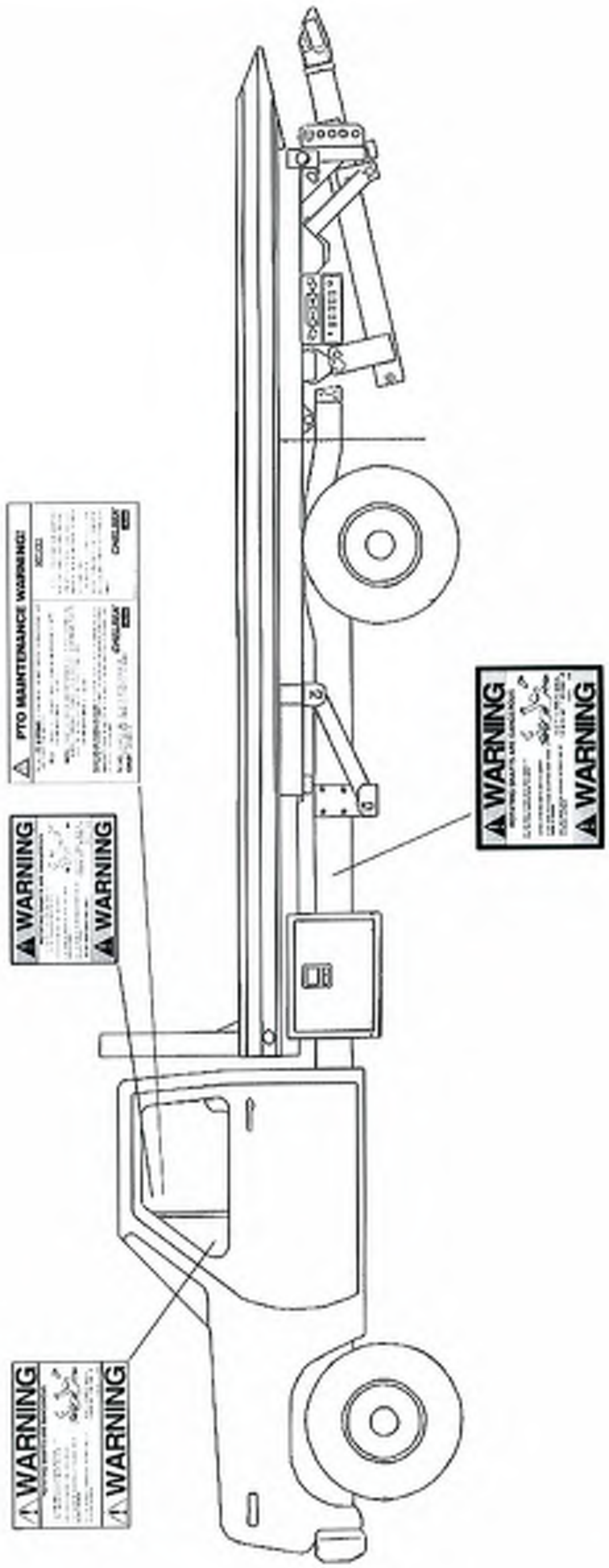
If you have questions regarding correct P.T.O. and transmission combination, please contact your local Chelsea® Auxiliary Power Specialist. They can help you select the properly matched components to ensure correct and efficient applications.

Chelsea P.T.O. Safety Label Instructions

1. The two black and orange on white 5" x 7" pressure sensitive vinyl labels, part number 379274; must be placed on the vehicle frame rails (one (1) on each side), in a position that would be HIGHLY visible to anyone that would go under the truck near the P.T.O. rotating shaft. If the vehicle is to be painted after these labels are installed, cover them with two (2) blank masking covers. Remove the masking covers after painting.
2. Place the one (1) black and orange on white 3.5" x 5" pressure sensitive vinyl label, part number 379275, on the visor nearest the operator of the vehicle, this must be placed near the P.T.O. visor label.
3. Place the one (1) red and white with black lettering 3.5" x 7.5" sensitive vinyl label, part number 379915 on the opposite side of the visor from the above label # 379275
4. Place the one (1) white and black heavy duty card, part number 379276, in the vehicle glove box. Again in a position highly visible to the operator, for example: try to place this card on top of whatever may be in the glove box.

If you require labels, please order part number 328946X at no charge from your local Chelsea Warehouse or send request directly to:

Parker Hannifin Corporation
Chelsea Products Division
8225 Hacks Cross Road
Olive Branch, MS 38654
Customer Service: (662) 895-1011


PTO MAINTENANCE WARNING!
WARNING
WARNING
WARNING
WARNING
WARNING
WARNING

Function of Auxiliary Power Shafts

An auxiliary power shaft transmits torque from the power source to the driven accessory. The shaft must be capable of transmitting the maximum torque and R.P.M. required of the accessory, plus any shock loads that develop.

An auxiliary power shaft operates through constantly relative angles between the power source and the driven accessory, therefore, the length of the auxiliary power shaft must be capable of changing while transmitting torque. This length change, commonly called "slip movement", is caused by movement of the powertrain due to torque reactions and chassis deflections.

Joint operating angles are very important in an auxiliary power joint application. In many cases, the longevity of a joint is dependent on the operating angles. (See chart below)

This information is limited to 1000 through 1310 series applications. For applications requiring a series larger than 1310, contact your local Chelsea distributor.

Determining Shaft Type

1) Solid or tubular?

a) In applications requiring more than 1000 R.P.M. or where the application necessitates a highly balanced auxiliary power shaft, a tubular shaft should be used.

b) Spicer's solid shafting auxiliary power joints are designed for 1000 or less R.P.M. intermittent service such as:

Driving small hydraulic pumps

Driving winches

Driving low speed product pumps

2) Joint Series should be determined using the chart on the following page.

SPICER® UNIVERSAL JOINT OPERATING ANGLES			
PROP. SHAFT R.P.M.	MAX. NORMAL OPERATING ANGLE	PROP. SHAFT R.P.M.	MAX. NORMAL OPERATING ANGLE
3000	5° 50'	1500	11° 30'
2500	7° 00'	1000	11° 30'
2000	8° 40'	500	11° 30'

Above based on angular acceleration of 100 RAD/SEC^2

Parker Chelsea
Parker Hannifin Corporation
Chelsea Products Division
Olive Branch, MS 38654 USA

Spicer® Universal Joint Engineering Data

Joint Series	1000	1100	1280	1310
Torque Rating Automotive (Gas or Diesel Engine) Lbs. ft. Continuous	50	54	95	130
Tubing				
Diameter	1.750	1.250	2.500	3.00
Wall Thickness	.065	.095	.083	.083
W = Welded S = Seamless	W	S	W	W
Flange Diameter (Swing Diameter) Rectangular Type	3.500	3.500	3.875	3.875
Bolt Holes - Flange Yoke				
Circle	2.750	2.750	3.125	3.125
Diameter	.312	.312	.375	.375
Number	4	4	4	4
Male Pilot Dia.	2.250	2.250	2.375	2.375
Distance Across Lugs Snap Ring Construction	2.188	2.656	3.469	3.469
Bearing Diameter	.938	.938	1.062	1.062

Maximum Operating Speed * By Tube Size, Solid Shaft Size, and Length
***(For speed below 500 R.P.M. or over 2500 R.P.M., contact your Chelsea Distributor)**

Tubing Dia. & Wall Thickness Joint & Shaft (W=Welded S=Seamless)	Max. Installed Length in Inches for Given R.P.M. Centerline to Centerline of Joints for a Two Joint Assembly or Centerline of Joint to Centerline of Center Bearing for a Joint & Shaft R.P.M. - Revolutions per Minute				
	500	**1000**	**1500**	**2000**	**2500**
1.750" X .065" W	117"	82"	67"	58"	52"
1.250" X .095" S	91"	64"	52"	45"	40"
2.500" X .083" W	122"	87"	70"	62"	55"
3.000" X .083" W	-	-	-	85"	76"
Solid Shaft Diameter					
.750"	60"	42"	35"	30"	27"
.812"	62"	44"	36"	31"	28"
.875"	65"	46"	37"	32"	29"
1.000"	69"	49"	40"	35"	31"
1.250"	77"	55"	45"	39"	35"

890 Family Overview

The 890 family of Power Take-Offs (P.T.O.) all install in the same manner to the transmission. The main difference will be the mounting plate that is used to attach the P.T.O. output section to the rear of the transmission case. Refer to the chart below for P.T.O. Series and Mounting Codes for information on your P.T.O.

Always refer to the proper Chelsea applications page for proper Transmission/P.T.O. model numbers. Or contact Chelsea Customer Service at 1.866.816.7950

App. Page	Transmission Models	Standard	Integral Cooler	Retarder	Mounting Locations		
					Left	Right	Top
ALL-13	Standard 3000 Family	X			890/897L "5"	890/897R "5"	
ALL-13C	Standard 3000 Family		X		N/A	890/897R "5"	
ALL-13R	Standard 3000 Family			X	890/897M "5"	890/897N "5"	
ALL-14	Standard 4000 Family	X			890/897H "5"		890/897U "5"
ALL-14C	Standard 4000 Family		X		890/897C "3"		890/897U "5"
ALL-14R	Standard 4000 Family			X	890/897J "3"		890/897K "5"
ALL-16	3000 Series w/83 Tooth P.T.O. Gear	X			890/897E "5"		890/897T "5"
ALL-16C	3000 Series w/83 Tooth P.T.O. Gear		X		N/A		890/897T "5"
ALL-16R	3000 Series w/83 Tooth P.T.O. Gear			X	890/897F "5"		890/897G "5"
ALL-16EV	3000/3500 EVS w/83 Tooth P.T.O. Gear	X			890/897E "5"		890/897T "5"
ALL-18	3700 Family	X			NO 890 APPLICATIONS		
ALL-19	4700/4800 Family	X			892/899H "5"		892/899U "5"
ALL-19C	4700/4800 Family		X		892/899C "3"		892/899U "5"
ALL-19R	4700/4800 Family			X	892/899J "3"		892/899K "5"

NOTE: P.T.O. Model Numbers show Mounting Code (L, R, H, etc) and Assembly Arrangement ("5", "3")

P.T.O. Pre Installation

1. At installation, the input housing is installed to the transmission first. The 890/897 comes from the factory assembled. Remove the 4 bolts that connect the tube section to the input housing (**Fig. 1**).

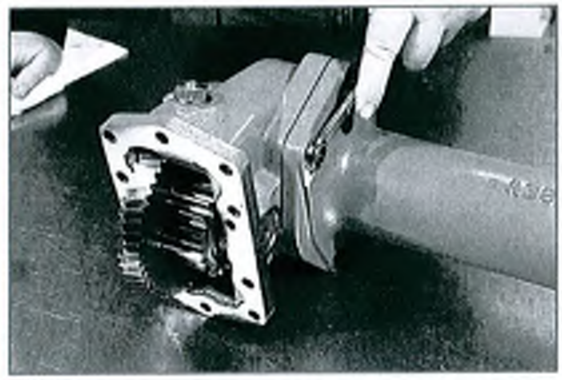


Fig. 1

2. Split the input from the output tube assembly. It will be tight because of the installed O-Ring seal. O-Ring must be installed into the O-Ring groove on the tube pilot shoulder (**Fig. 2**).

NOTE: If O-Ring is damaged replace with one supplied with P.T.O. Unit

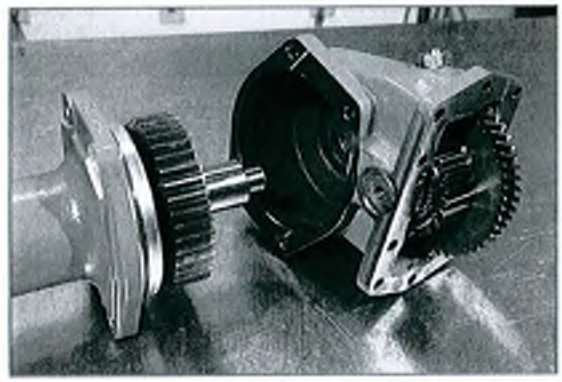


Fig. 2

3. Install the "T" fitting (1) into the pressure port on the valve cap as shown. Torque to 156-180 Lbs. in [18-20 N.m.] Next install the pressure switch (890 Series Only) (2) into the port in the valve cap as shown and torque to 120-140 Lbs. in [14-16 N.m.] (**Fig. 3**) (**Fig. 3a**).

NOTE: See Hose Installation Sketch SK-504 (890 Series) on page 18 and SK-492 (897 Series) on page 18

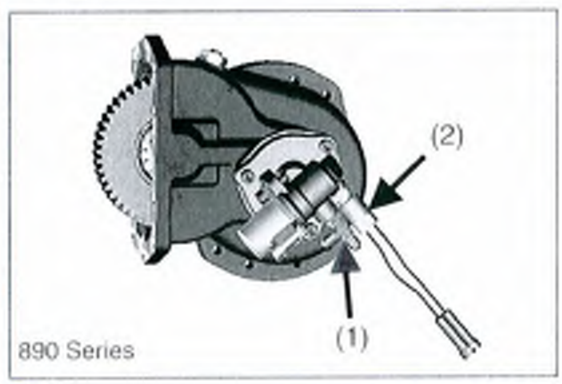


Fig. 3

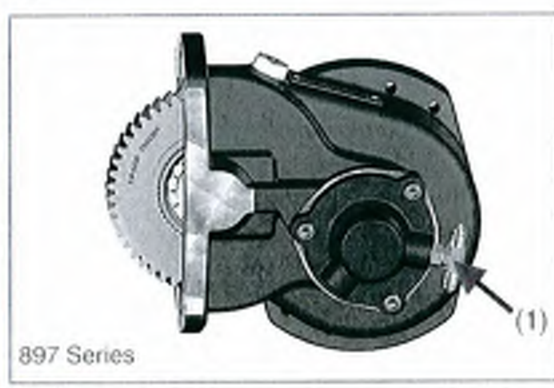


Fig. 3a

P.T.O. Pre Installation (Continued)

When installing a P.T.O., always wear protective clothing and safety glasses.

4. The suitable (by transmission model) **Mounting Bracket** is attached to the P.T.O. output end using the **Shoulder Cap Screws.** Torque to 30-35 Lbs. ft. [41-47 N.m.](**Fig. 4 & 4a**). (See Charts on page 19)

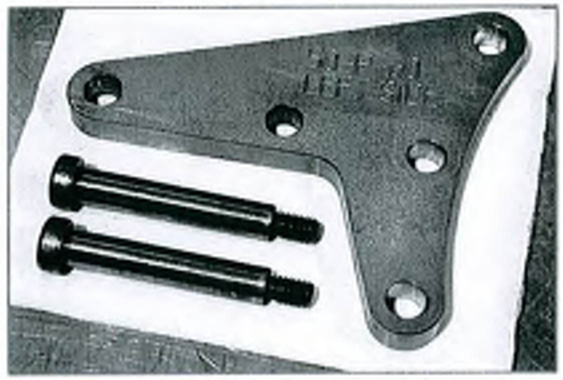


Fig.4

NOTE: When installing an 890 Family P.T.O. with the "DA" output on a 3000 series transmission. Install the bolts in the bracket prior to installing the bracket to the P.T.O. (**Fig. 4b**)

NOTE: Lightly lube the cap screw shaft to help with installation.

Fig. 4a

Fig. 4b

Mounting the P.T.O. on the Transmission

5. Begin by draining the oil from the transmission. Use caution, since the oil may be hot (**Fig. 5**).

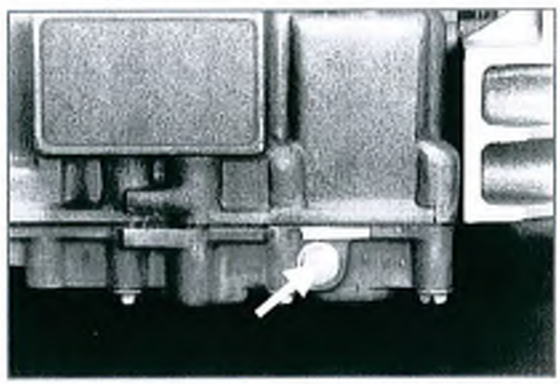


Fig. 5

6. Remove the P.T.O. aperture plate with a 15mm socket (**Fig. 6**).

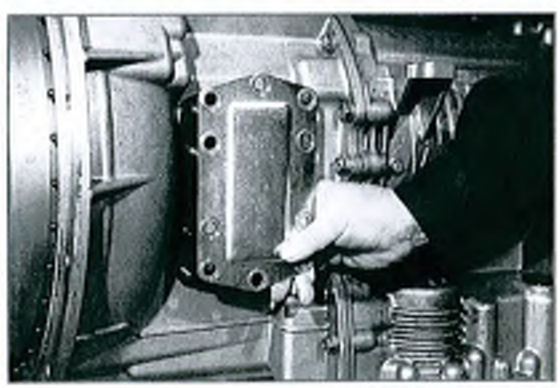


Fig. 6

Mounting the P.T.O. on the Transmission (Continued)

7. Remove the gasket and clean the aperture surface (**Fig. 7**).

NOTE: Do not reuse the gasket that comes with the transmission.

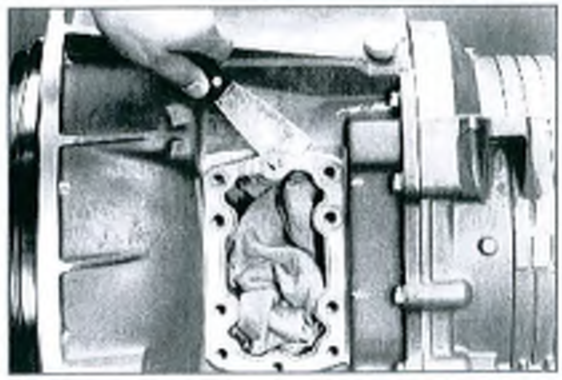


Fig. 7

8. Using a screwdriver, install the dowel pins until they bottom out (**Fig. 8**) (Refer to page 20 for correct location and use).

NOTE: Do not use sealing compounds because they are generally incompatible with automatic transmission fluid.

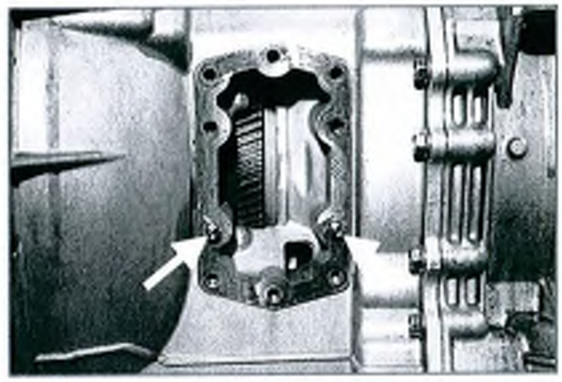


Fig. 8

9. Install the special gasket over the guide pins. The ribbed surface should face outward, toward the installer (**Fig. 9**).

NOTE: To ensure proper backlash and sealing of P.T.O. to transmission, only use gasket furnished with the P.T.O.

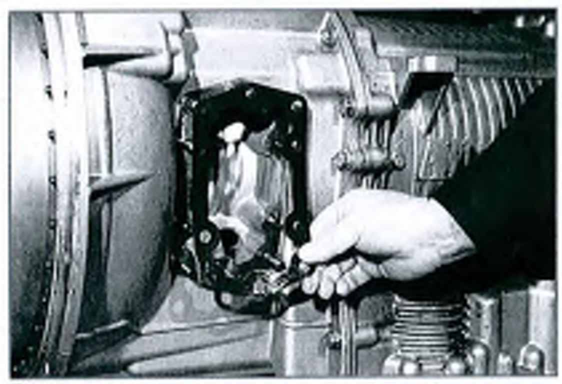


Fig. 9

10. Install the remaining capscrews. Torque all to 40 - 50 Lbs. ft. (54 - 68 N.m. or 5.5 - 6.9 Kg.m) (**Fig. 10**).

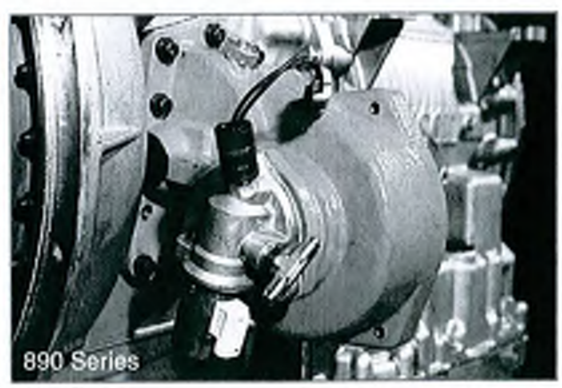


Fig. 10

Mounting the P.T.O. on the Transmission (Continued)

11. Securely attach the high pressure line to the P.T.O. valve "T" fitting (1), torque to 11-12 Lbs. ft. [15-16 N.m.] (**Fig. 11**) (**Fig. 11a**).

NOTE: For 890 Series see SK-504 page 18 for complete plumbing installation of the transmission pressure hose and the wet spline hose. See page 18 for the 897 Series

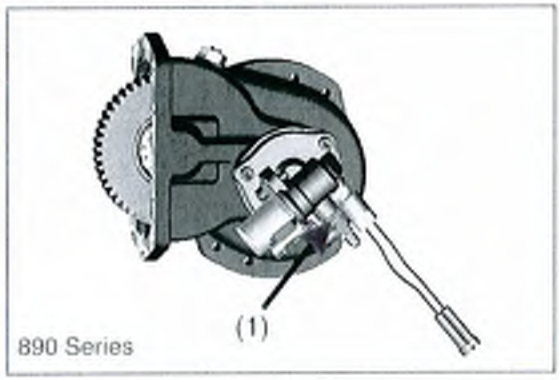


Fig. 11

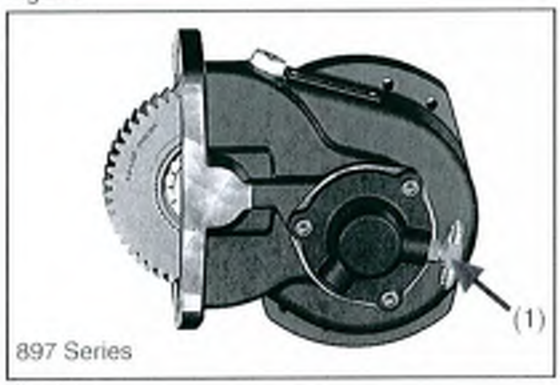


Fig. 11a

12. Install elbow fitting supplied with P.T.O. into transmission main pressure port and torque nut to 13 - 15 Lbs. ft. or 156-180 pds-in. See chart on page 19 for pressure port locations.

12a. Securely attach the high pressure line to the elbow fitting at the transmission high pressure port and torque to 11-12 Lbs. ft. [15-16 N.m.]. This fitting is included with the P.T.O. (**Fig. 12**).

NOTE: See SK-504 page 18 for complete plumbing installation of the transmission hose and the wet spline hose.

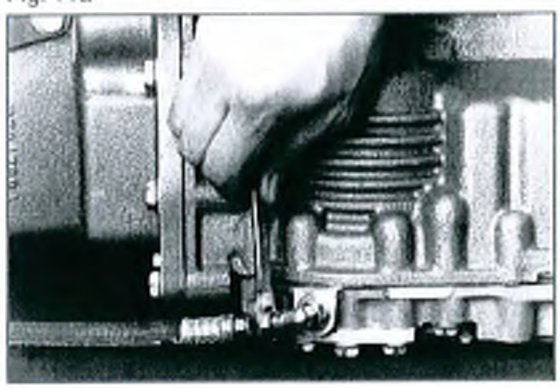


Fig. 12

13. The 3 bolts on the transmission that will line up with the bracket must be removed. New longer Bolts (380075 M12-1.75" x 55mm) will be used for mounting the bracket to the transmission for all transmissions except 3000 Series w/Retarders. For 3000 Series w/Retarder use bolt 380364 (M12-1.75" x 140mm). (**Fig. 13 & 13a**)

NOTE: See Bracket Installation Chart on page 19.


Fig. 13


Fig. 13a

Mounting the P.T.O. on the Transmission (Continued)

14. The tube assembly is lined up and inserted into the Input Housing. As this is done, the bolts for the bracket should be started into the rear of the transmission. (**Fig. 14**).

15. As soon as at least 1 bolt is started, the tube assembly cannot fall. The unit can be aligned and slipped together with the transmission taking the weight (**Fig. 15**).

NOTE: When attaching the tube to the input housing use 4 NEW cap screws supplied with the P.T.O.

16. The 4 Hex Head Cap Screws (378431-13, 3/8"-16 x 1.375") and flatwashers 380076-07 make the final attachment between the input housing and the tube assembly. Torque the Cap Screws to 30-35 Lbs. ft. [41-47 N.m.] (**Fig. 16**).

17. The 3 longer bolts in the transmission should be tightened to 75-85 Lbs. ft. [102-115 N.m.] (**Fig. 17**).

18. To complete installation of the P.T.O. see SK drawings on pages 15-17 for wiring and plumbing installation.

19. See SK-493 page 14 for installation of "XV", "AB" or "AC" Outputs.

20. When installing pumps use O-Ring supplied with P.T.O. between pump and P.T.O. output. Torque pump bolts to proper torque specifications. Refer to page 3 of this manual for proper pump bracket support requirements.

As with all auxiliary power systems, there are different concerns and needs with varying applications, duty cycles, and driven equipment. Chelsea endeavors to provide options that will ensure trouble free use of our products and system solutions.

For customers that would like an extra level of protection from pump seal leaks, there are double sealed pumps available from Parker to satisfy your needs. Please verify your requirements with your Parker/Chelsea P.T.O. and Pump experts.

WARNING: Do not run P.T.O. w/wet spline output option if pump is not installed and connected to hydraulic system. Failure to do so may damage P.T.O./Transmission. See page 21 for output cover plate options.

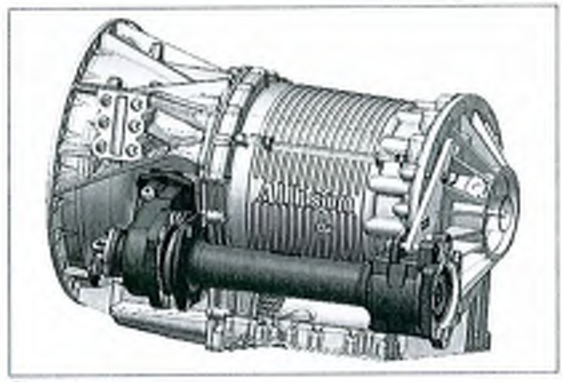


Fig. 14

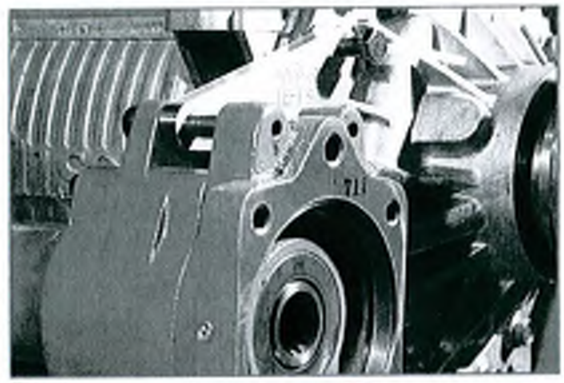


Fig. 15

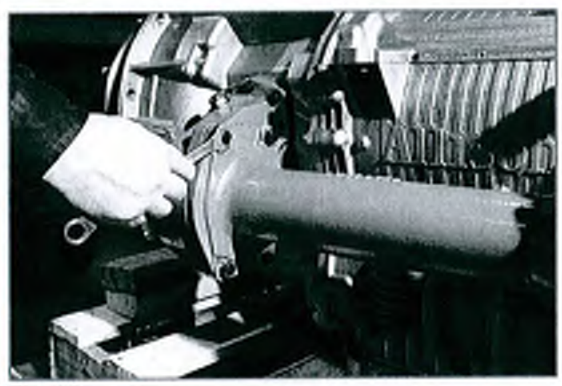
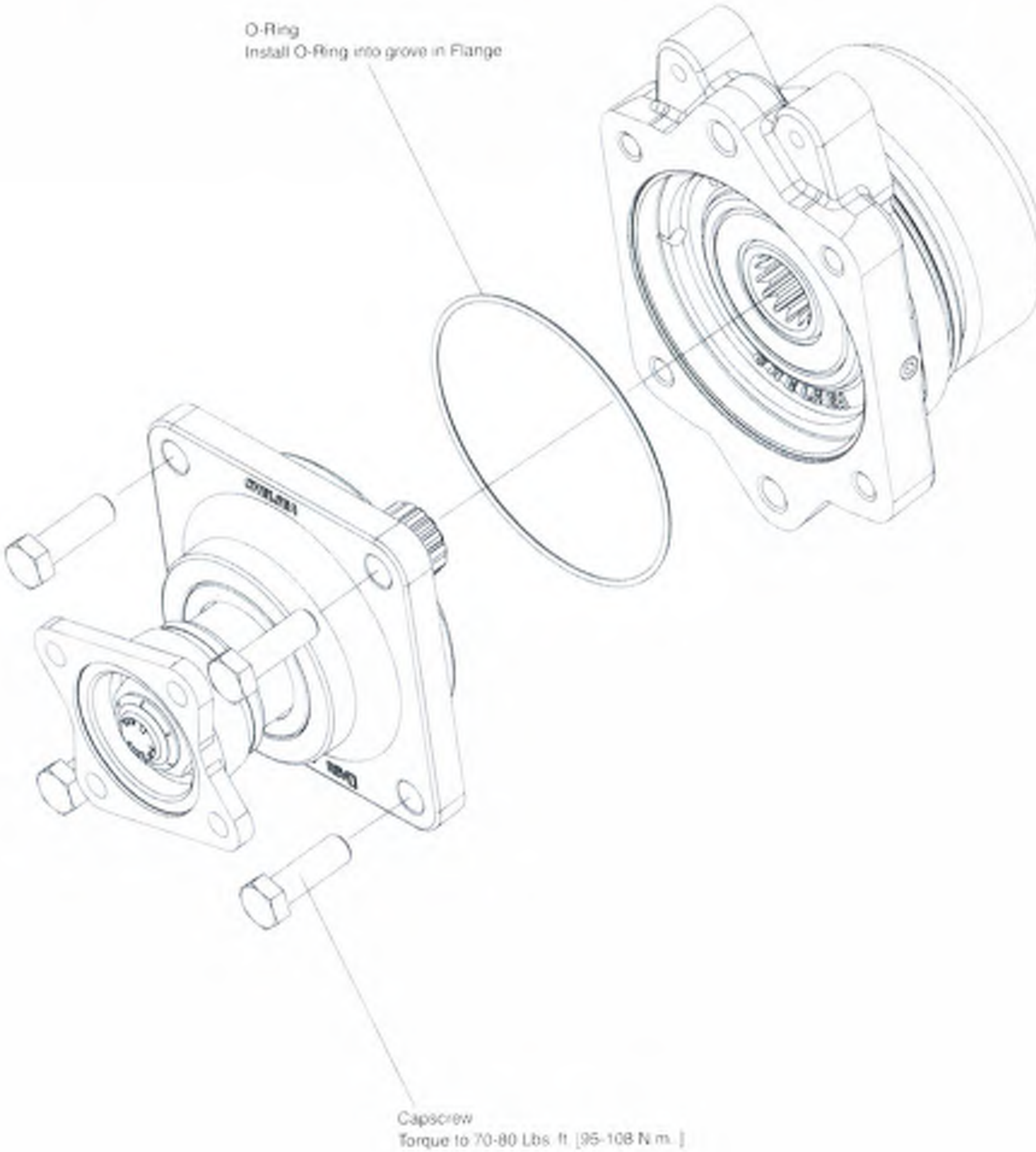


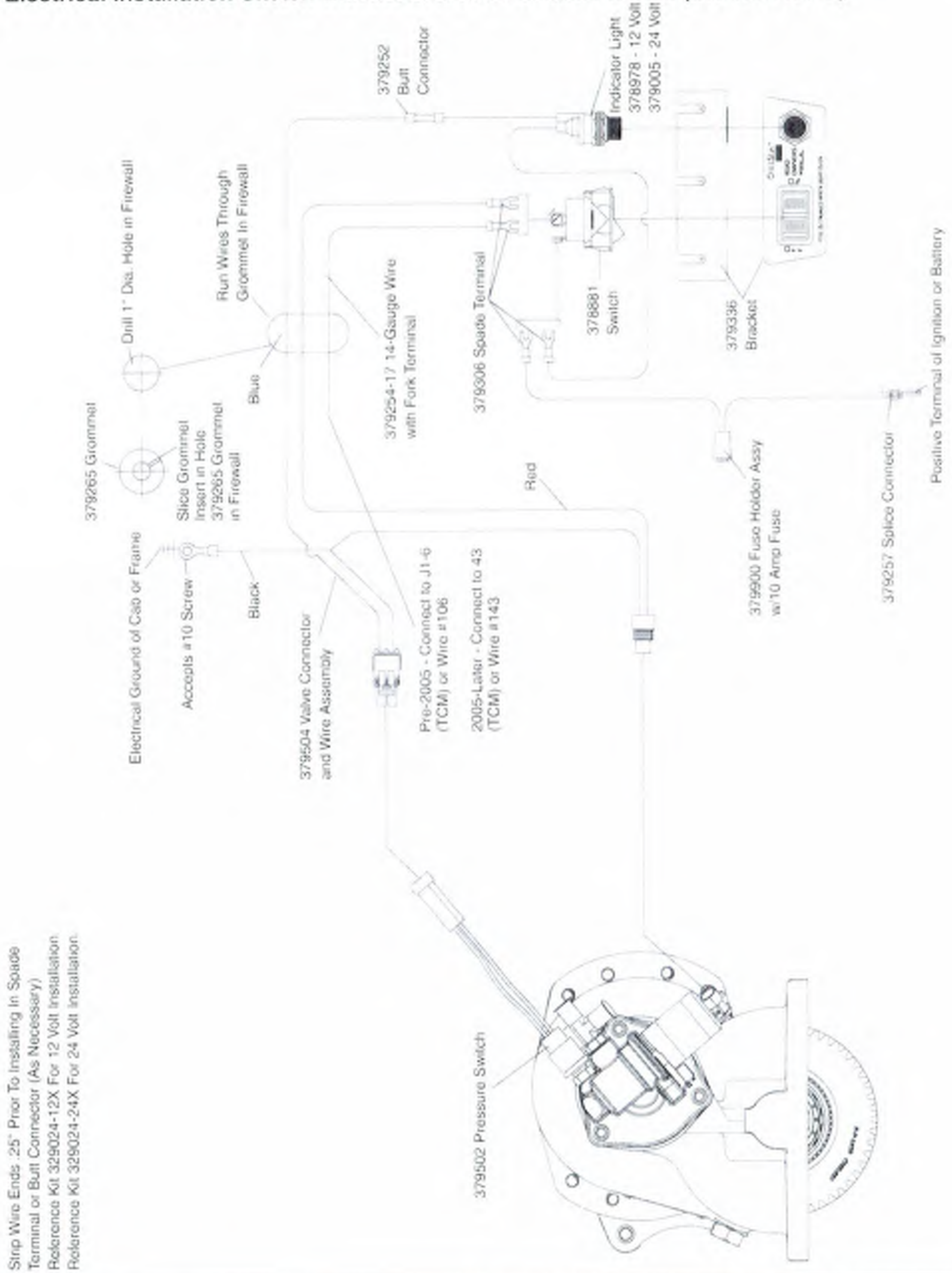
Fig. 16

Fig. 17

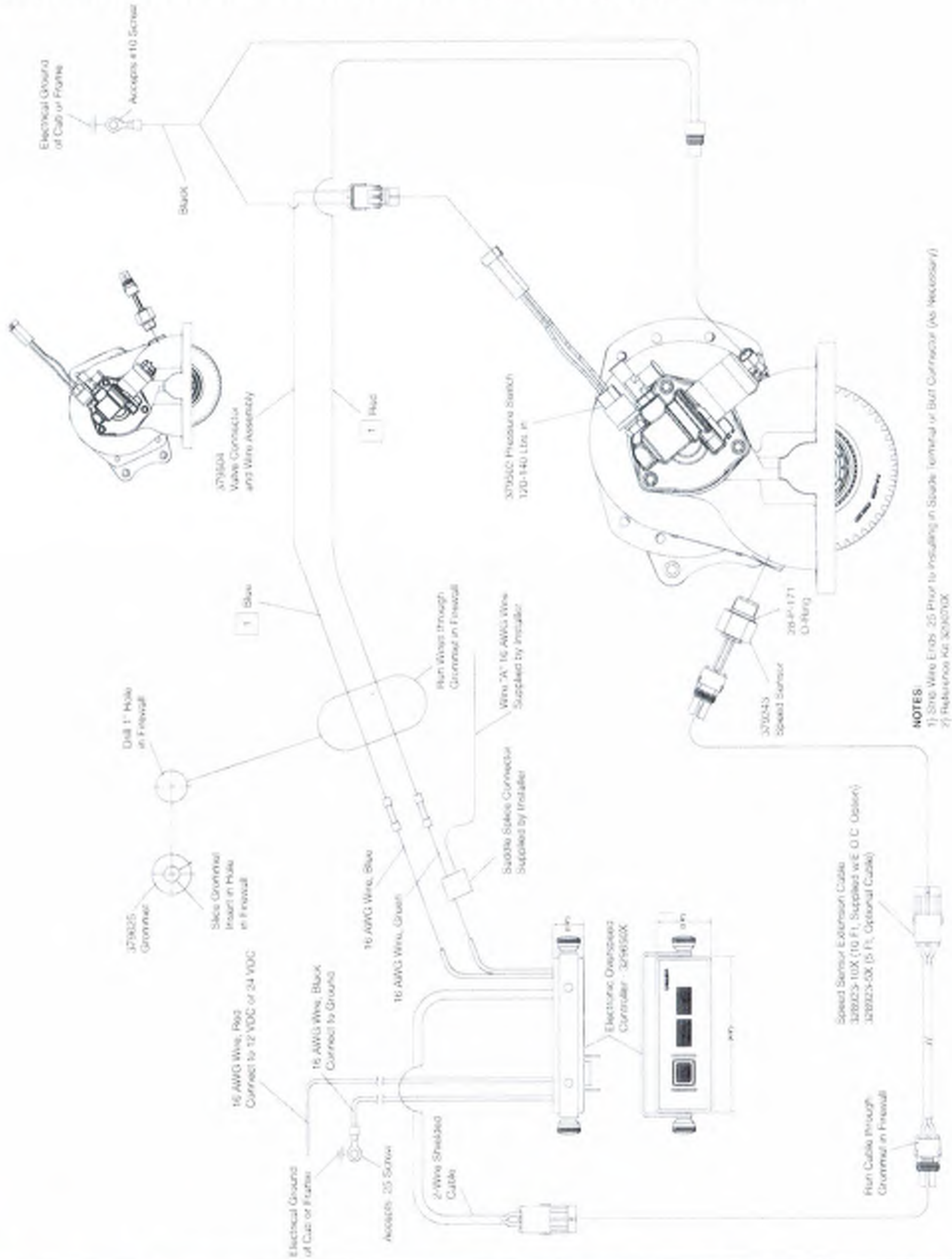
Installation Sketch "XV", "AB", "AC" Outputs 890/897 & 892/899 Series (SK-493)



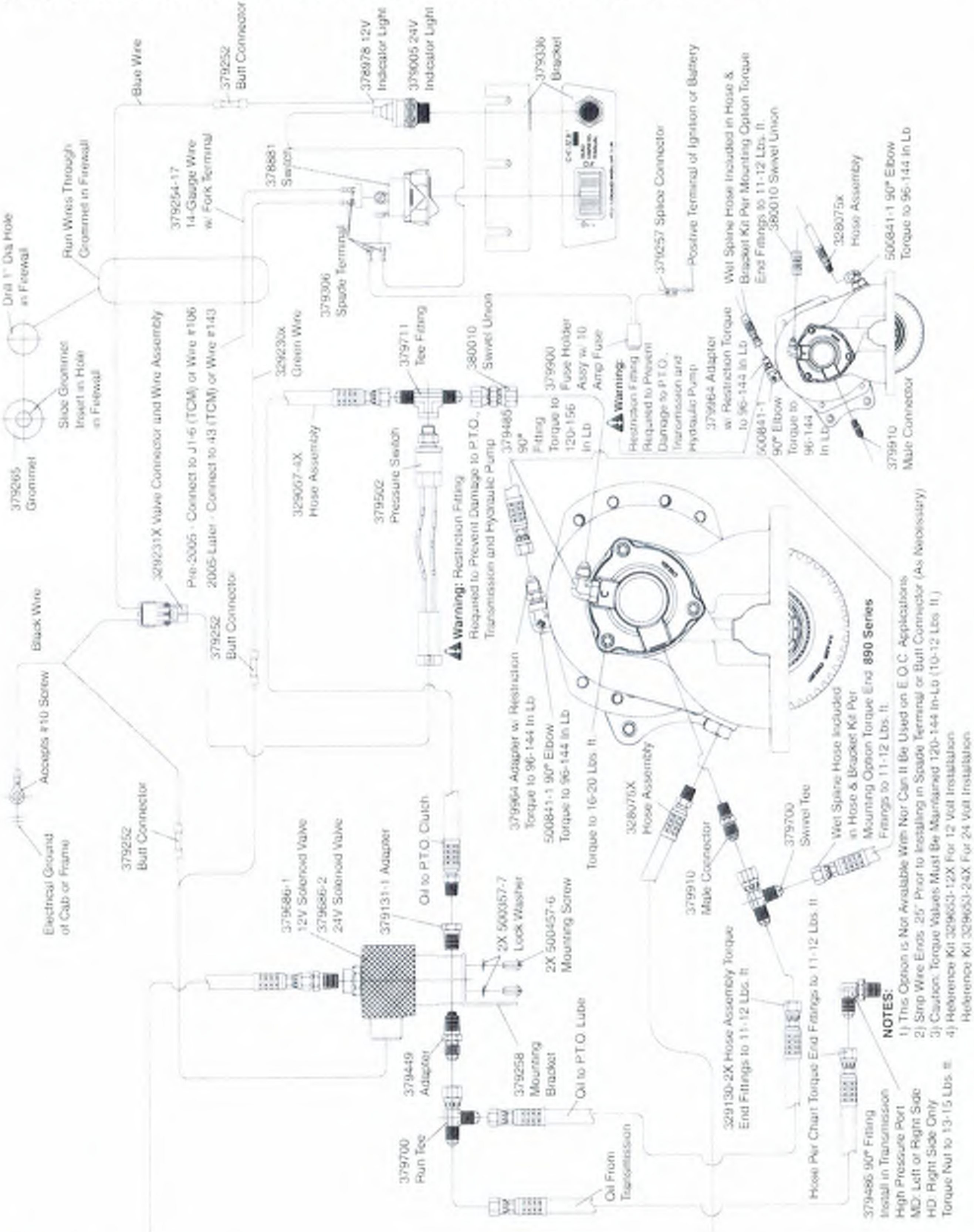
Electrical Installation Sketch without E.O.C. for 890/892 Series (SK-459 Rev C)



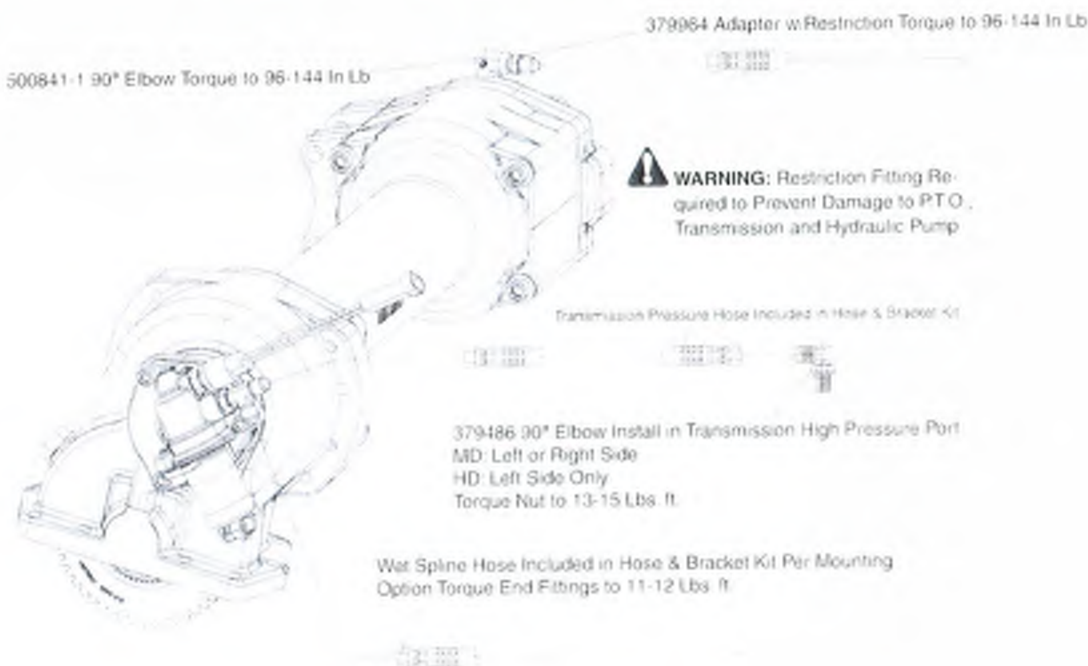
Electrical Installation Sketch with E.O.C. for 890/892 Series (SK-475 REV A)



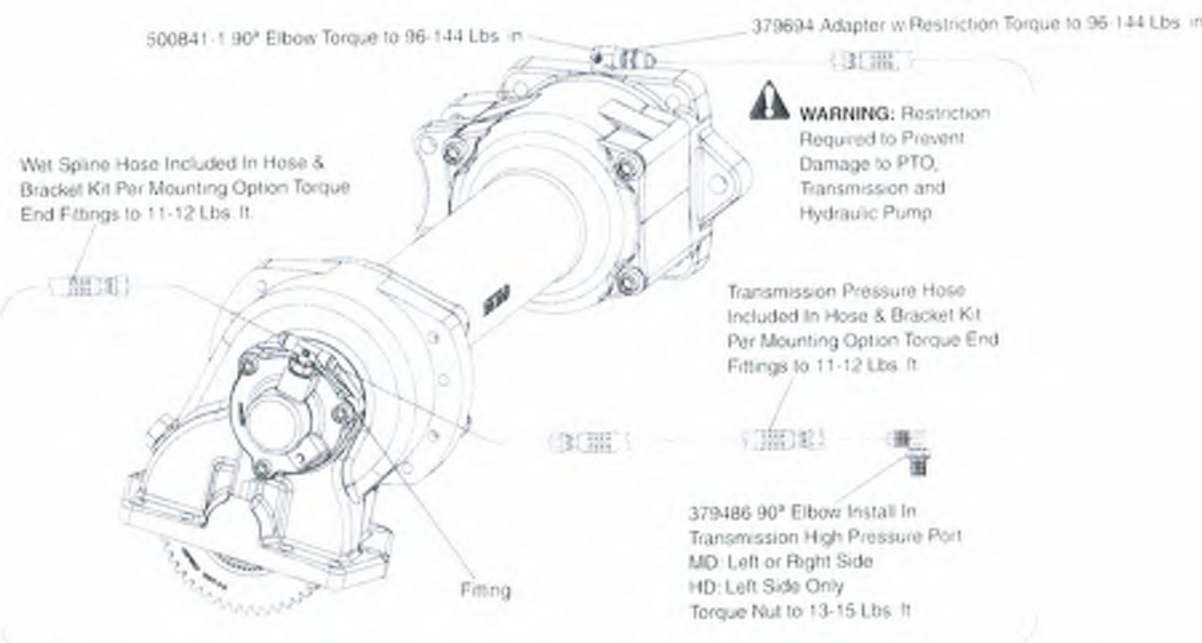
Installation Schematic Remote Solenoid 890/892 Series (SK-503 REV A)



Hose Installation Sketch for 890 and 892 Series (SK-504)



Hose Installation Sketch for 897/899 Series (SK-492 Rev A)

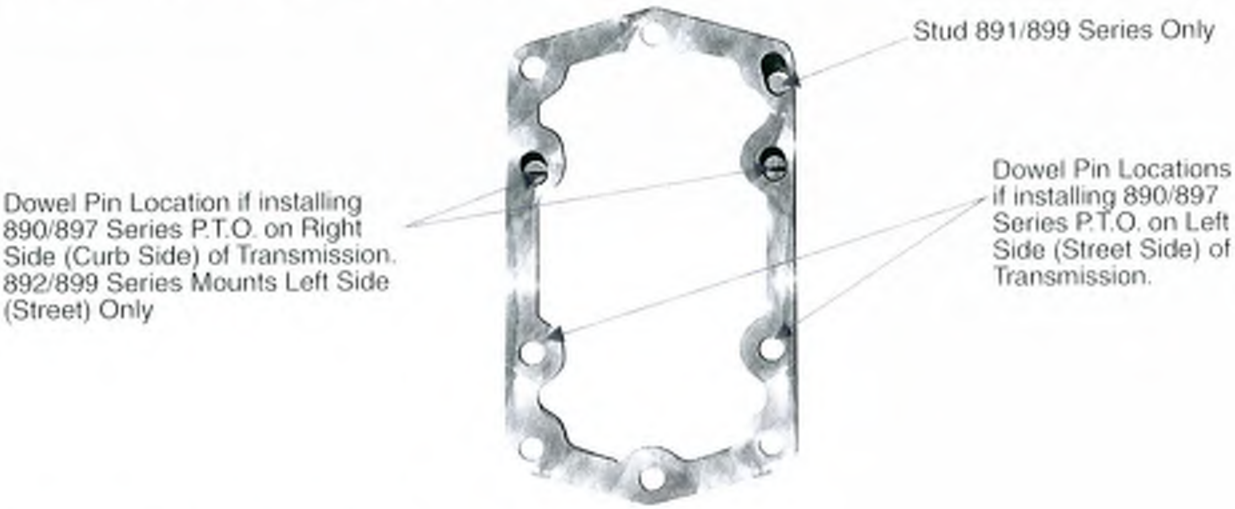


Bracket & Hose Installation Chart

P.T.O. SERIES	P.T.O. ARRANEGMENT	TRANSMISSION MODEL	LOCATION	BRACKET & HOSE KIT			
				KIT	Bracket	Hose-Pressure	Hose-Wet Spline
890/897L	5	MD (3000 Series)	LEFT	329645-1X	50-P-60	329130-5X	329130-11X
890/897R	5	MD (3000 Series)	RIGHT	329645-2X	50-P-61	329130-11X	329130-11X
890/897M	5	MD (3000 Series)	LEFT	329645-12X	50-P-128	329130-5X	329130-11X
890/897N	5	MD (3000 Series)	RIGHT	329645-13X	50-P-120	329130-11X	329130-11X
890/897H	5	HD (4000 Series)	LEFT	329645-3X	50-P-62	329130-4X	329130-11X
890/897U	5	HD (4000 Series)	TOP	329645-6X	50-P-73	329075-2X	329130-11X
890/897C	3	HD w/COOLER	LEFT	329645-7X	50-P-74	329130-4X	329130-11X
890/897J	3	HD w/RETARDER	LEFT	329645-10X	50-P-126	329130-4X	329130-11X
890/897K	5	HD w/RETARDER	TOP	329645-11X	50-P-127	329075-2X	329130-11X
890/897E	5	MD SIDE/TOP	LEFT	329645-4X	50-P-72	329130-5X	329130-11X
890/897T	5	MD SIDE/TOP	TOP	329645-5X	50-P-67	329075-2X	329130-11X
890/897F	5	MD SIDE/TOP	LEFT	329645-14X	50-P-129	329130-5X	329130-11X
890/897G	5	MD SIDE/TOP	TOP	329645-15X	50-P-75	329075-2X	329130-11X
892/899H	5	HD 4700/4800	LEFT	329645-8X	50-P-62	329130-4X	329075-2X
892/899U	5	HD 4700/4800	TOP	329645-9X	50-P-73	329075-2X	329075-2X
892/899C	3	HD 4700/4800 w/COOLER	LEFT	329645-15X	50-P-73	329130-4X	329075-2X
892/899J	3	HD 4700/4800 w/RETARDER	LEFT	329645-17X	50-P-126	329130-4X	329075-2X
892/899K	5	HD 4700/4800 w/RETARDER	TOP	329645-18X	50-P-127	329075-2X	329075-2X

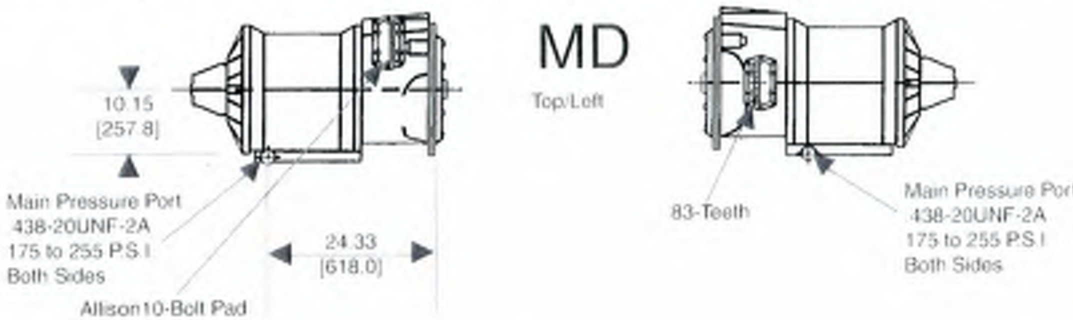
NOTE: Kit includes Bracket, Pressure Hose and Wet Spline Hose

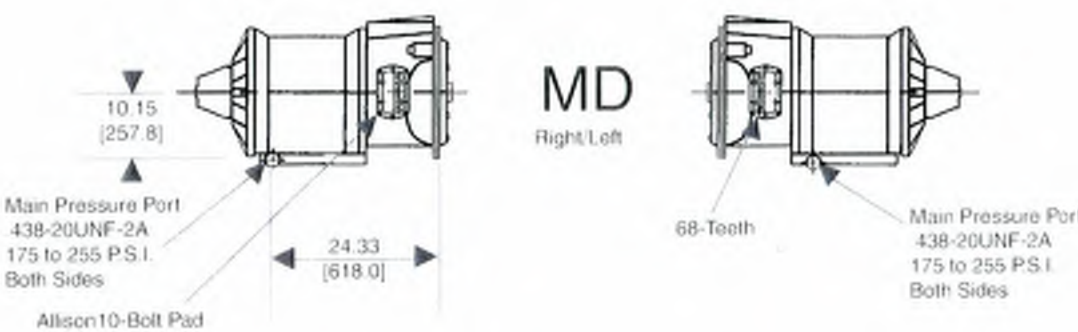
Installation Mounting Kit Instructions

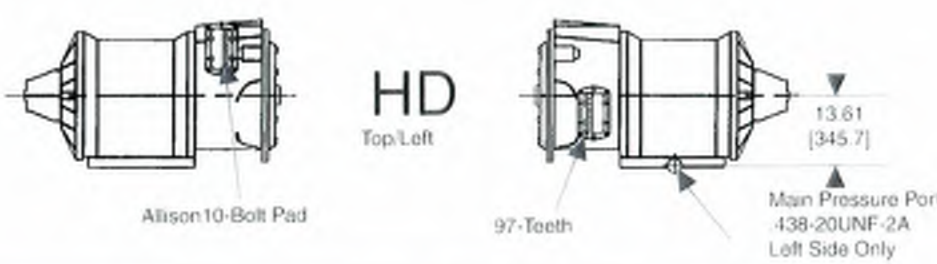


Pressure Port and Aperture Opening Identification

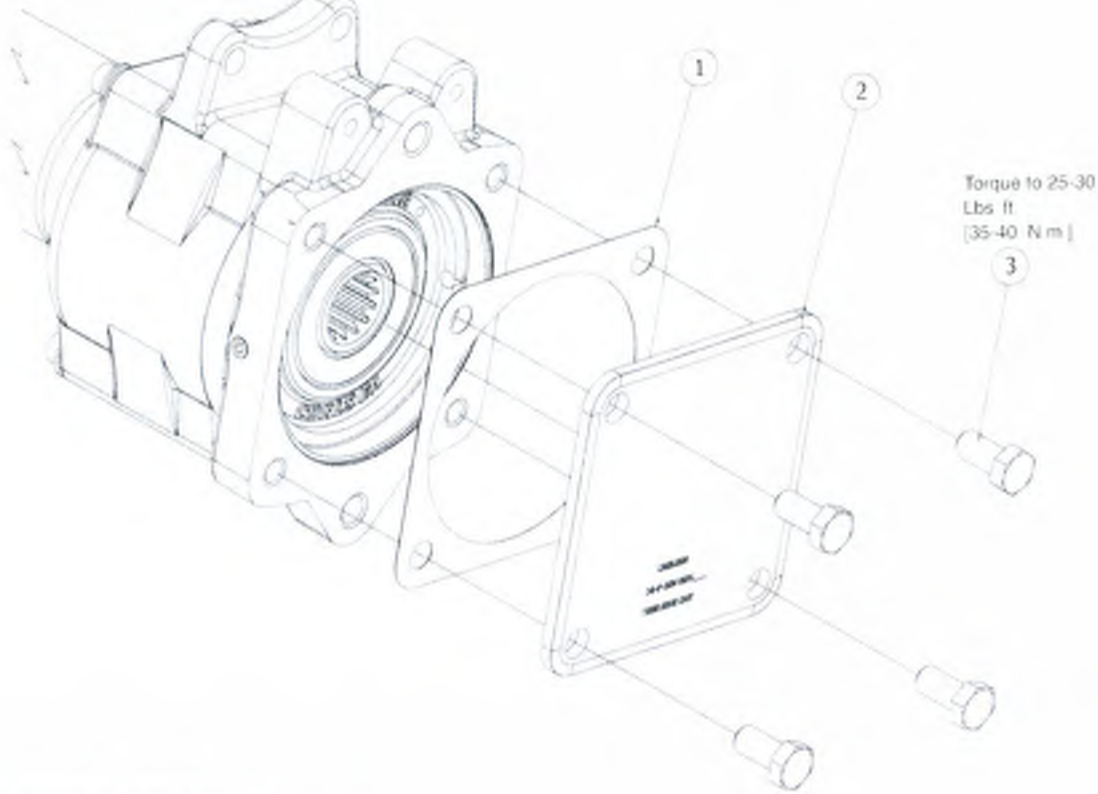
1. These drawings represent left and right views of the MD and HD pressure ports on the transmission.







Wet Spline Output Cover Plates



KITS: 329654X "XS", "CS" Output
329658X "XK", "AF", "AZ", "CK", "CF", "CZ" Output
329659X "XY", "CY" Output
329722X "DA" Output

Item	Part Number	Description	Quantity
1	**22-P-25-2**	Gasket "XS", "CS" Output	1 or
	35-P-104	Gasket "XK", "AF", "AZ", "CK", "CF", "CZ" Output	1 or
	379943	Gasket "XY", "CY" Output	1 or
	22-P-114	Gasket "DA" Output	1
2	**34-P-284**	Cover "XS", "CS"	1 or
	34-P-285	Cover "XK", "AF", "AZ" "CK", "CF", "CZ"	1 or
	379940	Cover "XY", "CY"	1 or
	34-P-309	Cover "DA" Output	1
3	**378433-10**	Capscrew "XS", "CS"	4 or
	378433-10	Capscrew "XK", "AF", "AZ", "CK", "CF", "CZ"	4 or
	379579-4	Capscrew "XY", "CY"	4 or
	500403-7	Hex Capscrew "DA"	4

P.T.O. Shifting Procedure & Precautions

CAUTION: This vehicle is equipped with a Power Take-Off. Shut engine off before working on the Power Take-Off or getting below the vehicle. Consult the operating instructions before using the P.T.O. (See sun visor.)

POWER TAKE-OFF OPERATION — VEHICLE STATIONARY

Automatic Transmission with Powershift P.T.O.s

Engage the P.T.O. with the engine at idle speed.

NOTE: Powershift P.T.O.s: The engine must be at idle or below 1000 R.P.M. when the P.T.O. is engaged. See the transmission manufacturer's instructions for special procedures.

IMPORTANT:

Failure to follow the proper shifting or operating sequences will result in premature P.T.O. failure with possible damage to other equipment.

Warning: Cold Weather Operation of Powershift P.T.O.s

During extreme cold weather operation [32° F (0° C) and lower], a disengaged Powershift Power Take-Off can momentarily transmit high torque that will cause unexpected output shaft rotation. This is caused by the high viscosity of the transmission oil when it is extremely cold. As slippage occurs between the Power Take-Off clutch plates, the oil will rapidly heat up and the viscous drag quickly decreases.

The Power Take-Off output shaft rotation could cause unexpected movement of the driven equipment, resulting in serious personal injury, death, or equipment damage.

To avoid personal injury or equipment damage:

- Driven equipment must have separate controls.
- Driven equipment must be left in the disengaged position when not in operation.
- Driven equipment must not be operated until the vehicle is allowed to warm up.

Power Take-Off Maintenance

Due to the normal and sometime severe torsional vibrations that Power Take-Off units experience, operators should follow a set maintenance schedule for inspections. Failure to service loose bolts or Power Take-Off leaks could result in potential auxiliary Power-Take-Off or transmission damage.

Periodic P.T.O. MAINTENANCE is required by the owner/operator to ensure proper, safe and trouble free operation.

Daily: Check all air, hydraulic and working mechanisms before operating P.T.O. Perform maintenance as required.

Monthly: Inspect for possible leaks and tighten all air, hydraulic and mounting hardware, if necessary. Torque all bolts, nuts, etc. to Chelsea specifications. Ensure that splines are properly lubricated, if applicable. Perform maintenance as required.

With regards to the direct mounted pump splines, the P.T.O. requires the application of a specially formulated anti-fretting, high pressure, high temperature grease. The addition of the grease has been proven to reduce the effects of the torsional vibrations, which result in fretting corrosion on the P.T.O. internal splines as well as the pump external splines. Fretting corrosion appears as a "rusting and wearing" of the pump shaft splines. Severe duty applications, which require long P.T.O. running times and high torque may require more frequent regreasing. Applications such as Utility Trucks that run continuously and are lightly loaded also require frequent regreasing due to the sheer hours of running time. It is important to note that service intervals will vary for each and every application and is the responsibility of the end user of the product. Chelsea also recommends that you consult your pump owners manuals and technical services for their maintenance guidelines. Fretting corrosion is caused by many factors and without proper maintenance; the anti-fretting grease can only reduce its effects on components.

Chelsea offers the grease to our customers in two packages. The first is a 5/8 fluid ounce tube (379688), which is included with every applicable P.T.O., and the second is a 14-ounce grease cartridge (379831). Chelsea also offers greaseable shafts for most all output designators.

Warranty: Failure to comply entirely with the provisions set forth in the appropriate Owner's Manual will result in voiding of ALL Warranty consideration.

Notes

Parker Chelsea

Parker Hannifin Corporation
Chelsea Products Division
Olive Branch, MS 38654 USA

Notes

Notes

Offer of Sale

The items described in this document and other documents or descriptions provided by Parker Hannifin Corporation, its subsidiaries and its authorized distributors are hereby offered for sale at prices to be established by Parker Hannifin Corporation, its subsidiaries and its authorized distributors. This offer and its acceptance by any customer ("Buyer") shall be governed by all of the following Terms and Conditions. Buyer's order for any such items, when communicated to Parker Hannifin Corporation, its subsidiary or an authorized distributor ("Seller") verbally or in writing, shall constitute acceptance of this offer.

1. Terms and Conditions of Sale: All descriptions, quotations, proposals, offers, acknowledgments, acceptances and sales of Seller's products are subject to and shall be governed exclusively by the terms and conditions stated herein. Buyer's acceptance of any offer to sell is limited to these terms and conditions. Any terms or conditions in addition to, or inconsistent with those stated herein, proposed by Buyer in any acceptance of an offer by Seller, are hereby objected to. No such additional, different or inconsistent terms and conditions shall become part of the contract between Buyer and Seller unless expressly accepted in writing by Seller. Seller's acceptance of any offer to purchase by Buyer is expressly conditional upon Buyer's assent to all the terms and conditions stated herein, including any terms in addition to, or inconsistent with those contained in Buyer's offer. Acceptance of Seller's products shall in all events constitute such assent.

2. Payment: Payment shall be made by Buyer net 30 days from the date of delivery of the items purchased hereunder. Amounts not timely paid shall bear interest at the maximum rate permitted by law for each month or portion thereof that the Buyer is late in making payment. Any claims by Buyer for omissions or shortages in a shipment shall be waived unless Seller receives notice thereof within 30 days after Buyer's receipt of the shipment.

3. Delivery: Unless otherwise provided on the face hereof, delivery shall be made F.O.B. Seller's plant. Regardless of the method of delivery, however, risk of loss shall pass to Buyer upon Seller's delivery to a carrier. Any delivery dates shown are approximate only and Seller shall have no liability for any delays in delivery.

4. Warranty: Seller warrants that certain Products, namely PTOs, SEMs, and Wet Line Kits sold hereunder shall be free from defects in material or workmanship for a period of twenty four months from the date of delivery to Buyer. Seller warrants that certain Products namely Pumps, and Hydraulic Accessories shall be free from defects in material or workmanship for a period of eighteen months from the date of delivery to the Buyer. The prices charged for Seller's products are based upon the exclusive limited warranty stated above, and upon the following disclaimer: **DISCLAIMER OF WARRANTY: THIS WARRANTY COMPRISES THE SOLE AND ENTIRE WARRANTY PERTAINING TO PRODUCTS PROVIDED HEREUNDER. SELLER DISCLAIMS ALL OTHER WARRANTIES, EXPRESS AND IMPLIED, INCLUDING MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.**

5. Limitation Of Remedy: SELLER'S LIABILITY ARISING FROM OR IN ANY WAY CONNECTED WITH THE ITEMS SOLD OR THIS CONTRACT SHALL BE LIMITED EXCLUSIVELY TO REPAIR OR REPLACEMENT OF THE ITEMS SOLD OR REFUND OF THE PURCHASE PRICE PAID BY BUYER, AT SELLER'S SOLE OPTION. IN NO EVENT SHALL SELLER BE LIABLE FOR ANY INCIDENTAL, CONSEQUENTIAL OR SPECIAL DAMAGES OF ANY KIND OR NATURE WHATSOEVER, INCLUDING BUT NOT LIMITED TO LOST PROFITS ARISING FROM OR IN ANY WAY CONNECTED WITH THIS AGREEMENT OR ITEMS SOLD HEREUNDER, WHETHER ALLEGED TO ARISE FROM BREACH OF CONTRACT, EXPRESS OR IMPLIED WARRANTY, OR IN TORT, INCLUDING WITHOUT LIMITATION, NEGLIGENCE, FAILURE TO WARN OR STRICT LIABILITY.

6. Changes, Reschedules and Cancellations: Buyer may request to modify the designs or specifications for the items sold hereunder as well as the quantities and delivery dates thereof, or may request to cancel all or part of this order, however, no such requested modification or cancellation shall become part of the contract between Buyer and Seller unless accepted by Seller in a written amendment to this Agreement. Acceptance of any such requested modification or cancellation shall be at Seller's discretion, and shall be upon such terms and conditions as Seller may require.

7. Special Tooling: A tooling charge may be imposed for any special tooling, including without limitation, dies, fixtures, molds and patterns, acquired to manufacture items sold pursuant to this contract. Such special tooling shall be and remain Seller's property notwithstanding payment of any charges by Buyer. In no event will Buyer acquire any interest in apparatus belonging to Seller which is utilized in the manufacture of the items sold hereunder, even if such apparatus has been specially converted or adapted for such manufacture and notwithstanding any charges paid by Buyer. Unless otherwise agreed, Seller shall have the right to alter, discard or otherwise dispose of any special tooling or other property in its sole discretion at any time.

8. Buyer's Property: Any designs, tools, patterns, materials, drawings, confidential information or equipment furnished by Buyer or any other items which become Buyer's property, may be considered obsolete and may be destroyed by Seller after two (2) consecutive years have elapsed without Buyer placing an order for the items which are manufactured using such property. Seller shall not be responsible for any loss or damage to such property while it is in Seller's possession or control.

9. Taxes: Unless otherwise indicated on the face hereof, all prices and charges are exclusive of excise, sales, use, property, occupational or like taxes which may be imposed by any taxing authority upon the manufacture, sale or delivery of the items sold hereunder. If any such taxes must be paid by Seller or if Seller is liable for the collection of such tax, the amount thereof shall be in addition to the amounts for the items sold. Buyer agrees to pay all such taxes or to reimburse Seller therefore upon receipt of its invoice. If Buyer claims exemption from any sales, use or other tax imposed by any taxing authority, Buyer shall save Seller harmless from and against any such tax, together with any interest or penalties thereon which may be assessed if the items are held to be taxable.

10. Indemnity For Infringement of Intellectual Property Rights: Seller shall have no liability for infringement of any patents, trademarks, copyrights, trade dress, trade secrets or similar rights except as provided in this Part 10. Seller will defend and indemnify Buyer against allegations of infringement of U.S. Patents, U.S. Trademarks, copyrights, trade dress and trade secrets (hereinafter 'Intellectual Property Rights'). Seller will defend at its expense and will pay the cost of any settlement or damages awarded in an action brought against Buyer based on an allegation that an item sold pursuant to this contract infringes the Intellectual Property Rights of a third party. Seller's obligation to defend and indemnify Buyer is contingent on Buyer notifying Seller within ten (10) days after Buyer becomes aware of such allegations of infringement, and Seller having sole control over the defense of any allegations or actions including all negotiations for settlement or compromise. If an item sold hereunder is subject to a claim that it infringes the Intellectual Property Rights of a third party, Seller may, at its sole expense and option, procure for Buyer the right to continue using said item, replace or modify said item so as to make it noninfringing, or offer to accept return of said item and return the purchase price less a reasonable allowance for depreciation. Notwithstanding the foregoing, Seller shall have no liability for claims of infringement based on information provided by Buyer, or directed to items delivered hereunder for which the designs are specified in whole or part by Buyer, or infringements resulting from the modification, combination or use in a system of any item sold hereunder. The foregoing provisions of this Part 10 shall constitute Seller's sole and exclusive liability and Buyer's sole and exclusive remedy for infringement of Intellectual Property Rights.

If a claim is based on information provided by Buyer or if the design for an item delivered hereunder is specified in whole or in part by Buyer, Buyer shall defend and indemnify Seller for all costs, expenses or judgments resulting from any claim that such item infringes any patent, trademark, copyright, trade dress, trade secret or any similar right.

11. Force Majeure: Seller does not assume the risk of and shall not be liable for delay or failure to perform any of Seller's obligations by reason of circumstances beyond the reasonable control of Seller (hereinafter 'Events of Force Majeure'). Events of Force Majeure shall include without limitation, accidents, acts of God, strikes or labor disputes, acts, laws, rules or regulations of any government or government agency, fires, floods, delays or failures in delivery of carriers or suppliers, shortages of materials and any other cause beyond Seller's control.

12. Entire Agreement/Governing Law: The terms and conditions set forth herein, together with any amendments, modifications and any different terms or conditions expressly accepted by Seller in writing, shall constitute the entire Agreement concerning the items sold, and there are no oral or other representations or agreements which pertain thereto. This Agreement shall be governed in all respects by the law of the State of Ohio. No actions arising out of the sale of the items sold hereunder or this Agreement may be brought by either party more than two (2) years after the cause of action accrues.

10.09-P

Sales Offices Worldwide

Canada
Parker Hannifin Canada
160 Chisholm Drive
Milton, Ontario L9T 3G9
Tel: (905) 693-3000
Fax: (905) 867-0789

Mexico
Parker Hannifin Corporation
Via de Ferrocarril a
Matamoros 730
Apodaca, N.L Mexico
Tel: (011) 52 81 8156 6000
Fax: (011) 52 80 8156 6076

Parker Hannifin Pty Ltd
Sales Company South Africa
10 Berne Avenue
Aeroport
Kempton Park
SOUTH AFRICA
1620
Tel: +9610700
Fax: +3927213

Brazil
Parker Hannifin Industria e Comercio Ltda.
Hydraulics Division
Av Frederico Ritter 1100
District Industrial
94930-000 Cachoeirinha
RS, Brazil
Tel: 55 51 3470 9131
Fax: 55 51 3470 6090

Pan American Div
7400 N W 19th St Suite A
Miami, FL 33126
UNITED STATES
Tel: (305) 470-8800
Fax: (305) 470-8809

Great Britain
Parker Chelsea Products
Parker Hannifin Limited
Bldg 93, Vantage Point.,
Pensnett Estate,
Kingswinford, W Midlands, DY6 7FR
UNITED KINGDOM
Tel: (011) 44 1384 282777
Fax: (011) 44 1384 401851

Chelsea Products
Parker Hannifin India Pvt. Ltd.
TTC Industrial Area, Mahape
Navi Mumbai - 400 709, India
Tel: +91 22 6513 7081 - 85
ext 260
Fax: +91 22 2768 6841

Australia
305 Frankston-Dandenong Road
Dandenong South, Victoria 3175
Tel: 61 3 9768-5555
Fax: 61 3 9768-5556

Australia
Parker Hannifin (Australia) Pty. Ltd.
9 Carrington Road
Castle Hill
New South Waltes, 2154
Tel: 61 2 9842-5812
Fax: 61 2 9842-5826

Parker Hannifin Singapore Pte
No 11 Fourth Chin Bee Rd
Jurong Town
SINGAPORE
619702
Tel: (+68) 87 -6300
Fax: (+62) 65 -5125

Parker Hannifin Hong Kong Ltd
8/f, Kin Yip Plaza
9 Cheung Yee Street
Cheung Sha Wan Kowloon
HONG KONG
Tel: (+02) 428-8008
Fax: (+02) 480-4256

Parker Hannifin Motion & Control (Shanghai) Co., Ltd.
280 Yunqiao Road, Jinqiao Export Processing Zone
Shanghai 201206, P. R. China
Tel: (+86) 21 6455 2002
Fax: (+86) 21 5463 1250

Parker Hannifin Beijing
Suite B9-B11
21/F Hanwei Plaza
No. 7 Guanghua Road
Chaoyang District
Beijing 100004, China
Tel: (+86) 10 6561 0520 - 5
Fax: (+86) 10 6561 0526 - 7

Parker Hannifin Corporation
Chelsea Products Division
8225 Hacks Cross Road
Olive Branch, Mississippi 38654 USA
Tel: (662) 895-1011
Fax: (662) 895-1069
www.parker.com/chelsea

FP 03/11 1,000

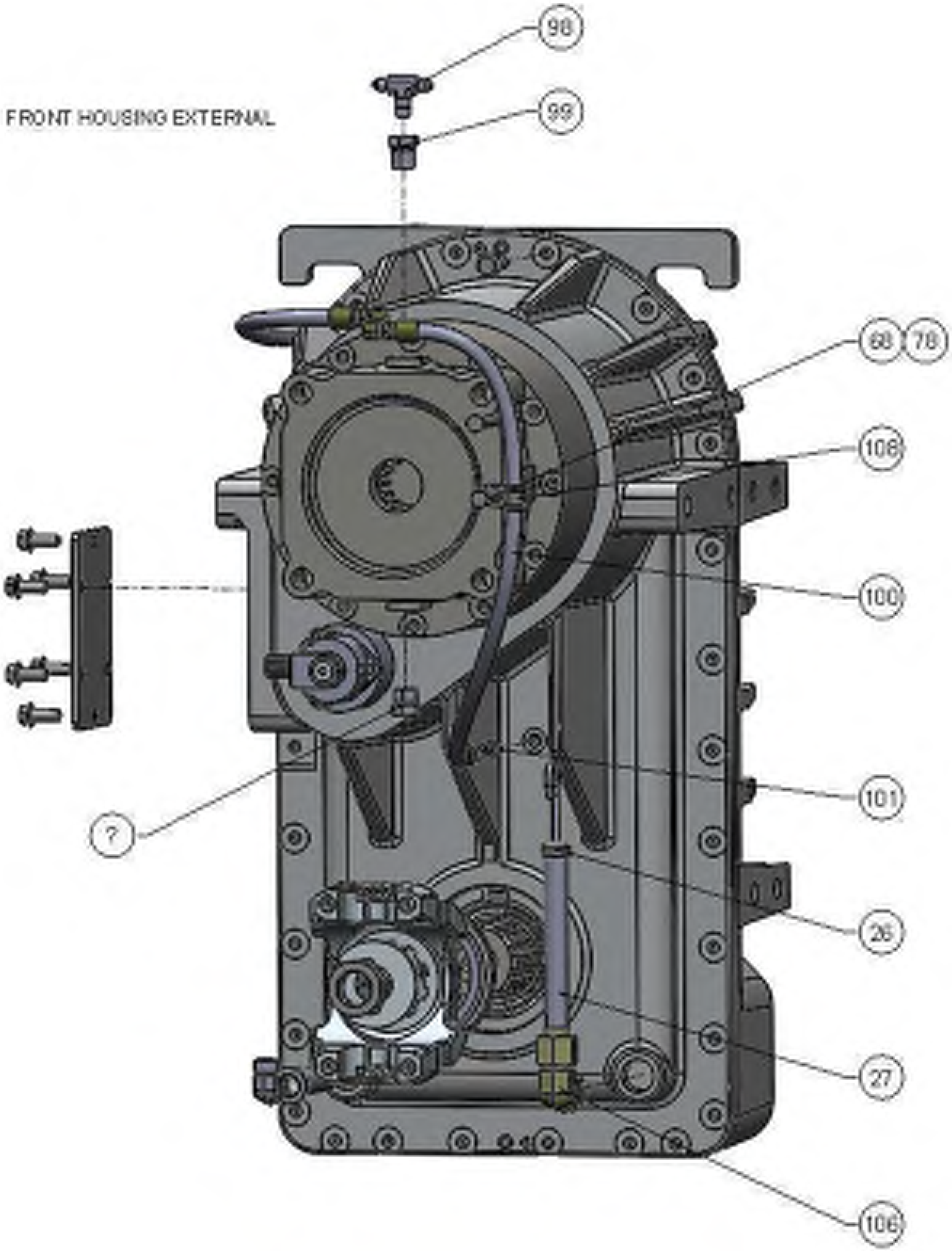
Service Manual

R. Cushman & Associates Inc.
Power Train Engineers
32840 West 8 Mile Road, Farmington, Michigan 48336
Phone (248) 477-9900 FAX (248) 477-7883
ISO 9001:2008 Cert - 0033879
www.rcushman.com

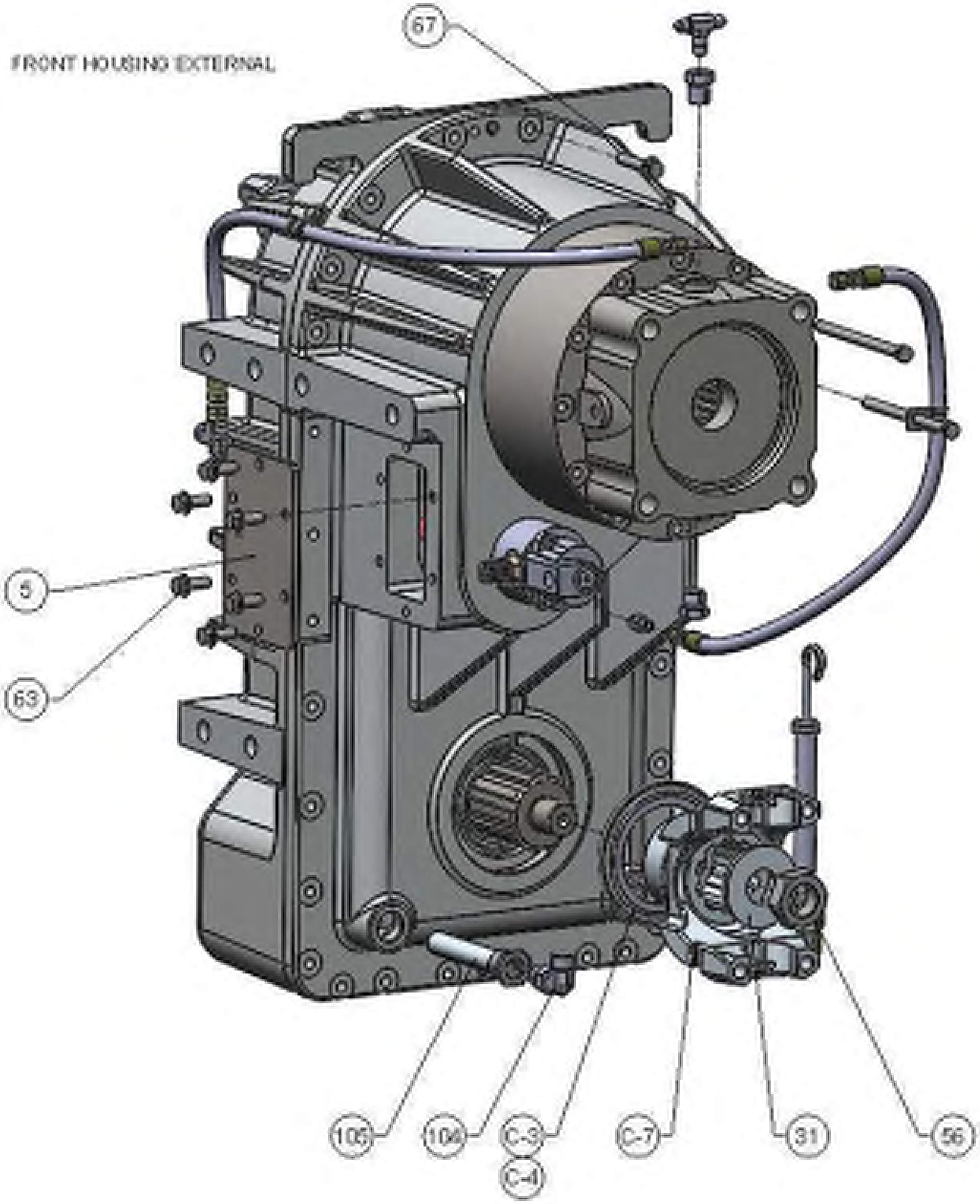
Specifications
Model 479A-1
Drawing Number 11035
Transfer Case
Creeper Drive
Gradall Industries, Inc. P.N. 80783073

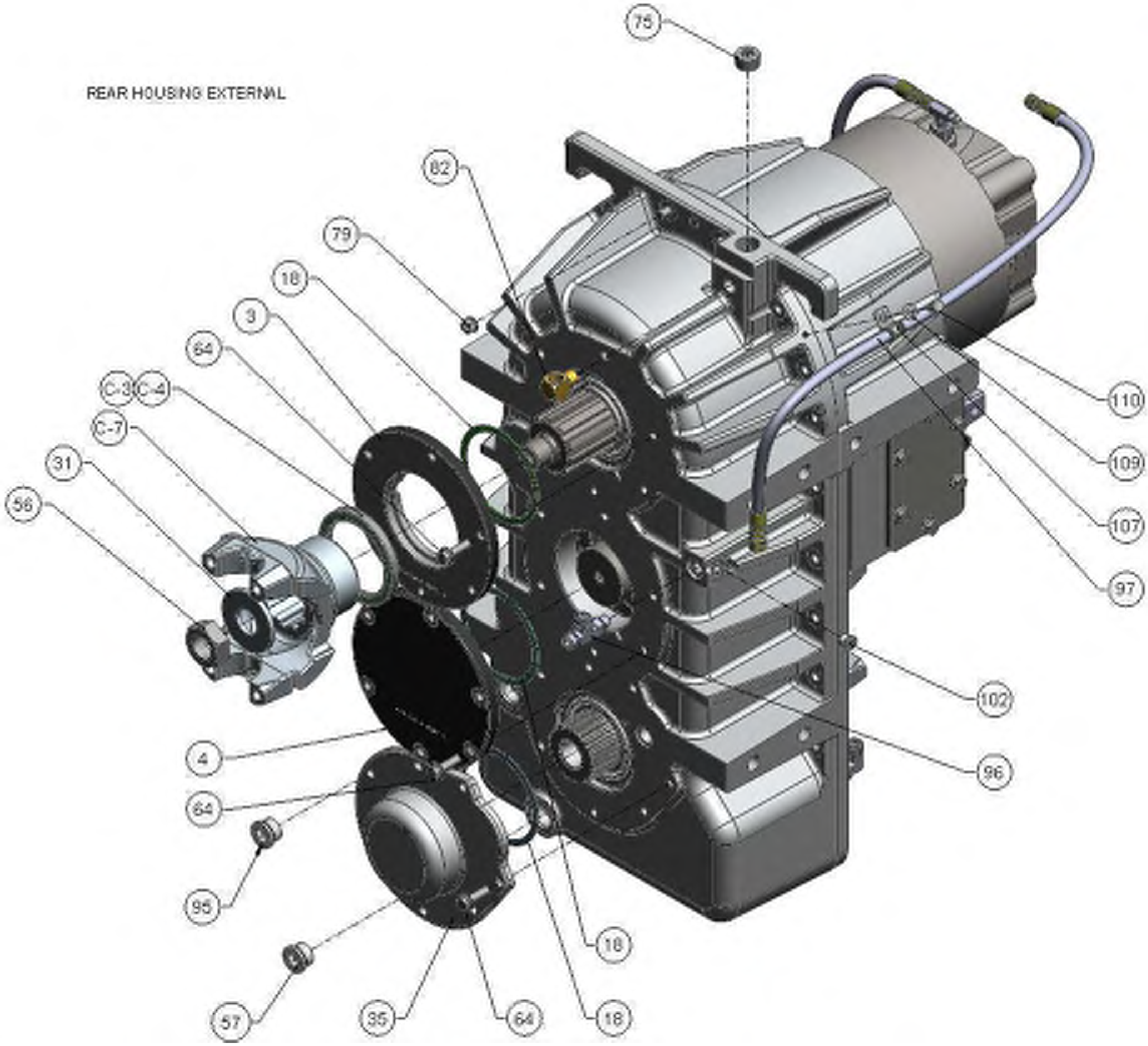
Description:	Model 479A is a combination transfer case and creeper drive. In road mode, power into the front top shaft, out of the bottom shaft to the rear axle with an air engaged front axle disconnect. In creep mode, a hydraulic motor drives an air engaged planetary reduction opposite the input shaft.
Input:	**Road** – – 2.75-10 splined shaft with a 3.75 inch seal diameter. Shipped with 1760 HR yoke # 6.3-4-711-1 **Creep –** SAE-D 4 bolt hydraulic motor pad through an air engaged 15.39:1 planetary drive. Switch is made when creep drive is engaged. Packard Weather Pack connector 12015792.
Output:	**Rear** - 2.75-10 splined shaft with a 3.75 inch seal diameter. Shipped with 1760 HR yoke # 6.3-4-711-1. **Front** - Air engaged front axle disconnect, 2.75-10 splined shaft with a 3.75 inch seal diameter. Shipped with 1760 HR yoke # 6.3-4-711-1. Switch is made when front axle is engaged. Packard Weather Pack connector 12015792.
Center distance:	16.92 inch center distance.
Gear ratio:	1.000:1 Road mode, 15.39:1 creep mode.
Housing:	High tensile Aluminum
Lube:	14 quarts initial fill, 11 quarts top off level, 75W-90 GL-5 synthetic gear lube, Optional Mobile 424
Mounting:	(6) 3/4-10 tapped x 1.50 deep mounting holes each side.
Size:	31.75 high, 16.25 inches wide, by 29.03 long from hydraulic motor face to input U-joint.
Weight:	Estimated 475 pounds
Vehicle:	Highway Speed Excavator **Engine:** largest engine - Detroit / Mercedes 322 hp @ 2200 rpm, 959 lb-ft @ 1400 rpm. **Transmission:** Allison 3500 RDS, 4.59:1, 2.25:1, 1.54:1, 1.00:1, 0.75:1, .64:1 or optional Allison 3000 3.49:1, 1.86, 1.00:1, 0.75:1, .64:1 for largest engine **Axles:** (3), drivers (2) Ratio 7.17:1 **Tires:** 11R24.5, 20.6 slr, 475 rpm **GVW:** 59,500 lb **Creep:** 6,400 lb-ft @ 90 rpm output.

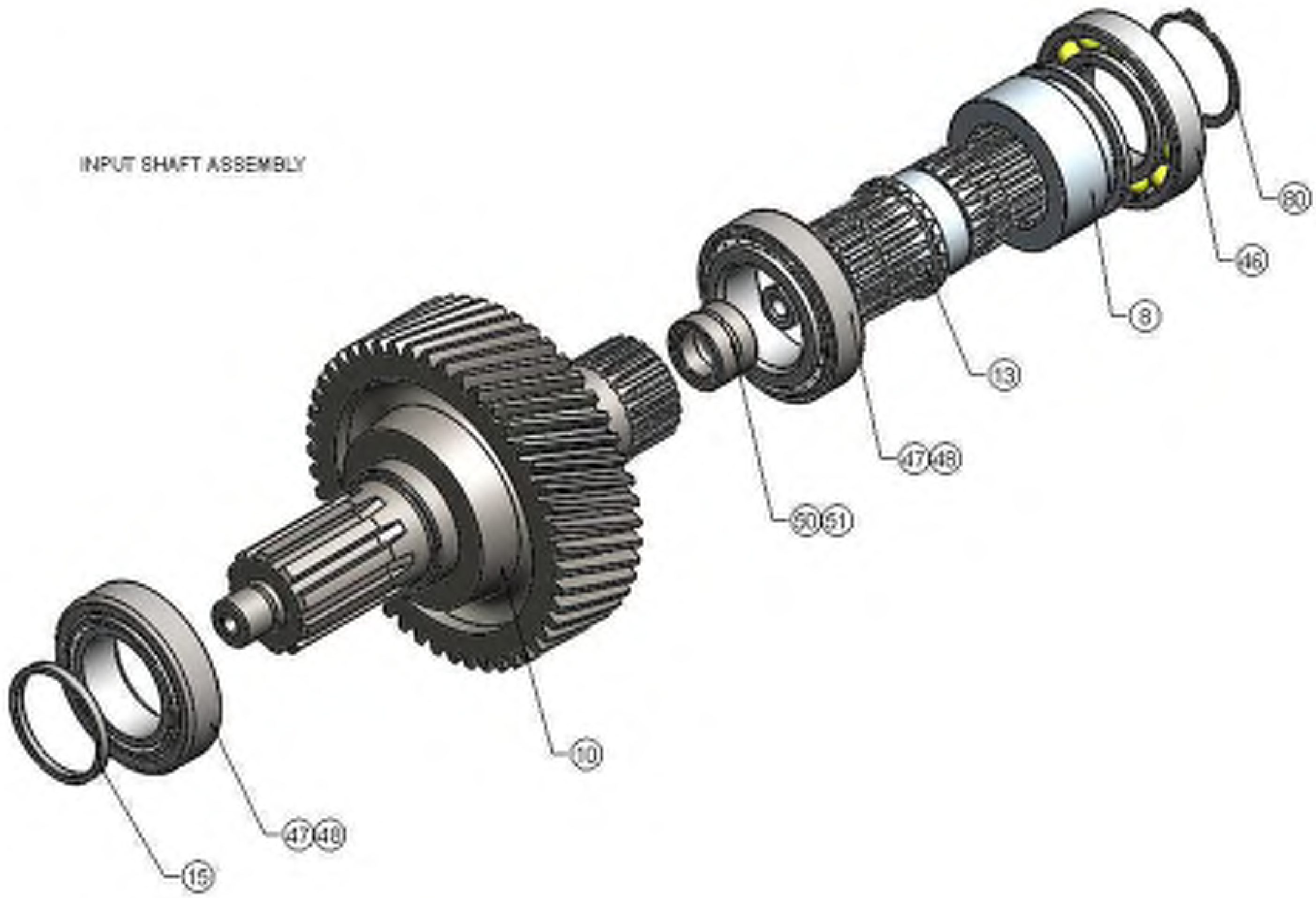
FRONT HOUSING EXTERNAL

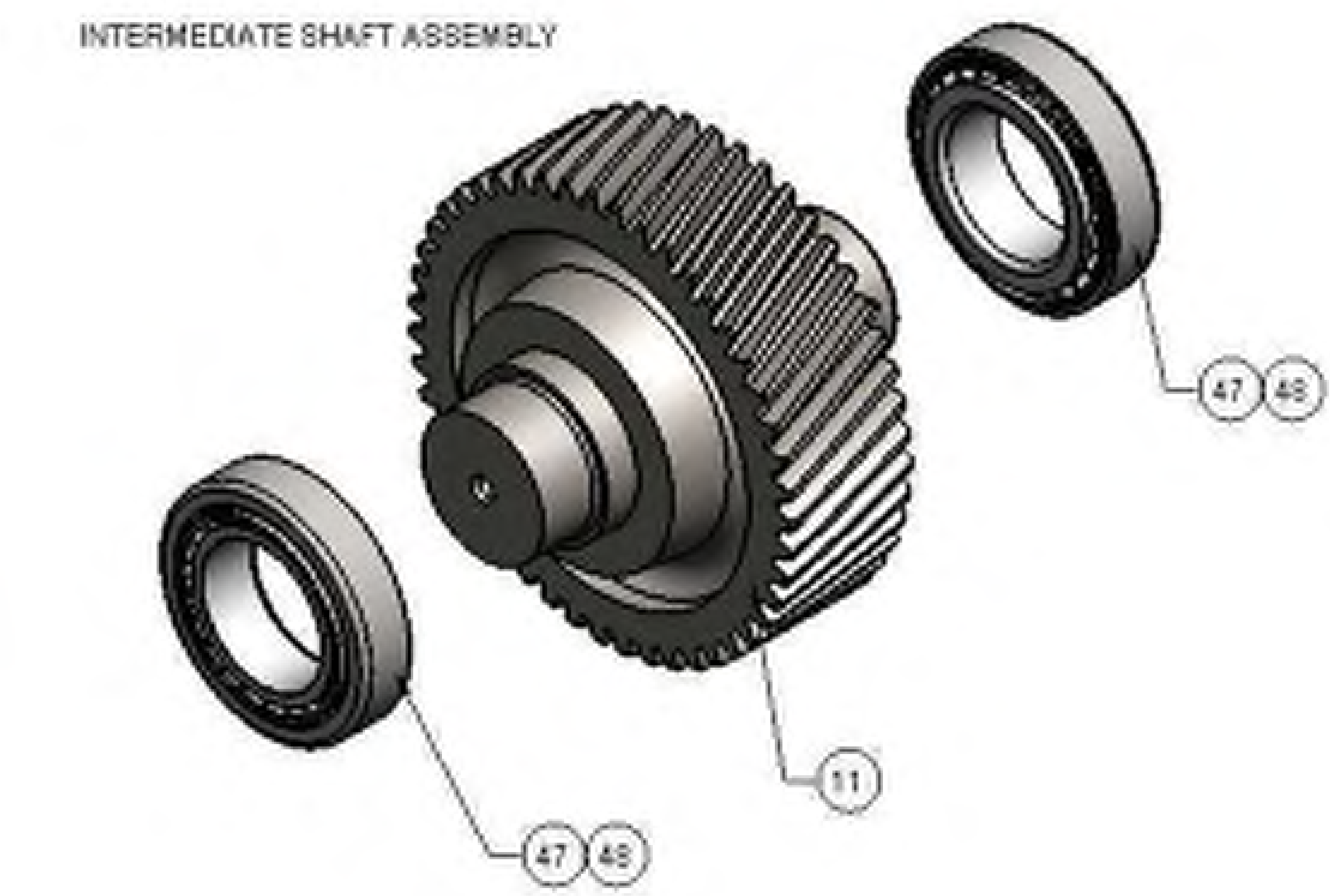


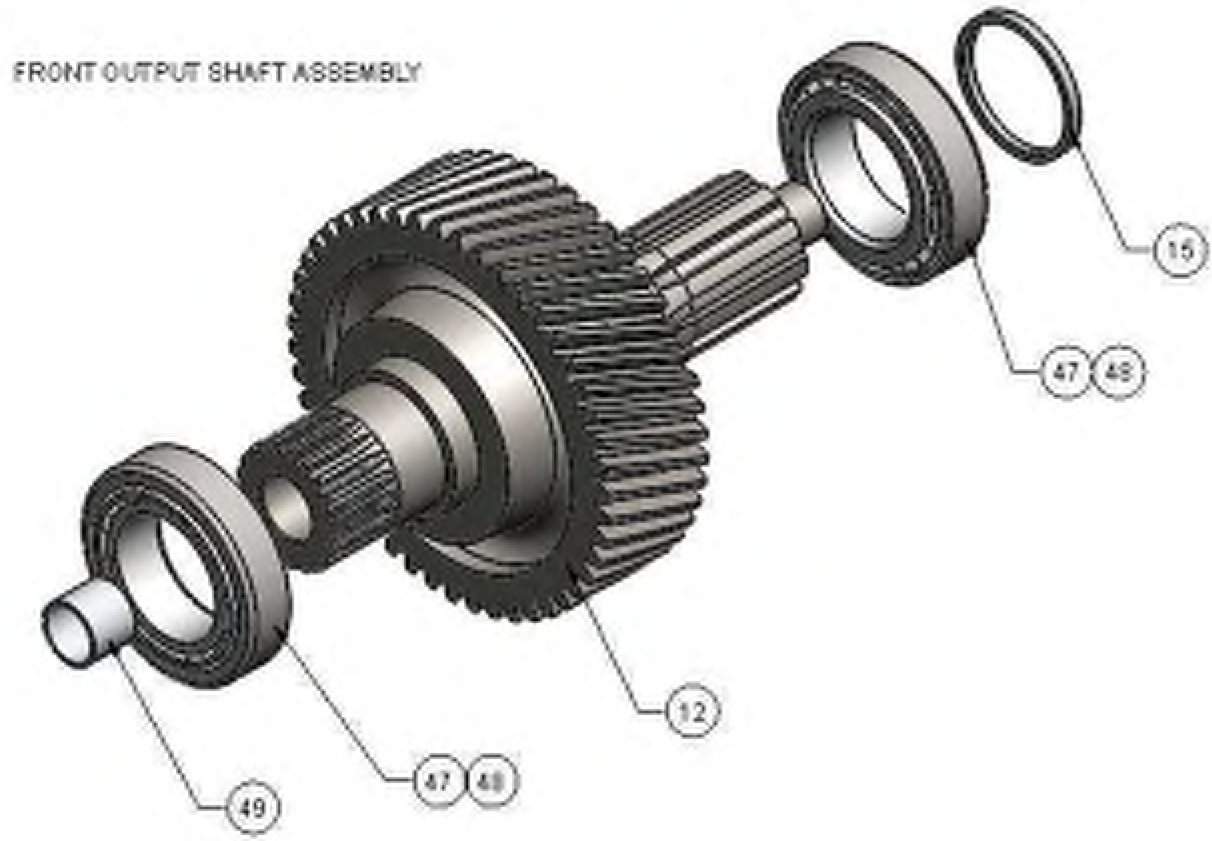
FRONT HOUSING EXTERNAL

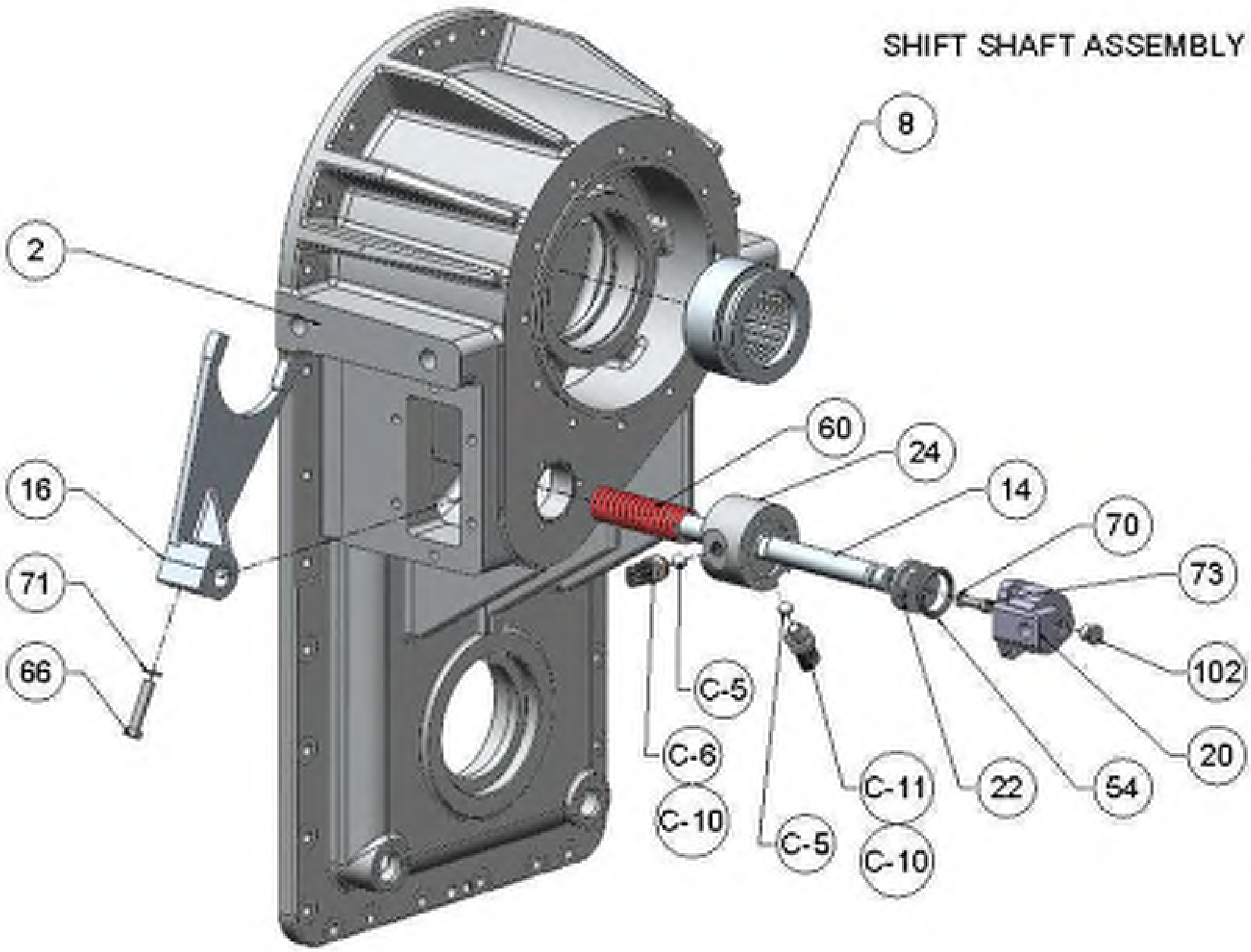


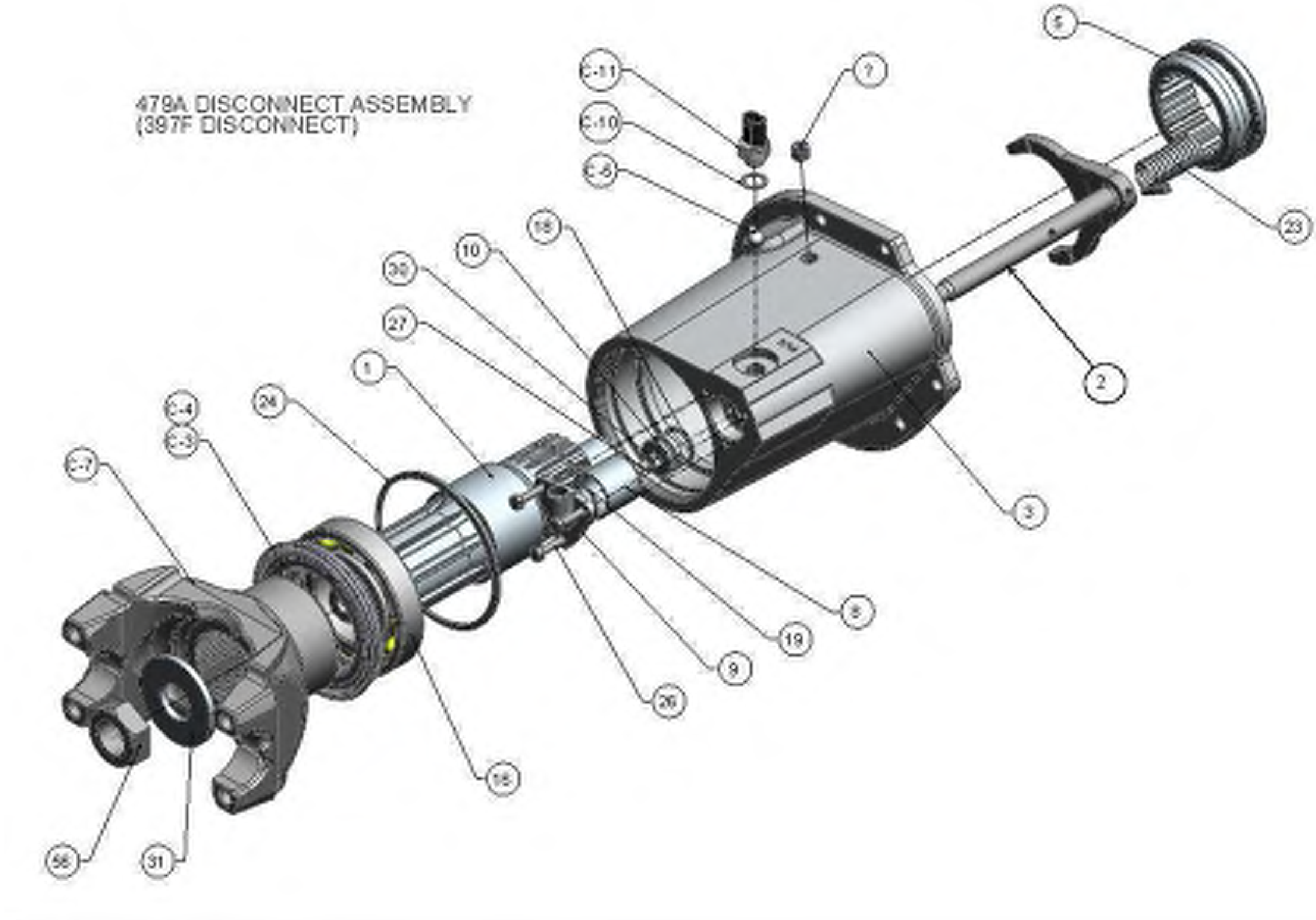

REAR HOUSING EXTERNAL
75
82
79
18
3
64
C-3
C-4
C-7
31
56
110
109
107
97
102
96
4
64
95
18
57
35
64
18


INPUT SHAFT ASSEMBLY
80
46
8
13
47 48
50 51
10
47 48
15


INTERMEDIATE SHAFT ASSEMBLY
47
48
11
47
48


FRONT OUTPUT SHAFT ASSEMBLY
15
47
48
12
49
47
48


SHIFT SHAFT ASSEMBLY
8
2
60
24
14
70
73
16
71
102
66
C-5
C-6
C-10
C-11
22
54
20
C-5
C-10


479A DISCONNECT ASSEMBLY
(397F DISCONNECT)

479 Bill of Material

Item Number	Part Number	Description	QTY
001		Housing - Front	1
002		Housing - Rear	1
003		Retainer - Seal	1
004		Cover - Bearing	1
005		Cover - Access	1
008		Collar - Shift	1
010		Gear and Shaft - Input	1
011		Gear and Shaft	1
012		Gear and Shaft - Output	1
013		Shaft - Planetary Input	1
014		Shaft - Shift	1
015		Spacer - Yoke	2
016		Fork - Shift	1
020		Cylinder - Shift (Short)	1
022		Piston - Shift	1
024		Adapter - Shift	1
025		Plate - Oil Passage	1
026		Dipstick	1
027		Tube - Dipstick	1
031		Washer - Yoke	2
035		Cover - Tophat	1
036		Planetary MDL 8 - 15.39:1 D Pad	1
046		Ball Bearing	1
047		Cup - Beraing	6
048		Cone - Bearing	6
049		Bushing - Disconnect	1
050		Bearing - Inner Race	1
051		Bearing - Heavy Duty Caged Roller	1
052		Snap Ring - Internal	1
054		O'ring	1
056		Locknut - 1 1/4-12	2
057		Magnetic Plug - #12 O'ring	1
058		Snap Ring	1
060		Spring - Return	1
061		Hardened Pull Dowel	2
063		Yellow Coated HFS-3/8-16x1.00LG.	6
064		Yellow Coated HFS-3/8-16x1.25LG.	19
065		Yellow Coated HFS-3/8-16x1.50LG.	10
066		H.H.C.S	1
067		Yellow Coated HFS-3/8-16x2.00LG.	18
068		Yellow Coated HHCS-3/8-16x5.50LG.	12

069		Yellow Coated SHCS-1/4-20x2.75LG.	3
070		Antivibration Washer - 5/16	1
071		Antivibration Washer - Preglued	12
073		S.H.C.S	1
075		Hollow Hex Pipe Plug - 3/4 N.P.T	1
076		Breather - 3/8 N.P.T	1
078		Yellow Coated FW-.375 DIA.	12
079		Yellow Coated FLN-3/8-16	18
080		Snap Ring - External	1
081		Snap Ring - External Light Series	3
082		Short Body Street Elbow	1
083		Hex Flange Screw	11
095		#12 O'ring Plug	2
096		#6 ORFS to #6 O'ring Run Tee	1
097		#4 Lube Line STR-STR (33.00" Long)	1
098		1/4 NPTP to #4 JIC Tee - .093	1
099		Reducer Bushing	1
100		#4 Lube Line STR-STR (26.50" Long)	1
101		#4 O'ring to #4 JIC STR - .062	1
102		#6 O'ring Hollow Hex Plug	3
103		o-ring	1
104		Strainer - #12 O'ring	1
105		#8 O'ring to #8 ORFS Elbow	1
106		#12 O'ring to #12 JIC Elbow	1
107		Hose Clamp	1
108		Hose Clamp - 9/16 ID.	1
109		Flat Washer - 1/4 Diameter	1
110		H.H.C.S	1
119		Snap Ring	1
018A		Shim - .005 Thick	9
018B		Shim - .007 Thick	9
018C		Shim - .020 Thick	9

Customer Specific Bill of Material (479-001)

Item Number	Part Number	Description	QTY
C-002		Seal	1
C-003		Oil Seal	1
C-004		Sleeve - Oil Seal	1
C-005		Ball - Switch	1
C-006		Switch - (N/C)	1
C-007		Yoke - 1710 HR (Painted Black)	2
C-008		Name Plate - Gradall	1

C-009		Drive Screw	4
C-010		Washer - Switch Gasket	2
C-011		Switch - (N/O)	1

479A Disconnect Assembly (397F Disconnect)

Item Number	Part Number	Description	QTY
001		Shaft - Disconnect	1
002		Fork and Shaft Assembly	1
003		Housing - Disconnect	1
005		Collar - Disconnect	1
008		Cylinder - Shift	1
009		Cap - Air Inlet	1
010		Piston - Shift	1
016		Ball Bearing	1
018		Block Vee Seal	1
019		O'ring	2
023		Spring - Return	1
024		Snap Ring - Internal	1
026		H.H.C.S. - GRADE 8	3
027		S.H.C.S.	1
030		Antivibration Washer - 5/16	1

Customer Specific Bill of Material (479A-001)

Item Number	Part Number	Description	QTY
C-002		Seal	1
C-003		Oil Seal	2
C-004		Sleeve - Oil Seal	2
C-005		Ball - Switch	3
C-006		Switch - (N/C)	1
C-007		Yoke - 1710 HR (Painted Black)	3
C-008		Name Plate - Gradall	1
C-009		Drive Screw	4
C-010		Washer - Switch Gasket	3
C-011		Switch - (N/O)	2

R. Cushman & Associates Inc.
Power Train Engineers
32840 West 8 Mile Road, Farmington, Michigan 48336
Phone (248) 477-9900 FAX (248) 477-7883
ISO 9001:2008 Cert - 0033879
www.rcushman.com

LUBRICATION SPECIFICATION

NOTE: This is a general lubrication specification. Please refer to the lubrication recommendation for your specific model. All gearboxes will be tested with 75W-90 Synthetic lube. Units shipped factory filled will use 75W-90 Synthetic oil.

ON HIGHWAY SERVICE:	**Mineral Oil**	**Synthetic Oil**
Check oil level	2,000 miles	2,000 miles
Initial flush and oil change	3,000 miles	3,000 miles
Scheduled flush and oil change	25,000 miles	50,000 miles
OFF HIGHWAY SERVICE:		
Check oil level	24 hours	24 hours
Initial flush and oil change	50 hours	50 hours
Scheduled flush and oil change	500 hours	1000 hours
INDUSTRIAL / STATIONARY SERVICE:		
Check oil level	50 hours	50 hours
Initial flush and oil change	100 hours	100 hours
Scheduled flush and oil change	500 hours	1000 hours

NOTE: If the lube system incorporates a lubricating oil pump:

1. Remove and clean suction oil screen and change filter if supplied at each oil change.
2. After oil change, or after a period of inactivity, check lube pump for proper operation.

REFILL: Remove all dirt around the drain and filler plugs. Drain oil in a suitable container and dispose of properly. Refill with new oil of the grade recommended to either the bottom of the filler hole or full level indication. Run unit for several minutes and recheck oil level.

OPERATING TEMPERATURE:

Normal operating temperature	100°F TO 190°F
Maximum continuous operating temperature	225° F.
Maximum short duration operating temperature	250°F

NOTE: Operation at temperatures exceeding 250°F will result in rapid breakdown of oil, premature seal failure, and will shorten the life of the gearbox.

RECOMMENDED OIL:
75W-90 Synthetic, MIL-L 2105E, API Service MT-1 and GL-5 above -40°F.
Optional oil: Multipurpose gear Lube, GL-5 per MIL-L-2105E
75W below -30° F. 75W-90 above -30° F or 80W-90 above 0° F

NOTE: Do not mix synthetic lubricants and mineral oil, foaming and other problems may occur. If changing from a mineral oil or synthetic, flush system thoroughly before installing oil.

02/26/10

R. Cushman & Associates Inc.
Power Train Engineers
32840 West 8 Mile Road, Farmington, Michigan 48336
Phone (248) 477-9900 FAX (248) 477-7883

Model 479 Seal Replacement Installation Instructions:

Prepared 8-01-2011 MB

Models covered:

Location	Seal Part Number	Inner Sleeve Part Number	Seal Driver	Inner Sleeve Driver
Input (Upper)	34889	N/A	TBD	N/A
Output (Rear)	DOS908-1	DOS908-2	TBD	TBD
Output (Front Disconnect)	DOS908-1	DOS908-2	TBD	TBD

Tools and supplies required:

Seals and drivers
Heavy hammer or beater bar
1 ¼-12 nylon lock nut
1 13/16 socket with ¾” Drive
Impact Gun with ¾” that can produce 300 lbft of torque
Torque wrench that can produce 300 lbft of torque
Seal puller
Denatured Alcohol or Mineral Spirits
Scraper
Standard Automotive Grease
RTV (Silicone) Sealant

Instructions:

1. Identify seal location and select appropriate seal and inner sleeve. The seals are designed to fit the standard yokes. The 6-4-4551-1 yoke on the input does not have a seal sleeve.

2. Remove yoke nut with impact gun and socket. Discard used yoke nut. A new yoke nut should be installed whenever the yoke nut is removed.

3. Remove yoke washer and yoke. Using scraper remove the RTV on the yoke face, yoke washer, and end of shaft.

4. Remove the existing seal with a seal puller, taking care not to damage the seal bore

5. Remove the seal sleeve from the yoke (if applicable), taking care not to damage the yoke OD where the sleeve rides.

6. Using denatured alcohol or mineral spirits, clean the seal bore so that it is free of dirt, oil, and debris. Similarly, clean the surface of the yoke on which the inner sleeve will ride.

7. Using the appropriate driver and hammer or beater, drive seal in location until driver hits hard, indicating that the seal is flush against its seating surface.

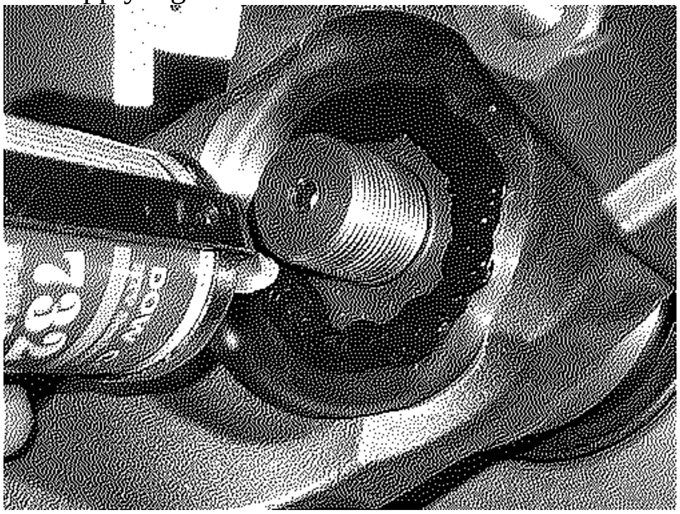
8. Inspect the seal to ensure that it is flush and square to

the seating surface

If an inner sleeve is required and the 6-4-4551-1 yoke has a sleeve installed skip step 9.

9. If an inner sleeve is required, install the inner sleeve on the yoke using the appropriate driver and hammer or beater. Gentle drive the seal until the driver bottoms on the yoke and locate the inner sleeve in the correct location. **BE CAREFUL NOT TO STRIKE THE DRIVER WITH TOO MUCH FORCE OR THE SLEEVE WILL OVER TRAVEL.**

10. Install the yokes and/or seal sleeve onto the shaft.
11. Apply a generous bead of RTV to the outer surface of the yoke at the spline.



12. Install the yoke washer and yoke nut
13. Tighten the yoke nut to 300 lbft .

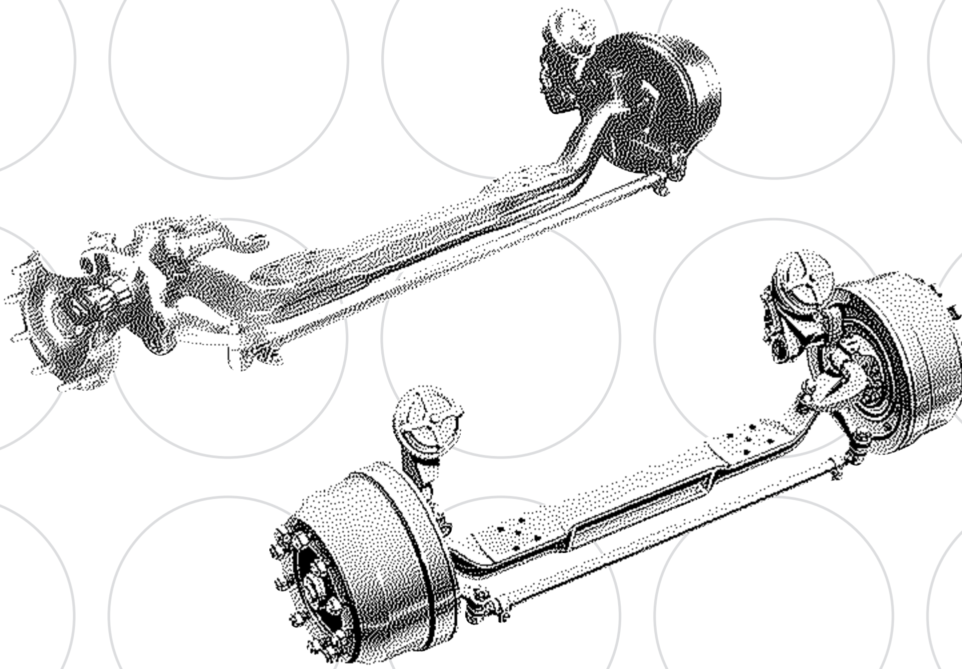
MERITOR®

Maintenance Manual 2

Front Non-Drive Steer Axles

All Meritor Conventional, Easy Steer Plus™ and MFS Series

Revised 10-06



About This Manual

This manual provides maintenance and service information for the Meritor conventional, Easy Steer Plus™ and MFS Series front non-drive steer axles.

Before You Begin

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Hazard Alert Messages and Torque Symbols

⚠ WARNING

A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.

⚠ CAUTION

A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components.

This symbol alerts you to tighten fasteners to a specified torque value.

How to Obtain Additional Maintenance and Service Information

On the Web

Visit Literature on Demand at meritorhvs.com to access product, service, aftermarket, and warranty literature for ArvinMeritor's truck, trailer and specialty vehicle components.

ArvinMeritor's Customer Service Center

Call ArvinMeritor's Customer Service Center at 800-535-5560.

Technical Electronic Library DVD

The DriveTrain Plus™ by ArvinMeritor Technical Electronic Library DVD contains product and service information for most Meritor and Meritor WABCO products. Specify TP-9853.

How to Obtain Tools and Supplies Specified in This Manual

Call ArvinMeritor's Commercial Vehicle Aftermarket at 888-725-9355 to obtain Meritor tools and supplies.

SPX Kent-Moore, 28635 Mound Road, Warren, Michigan, 48092. Call the company's customer service center at 800-345-2233, or visit their website at spxkentmoore.com.

Tiger Tools. Call the company's customer service center at 800-661-4661, or visit their website at tigertool.com.

For Owatonna Tools, contact OTC Tool and Equipment Division, 655 Eisenhower Drive, Owatonna, Minnesota, 55060.

Great Lakes Tool Specialties, 8530 M-89, Richland, Michigan, 49083. Call the company's customer service center at 800-877-9618 or 616-629-9628.

For Snap-On® tools, contact your local Snap-On® dealer.

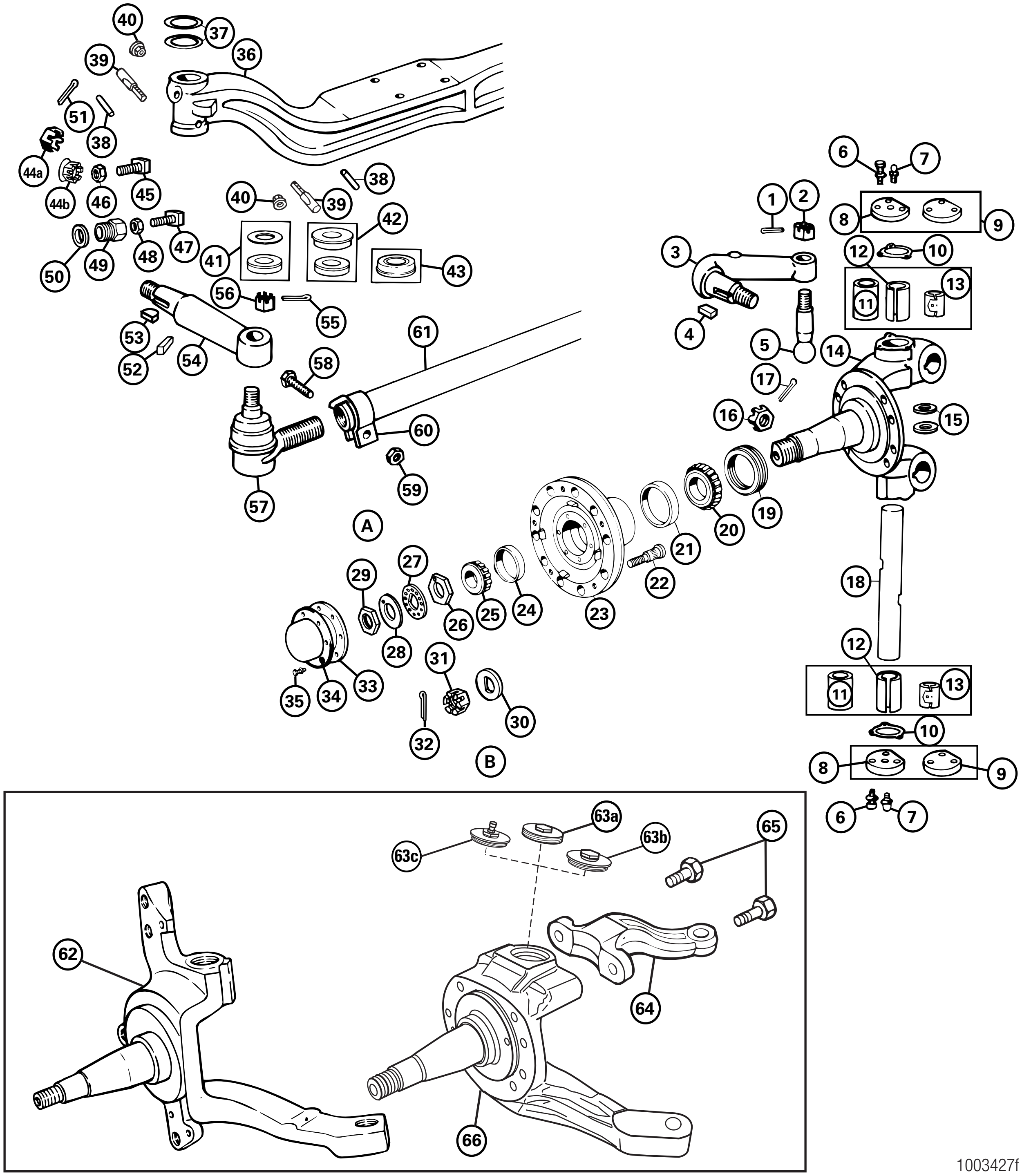
The Technology Maintenance Council (TMC) of the American Trucking Associations

For more information on total vehicle alignment, refer to Recommended Practice RP 642 included in the Recommended Practices Manual published by The Technology Maintenance Council (TMC) of the American Trucking Associations, Inc., 2200 Mill Road, Alexandria, Virginia, 22314. You can contact TMC at 800-838-1763 or visit their website at www.trucking.org.

Contents

Contents

Axle with a Conventional Wheel End



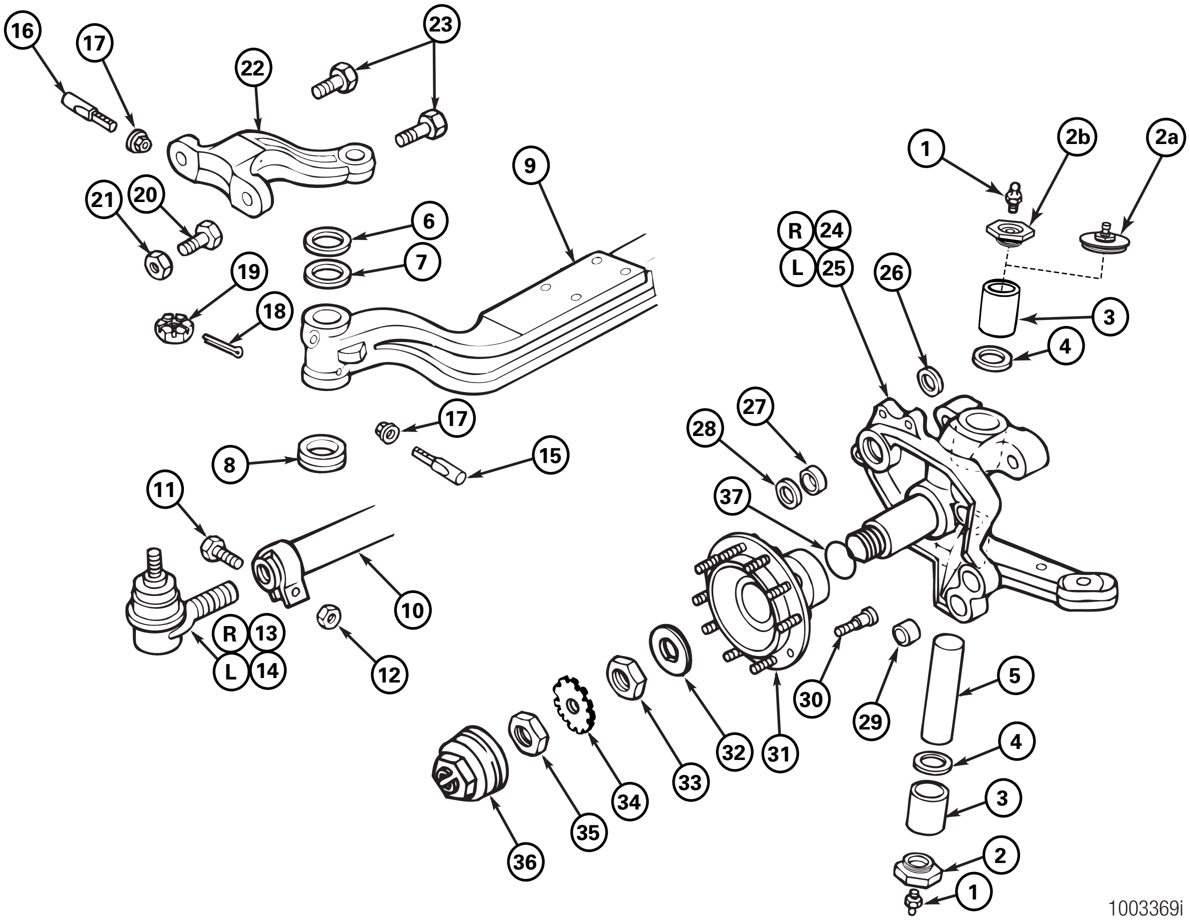
1003427f

1 Exploded Views

Item	Description
A	Double Nut
B	Single Nut
1	Cotter Pin
2	Drag Link-to-Steering Arm Castle Nut
3	Steering Arm
4	Key
5	Ball Stud
6	Capscrew and Washer
7	Grease Fitting
8	Greaseable Knuckle Cap
9	Sealed Knuckle Cap
10	Gasket
11	Easy Steer™ King Pin Bushing
12	Bronze King Pin Bushing
13	Nylon King Pin Bushing
14	Knuckle
15	King Pin Bushing Seal
16	Tie Rod Arm-to-Knuckle Castle Nut
17	Cotter Pin
18	King Pin
19	Hub Grease Seal
20	Inner Wheel Bearing Cone
21	Inner Wheel Bearing Cup
22	Stud
23	Hub
24	Outer Wheel Bearing Cup
25	Outer Wheel Bearing Cone
26	Adjusting Nut
27	Pierced Lock Ring
28	Lock Washer
29	Wheel Bearing Nut
30	“D” Washer
31	Adjusting Nut
32	Cotter Pin
33	Gasket
34	Hubcap

Item	Description
35	Capscrew and Washer
36	Axle Beam
37	Shims
38	Tapered Draw Key
39	Threaded Draw Key
40	Threaded Draw Key Nut
41	Thrust Bearing and Flat-Type Bearing Seal
42	Thrust Bearing and Cover-Type Bearing Seal
43	Integral Thrust Bearing and Oil Seal
44a	Steering Arm-to-Knuckle Castle Nut
44b	Steering Arm-to-Knuckle Castle Nut, Flared Base
45	3/4-Inch Stop Bolt
46	3/4-Inch Jam Nut
47	1/2-Inch Stop Bolt
48	1/2-Inch Jam Nut
49	3/4-Inch Adapter
50	Washer
51	Cotter Pin
52	Square Key
53	Woodruff Key
54	Knuckle Tie Rod Arm
55	Cotter Pin
56	Tie Rod Arm-to-Tie Rod End Castle Nut
57	Tie Rod End
58	Clamp Bolt
59	Clamp Lock Nut
60	Cross Tube Clamp
61	Cross Tube
62	Knuckle with Integral Tie Rod Arm and Torque Plate
63a	Old Style Threaded Knuckle Cap
63b	New Style Threaded Knuckle Cap
63c	Round Threaded Knuckle Cap
64	Bolt-On Steering Arm
65	Steering Arm Capscrew
66	Knuckle with Integral Tie Rod Arm

Axle with a Unitized Wheel End



1 Exploded Views

Item	Description
1	Grease Fitting
2a	New, Round King Pin Cap
2b	Old, Hexagon King Pin Cap
3	King Pin Bushing
4	King Pin Seal
5	King Pin
6	0.10-Inch Shim
7	0.05-Inch Shim
8	Thrust Bearing and Seal Assembly
9	Axle Center Beam
10	Cross Tube Assembly
11	Cross Tube Clamp Bolt
12	Cross Tube Nut, Right-Hand
13	Cross Tube End, Right-Hand
14	Cross Tube End, Left-Hand
15	Lower Draw Key
16	Upper Draw Key
17	Draw Key Nut
18	Tie Rod End Nut Cotter Pin
19	Cross Tube End Nut
20	Stop Screw
21	Stop Nut
22	Steering Arm
23	Steering Arm Capscrew
24	Knuckle and Tie Rod Assembly, Right-Hand
25	Knuckle and Tie Rod Assembly, Left-Hand
26	O-Ring
27	Bushing
28	Grease Seal Assembly
29	Bushing
30	Wheel Stud
31	Unitized Wheel End
32	Flat Thick Washer
33	Wheel Bearing Nut

Item	Description
34	Star/Lock Washer
35	Wheel Bearing Nut
36a	Threaded Hubcap
36b	Snap-Ring Hubcap
37	Spindle O-Ring

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Description

The descriptions and procedures contained in this maintenance manual are applicable to all Meritor front non-drive steer axles.

Meritor front non-drive steer axles in this manual feature the following components. Figure 2.1 and Figure 2.2.

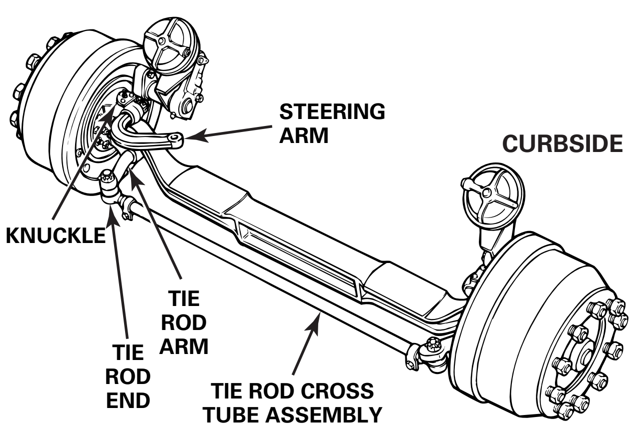


Figure 2.1

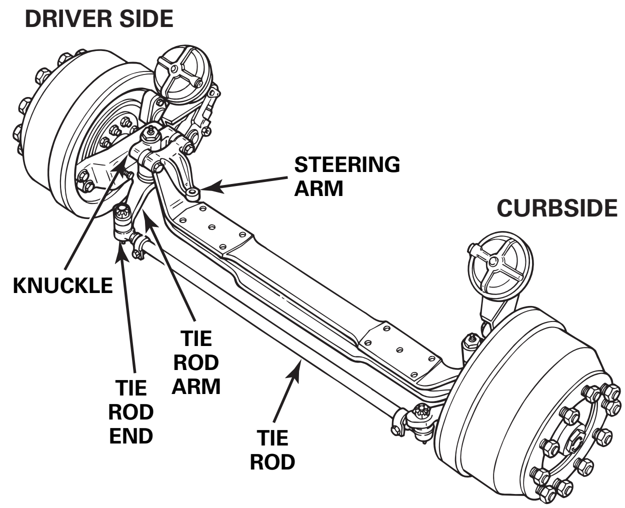


Figure 2.2

Tie Rod Arm, Knuckle and King Pin

The right tie rod arm is a mirror image of the left, and they are linked by the cross tube assembly. An integral tie rod design is used on Easy Steer Plus™ and MFS axles.

The right knuckle and king pin assembly is similar to the left, except that it does not have a steering arm attached to it as in a manual steering system.

A power steering system requires a steering arm in various applications for attachment of the auxiliary assist cylinder to the right knuckle.

Steering Knuckle

Steering knuckles are rated according to the capacity of the front axle. All models use straight king pins. Three types of king pin bushings are used: nylon, bronze and Easy Steer™.

The brake spider has been combined into the knuckle of the Easy Steer Plus™ axle.

Steering Arms

The steering arm, usually a forged component, converts the drag link force into a turning movement through the left king pin and the knuckle. Bolt-on steering arms are used on Easy Steer Plus™ and MFS axles.

Pitman Arm

The Pitman arm converts the output torque from the steering gear into the control force applied to the drag link. This linkage component connects the steering gear to the linkage at the center link end.

Unitized Wheel End

NOTE: A unitized wheel end has no user-serviceable parts. Figure 2.2.

Unitized wheel ends are enclosed units with bearings lubricated for the life of the entire component. This is an alternative to conventional wheel ends. Refer to Table A for a list of Meritor axle models equipped with unitized wheel ends.

Table A: Meritor Axle Models Equipped with Unitized Wheel Ends

MFS-10-143D-N	MFS-13-153D-N	FF-983
MFS-10-144D-N	MFS-13-144D-N	FF-984
MFS-12-122D-N	FF-981	FF-986
MFS-12-143D-N	FF-982	FF-987
MFS-12-144D-N		

A unitized wheel end has "half moons" embossed on the center of the hubcap. Figure 2.3.

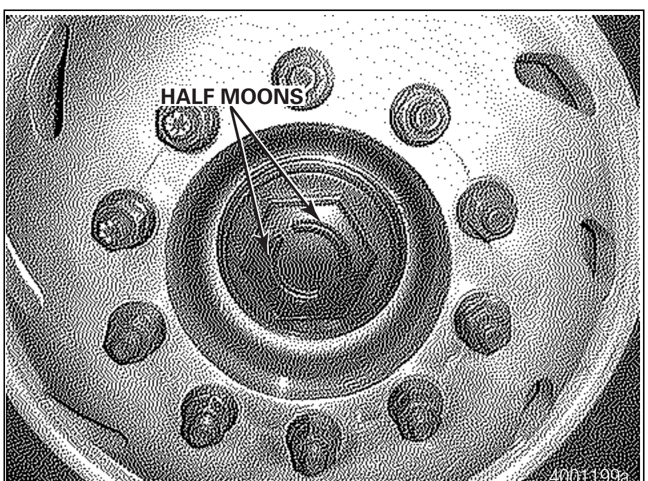


Figure 2.3

If the hubcaps are missing, you can use the axle model number to determine if the axle is equipped with unitized wheel ends. To identify the model number, refer to the axle identification plate on the front of the beam. Figure 2.5.

A unitized wheel end also has been referred to as a truck hub unit, Easy Steer Plus™ and a unitized hub.

Tie Rod Assembly

Forged or cast tie rod assemblies are used on Meritor front non-drive steer axles. The tie rod assembly links both steering knuckles for uniform movement and maintains steering control.

Cross Tube and Clamp Assembly

The cross tube and clamp assembly runs approximately parallel to the front axle. The cross tube has right-hand and left-hand threads on the appropriate side of the vehicle. Tie rod clamps secure the tie rod ends into the cross tube.

Tie Rod Ends

The tie rod ends include a ball joint and boot which thread into the cross tube. Depending on the manufacturer's design, tie rod ends can be greaseable or non-greaseable.

Tie rod ends are either right-hand or left-hand threaded and correspond to the inside threads at each end of the cross tube. Figure 2.4.

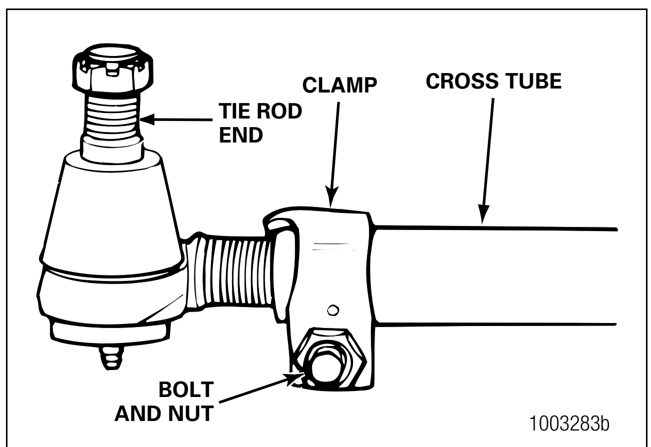


Figure 2.4

Identification

The axle build information and assembly date for Meritor front non-drive steer axles is on the axle identification tag. Figure 2.5.

The identification tag is fastened to the center of the beam at the front surface. The axle assembly date is located in either the lower right-hand or left-hand corner of the tag.

The Julian method is used to indicate the axle assembly date and is shown in Figure 2.5. The first two digits indicate the year, and the last three digits indicate the day of the year.

In the following example, 01 is the year 2001 and 327 refers to November 22.

To identify the model number, refer to the identification plate on the front of the beam. Use the complete model number to obtain parts.

Refer to Figure 2.6 for an explanation of non-MFS model numbers. Refer to Figure 2.7 for an explanation of MFS model numbers.

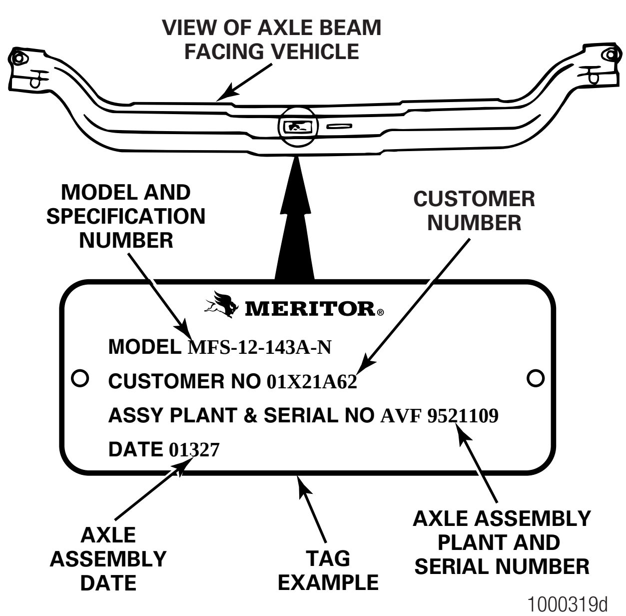


Figure 2.5

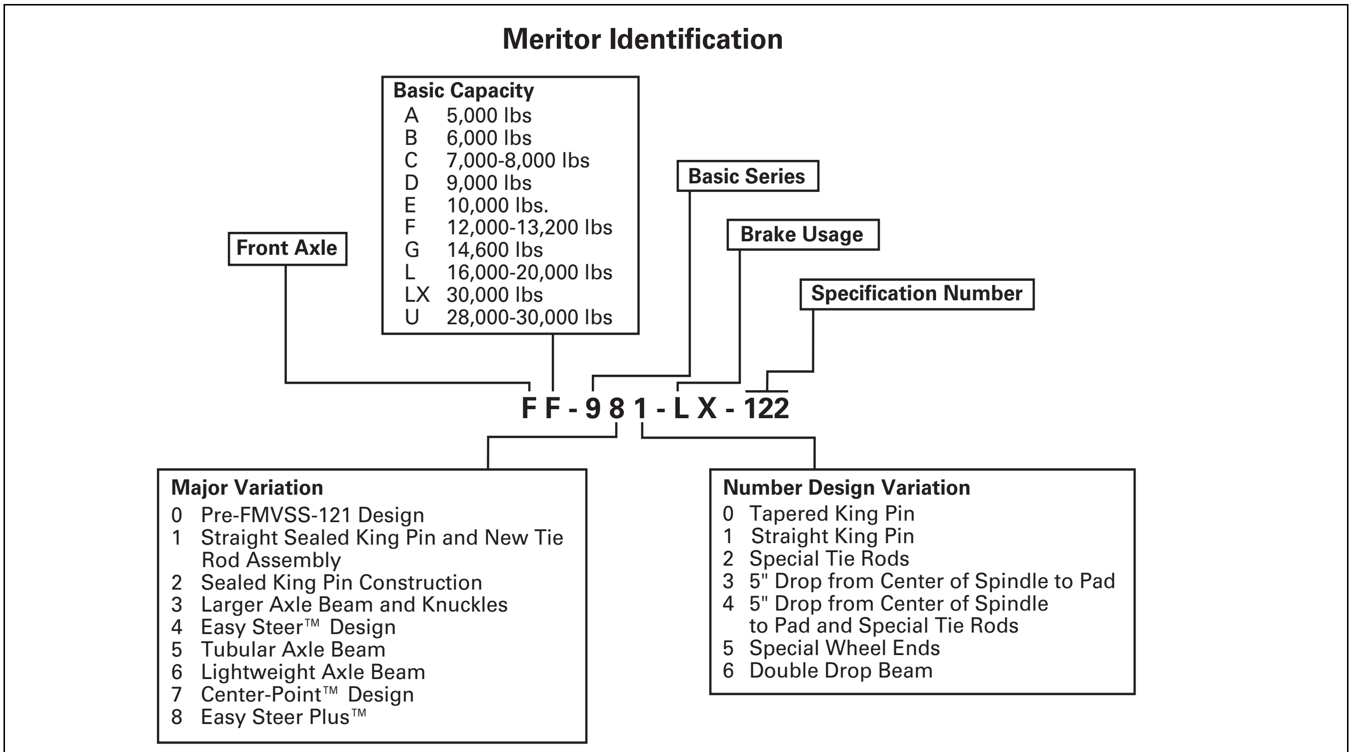


Figure 2.6

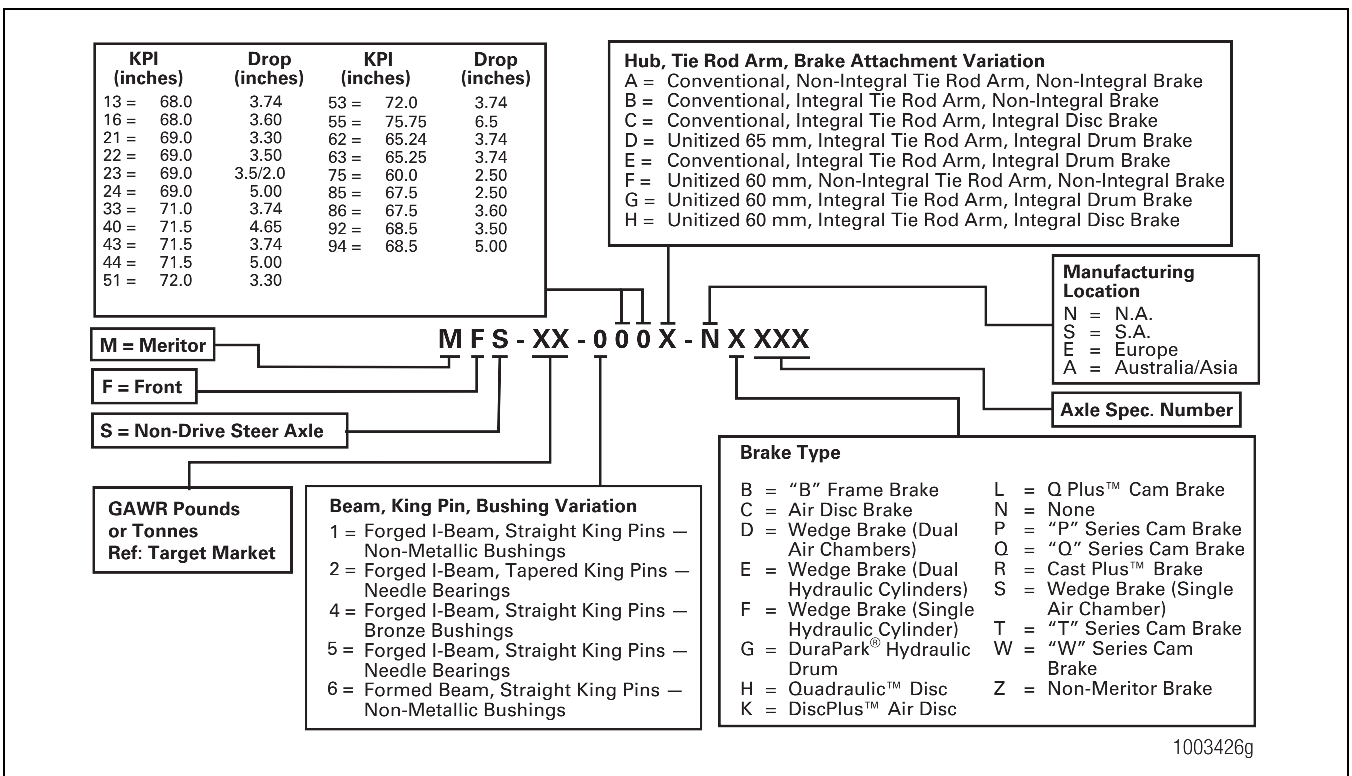


Figure 2.7

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Replace damaged or out-of-specification axle components. Do not bend, repair or recondition axle components by welding or heat-treating. A bent axle beam reduces axle strength, affects vehicle operation and voids Meritor's warranty. Serious personal injury and damage to components can result.

Before inspecting axle components, verify that the correct tools are available. Using the correct tools will ensure safety and provide the most accurate results.

- Dial indicator
- Tire blocks
- Jack
- Safety stands
- Pry bar
- Torque wrench

Inspection

Incompatibility of Wheel Separator Plates and Unitized Wheel Ends

Meritor has determined that wheel separator plates are incompatible with the SKF Phase IV unitized wheel end on some front axle assemblies. Vehicles with wheel mounting flanges of 0.437-inch (11.1 mm) or less and brake drum mounting flanges of 0.25-inch (6.4 mm) or less assembled between September 1996 and March 1998 are affected.

Meritor has determined that the use of plates in the above combination, and time frame, potentially reduces the service life of the hub, which could result in an SKF hub flange fracture. If a hub flange fractures, vehicle control, braking and stability are affected, and the wheel may separate from the vehicle.

Meritor has further determined that vehicles equipped with other wheel-end configurations not defined above, are not affected by the use of wheel separator plates if correctly installed and maintained. Also, Meritor has determined that FF-980 Series front axle assemblies installed into vehicles after April 1998 can be used with any wheel-end configuration and wheel separator plates, when correctly installed and maintained.

A wheel separator plate is a 0.040-inch (1.016 mm) plastic spacer, which some vehicle users install between the wheel and the brake drum onto front axle assemblies.

Wheel separator plates are intended to protect the wheels from corrosion and fretting fatigue.

Recommendation

Meritor believes that the wheel attachment clamp joint must be carefully maintained with:

- Correct hardware.
- Clean, flat, uncontaminated mounting surfaces.
- Correct nut torquing and retorquing practices.

Meritor believes that installing a wheel separator plate may make it more difficult to ensure correct wheel clamp with use over time. Refer to the wheel separator plate manufacturer's recommended wheel stud nut torque maintenance practices.

Meritor further believes that the use of more than one wheel separator plate in a wheel end is inappropriate and that a wheel separator plate should never be installed between the hub and the drum. This practice is expressly prohibited with Meritor axle models MFS-12, FF-981, FF-982, FF-983, FF-984, FF-986 and FF-987.

Therefore, Meritor recommends that vehicle owners who install and use wheel separator plates should also increase the frequency of their wheel-end maintenance, consistent with wheel separator plate manufacturer's recommended practices, so they are confident that the intended wheel attachment clamp integrity is maintained.

In addition, Meritor recommends that the users of wheel separator plates should contact the wheel separator plate manufacturers to obtain recommendations and approval for any special application or more demanding environments (i.e., use at elevated temperature ranges or frequent stop-start cycling) which may also potentially affect the integrity of the wheel attachment system.

Inspect Parts

Fasteners

1. Verify that all fasteners are tightened to the specified torque.
2. Use a torque wrench to check the torque. As soon as the fastener starts to move, record the torque. Correct if necessary.
3. Replace any worn or damaged fasteners.

Wear and Damage

Inspect the parts of the axle for wear and damage. Look for bent or cracked parts. Replace all worn or damaged parts.

Pivot Points

Verify that pivot points are not loose. Verify that the pivot points are lubricated.

Operation

Verify that all the parts move smoothly through the complete turning radius.

Tire Wear

Inspect the tires for wear patterns that indicate suspension damage or misalignment. Correct if necessary.

Steering Arm Bolts

Check the torque on all bolt-on steering arm bolts every 200,000 miles (320 000 km). Refer to Section 9.

Draw Key Nuts

On axles with either conventional or unitized wheel ends, tighten the draw key nuts to 30-45 lb-ft (41-61 N•m) at the following intervals. Figure 3.1.

- After the first 6,000 miles (10 000 km) of new vehicle operation
- Every 36,000 miles (58 000 km) of operation

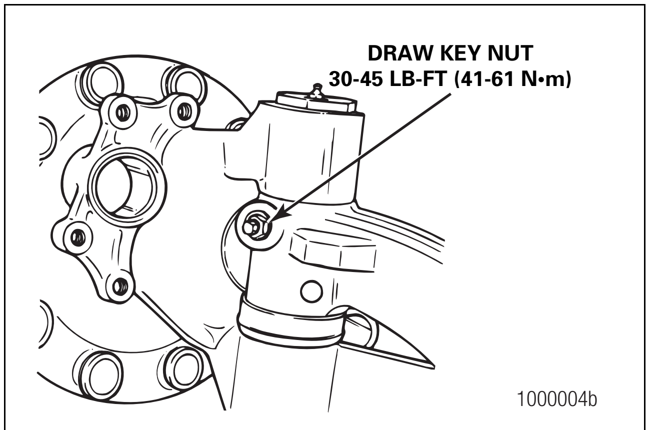


Figure 3.1

Steering Knuckle Vertical End Play

Table B: End Play Specifications

New or Rebuilt Axles	0.001-0.010-inch (0.025-0.254 mm)
In-Service Axles	0.001-0.030-inch (0.025-0.762 mm)

Axles with Conventional Wheel Ends

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Set the parking brake.
2. Use a jack to raise the vehicle until the front wheels are off the ground. Support the front axle with safety stands.
3. Install a dial indicator with the base on the I-beam and the tip on the top knuckle cap. Figure 3.2.

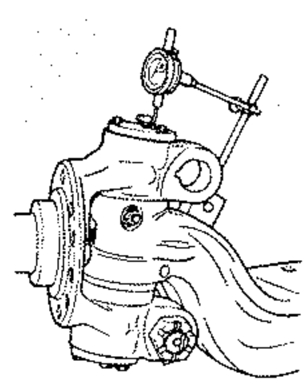


Figure 3.2

4. Place a pry bar between the boss for the tie rod arm and the I-beam. Push the knuckle to the BOTTOM of vertical travel. Figure 3.3.

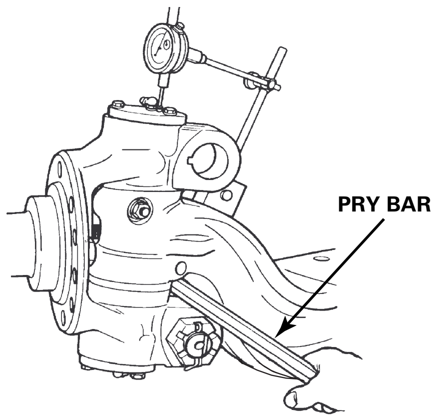


Figure 3.3

5. Set the dial indicator on ZERO.
6. Use the pry bar to push the knuckle UPWARD. Record the reading on the dial indicator.
   - **If the reading is ZERO:** Remove the knuckle. Refer to Section 4. Remove the shims from the shim pack. Refer to Section 6.
   - **If the reading is more than the correct end play specifications in Table B:** Remove the knuckle. Refer to Section 4. Add shims to the shim pack. Refer to Section 6.

Axles with Unitized Wheel Ends

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Set the parking brake.
2. Use a jack to raise the vehicle until the front wheels are off the ground. Support the front axle with safety stands.
3. Turn the wheels STRAIGHT ahead.
4. Install a dial indicator for each side of the axle beam.
   - **For a curbside knuckle:** Install a dial indicator with the base on the axle beam. Place the dial indicator tip onto the upper king pin cap.
   - **For a driver side knuckle:** Remove the king pin cap. Install a dial indicator with the base on the steering arm. Place the dial indicator tip onto the exposed king pin top.
5. Set the dial indicator to ZERO.
6. Raise the jack until you start to lift the axle beam off the safety stands. Measure and record the dial indicator reading.
7. Lower the jack.
8. Place a jack and a wood block, with a hole that allows clearance for the lower king pin grease fitting, under the lower king pin cap area. Figure 3.4.

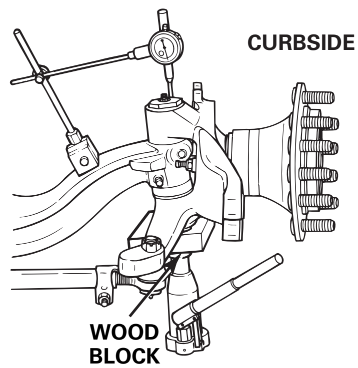


Figure 3.4

9. Compare the reading you obtained with the correct end play specifications in Table B.
   - **If the reading is ZERO:** Remove the knuckle. Refer to Section 4. Remove shims from the shim pack. Refer to Section 6.
   - **If the reading is more than the correct end play specifications:** Remove the knuckle. Refer to Section 4. Add shims to the shim pack. Refer to Section 6.

Alternate Method to Measure End Play on Axles with Unitized Wheel Ends

1. Turn the wheels to the RIGHT for a curbside knuckle or LEFT for a driver-side knuckle measurement.
2. Place a pry bar between the tie rod arm and the axle beam. Figure 3.5.

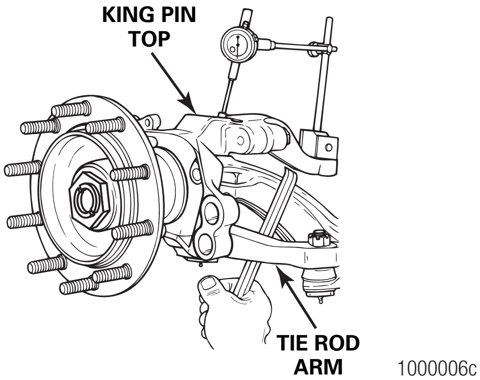


Figure 3.5

3. Set the dial indicator to ZERO.
4. Lift the knuckle UPWARD using a pry bar. Record the reading on the dial indicator.
5. Compare the reading you obtained with the correct end play specifications in Table B.
   - **If the reading is ZERO:** Remove the knuckle. Refer to Section 4. Remove shims from the shim pack. Refer to Section 6.
   - **If the reading is more than the correct end play specifications:** Remove the knuckle. Refer to Section 4. Add shims to the shim pack. Refer to Section 6.

Upper and Lower King Pin Bushings

Wheel-to-Hub Mounting

To help determine the cause of movement and looseness, first check the wheel-to-hub mounting.

1. Verify that the wheel is mounted correctly and all wheel-end fasteners and hardware are tightened to the correct specification.
2. Apply the service brake to lock the hub and spindle together.
   - **If movement is detected:** The king pin or king pin bushings should be inspected. Refer to the procedure below.
   - **If applying the service brake eliminates the movement:** Proceed to Unitized Wheel Ends, Detailed Inspection in this section to determine the unitized wheel-end hub end play.

Axles with Conventional and Unitized Wheel Ends

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Set the parking brake.
2. Use a jack to raise the vehicle until the wheels are off the ground. Support the vehicle with safety stands.
3. Check the upper king pin bushing for wear. Install a dial indicator with the base on the I-beam and the tip against the side of the top of the knuckle. Figure 3.6 and Figure 3.7.

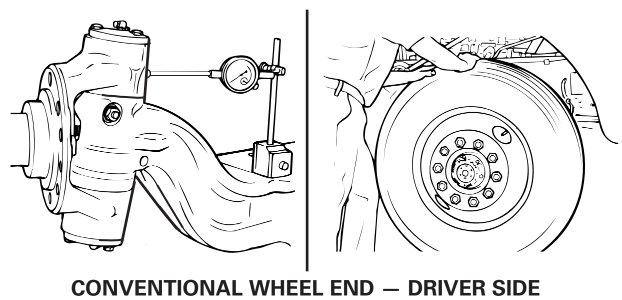


Figure 3.6

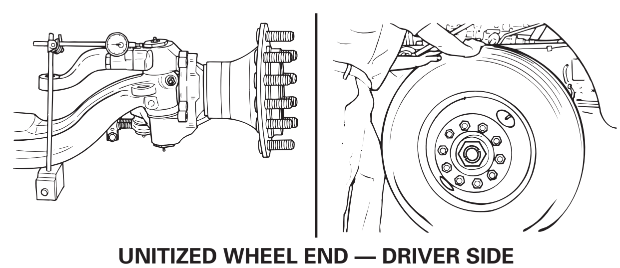
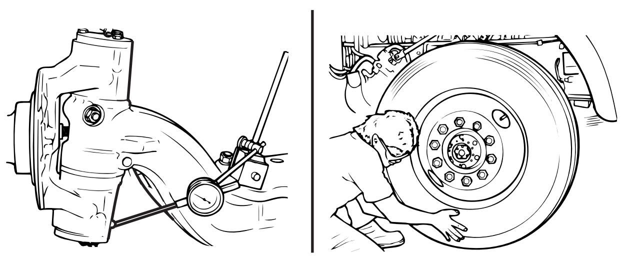


Figure 3.7

4. Set the dial indicator to ZERO.
5. Move the top of the tire side-to-side TOWARD and AWAY from the vehicle.
   - **If the dial indicator moves a total of 0.010-inch (0.254 mm):** The upper bushing is worn or damaged. Replace both bushings in the knuckle. Refer to Section 4, Section 5 and Section 6. Figure 3.6 and Figure 3.7.

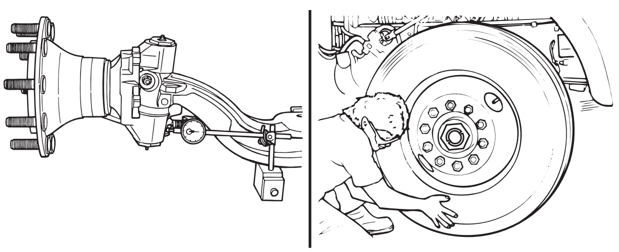
6. Check the lower king pin bushing. Install a dial indicator so that the base is on the I-beam and that the tip is against the side of the bottom of the knuckle. Figure 3.8 and Figure 3.9.



CONVENTIONAL WHEEL END — FRONT VIEW CURBSIDE

1000324d

Figure 3.8



UNITIZED WHEEL END — FRONT VIEW CURBSIDE

1000008e

Figure 3.9

7. Set the dial indicator to ZERO.
8. Move the bottom of the tire side-to-side TOWARD and AWAY from the vehicle.
   - **If the dial indicator moves a total of 0.010-inch (0.254 mm):** The lower bushing is worn or damaged. Replace both bushings in the knuckle. Refer to Section 4, Section 5 and Section 6. Figure 3.8 and Figure 3.9.

Unitized Wheel Ends

⚠ WARNING

You must follow the unitized wheel-end maintenance and inspection procedures provided in this manual to prevent serious personal injury and damage to components.

The unitized wheel end is sealed and greased for life and does not require lubrication. If you disassemble, or attempt to repair or lubricate a unitized wheel-end assembly, you will void the Meritor warranty. The inspection procedures provided in this manual do not instruct you to disassemble the unitized wheel end.

- Unitized wheel ends are not adjustable.
- Do not attempt to set or adjust end play.

Axles with Unitized Wheel-End Hubs and Assembly Dates of July 1, 2000 to May 8, 2002

Vehicles built between July 1, 2000, and May 8, 2002 may be equipped with wheel-end seals that allow contaminants to enter the hub and wheel bearings. Contaminated wheel bearings will damage the hub and spindle.

Check the vehicle's identification decal located on the driver-side door jamb to determine if the vehicle was built between 7-1-00 and 5-8-02. If the vehicle was built during this time period, also check the axle identification plate on the front of the beam to determine the axle model and axle assembly date, which is shown as a Julian date. Refer to Section 2.

You must increase the frequency of inspection intervals on unitized wheel ends with assembly dates of 00182 to 02098 to identify contaminated hubs. Refer to the inspection procedures in this section. The inspection frequency for axles with assembly dates of 00182 to 02098 has been increased to include a Basic Inspection performed as part of the fleet's normal preventive maintenance schedule, or not to exceed 50,000 miles (80 467 km). Disregard original inspection intervals specified in this manual and begin with this more frequent schedule for vehicles assembled within the above time period.

NOTE: This more frequent inspection schedule differs from the usual recommendation, which begins Basic Inspections at maximum 50,000-mile (80 467 km) intervals only after the initial Detailed Inspection has been performed at 200,000 miles (321 800 km).

Wheel-to-Hub Mounting

To help determine the cause of movement and looseness, first check the wheel-to-hub mounting.

1. Verify that the wheel is mounted correctly and all wheel-end fasteners and hardware are tightened to the correct specification.
2. Apply the service brake to lock the hub and spindle together.
   - **If you detect movement or looseness:** The king pin or king pin bushings should be inspected. Refer to procedure in this section.
   - **If applying the service brake eliminates movement or looseness:** Proceed to Detailed Inspection to determine the unitized wheel-end hub end play.

If the Vehicle is Equipped with ABS on the Steer Axle

In addition to scheduled preventive maintenance, if driver reports indicate the ABS light has been coming ON, and ABS diagnostics indicate the sensor gap is out-of-adjustment, check for possible wheel-end looseness as the cause.

Basic Inspection

After the initial 200,000-mile (321 800 km) detailed inspection, perform a basic inspection at each scheduled preventive maintenance interval, not to exceed 50,000-mile (80 467 km) intervals.

1. Park the vehicle on a level surface. Block the rear wheels to prevent the vehicle from moving.
2. Raise the vehicle so that the front wheels are off the ground. Support the vehicle with safety stands. Do not use a jack to support the vehicle.

   NOTE: If a ticking sound is detected during rotation, this does not indicate a hub problem. It is a normal occurrence.

3. Visually inspect the unitized wheel end as you rotate the tire and unitized wheel-end assembly. Verify that it rotates smoothly and without noise. While rotating the wheel, grasp the brake chamber to feel for unitized wheel-end hub vibration.
   - **If the tire and unitized wheel end assembly does not rotate smoothly, or you hear noise (such as wheel bearing grind) or feel wheel-end hub vibration during rotation:** Perform a detailed inspection. Refer to Detailed Inspection in this section.
   - **If the wheel end rotates smoothly:** Proceed to Step 4.
4. Grasp the tire and wheel-end assembly at the nine and three o'clock positions. Check for vertical and horizontal movement. With your hands, apply approximately 50 lb (23 kg) of force to the assembly. You should not feel or see any looseness or movement.
   - **If you feel or see any movement or looseness in the tire and wheel-end assembly:** Perform a detailed inspection to determine the cause of the movement, such as worn king pin bushings or pins; wheel-to-hub-mounting end play; unitized wheel-end hub end play; or a combination of them all. To determine unitized wheel-end hub end play, refer to Detailed Inspection in this section.

     If other front axle components, such as king pin bushings, require inspection or service, refer to the appropriate procedures in this manual.

Detailed Inspection

Perform detailed inspections after the initial 200,000 miles (321 800 km) of operation and after every additional 200,000 miles (321 800 km) of operation thereafter.

1. Park the vehicle on a level surface. Block the rear wheels to prevent the vehicle from moving.
2. Remove the hubcap.
3. Raise the vehicle so that the front wheels are off the ground. Support the vehicle with safety stands. Do not use a jack to support the vehicle.

   NOTE: The outboard and inboard seals may purge small amounts of grease that are visible during inspection. Figure 3.10. This is a normal occurrence.

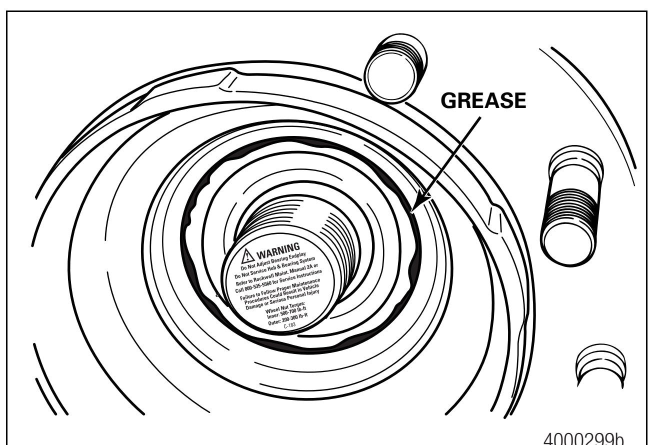


Figure 3.10

4. Remove the wheel and drum. Attach the magnetic base of a dial indicator onto the end of the spindle. Figure 3.11. Touch the indicator stem perpendicular against the unitized wheel-end mounting face.

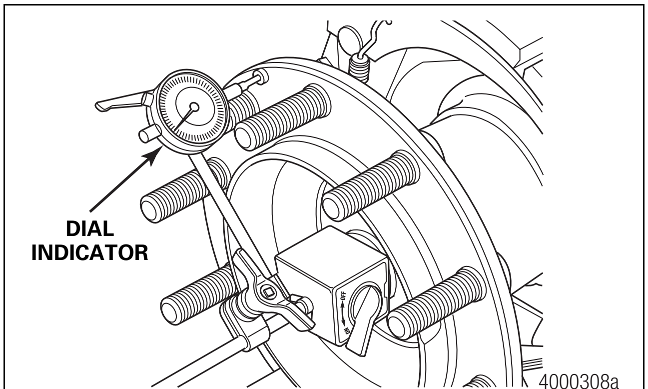


Figure 3.11

5. Set the dial indicator to ZERO. Do not rotate the wheel end. Place your hands at the nine and three o'clock positions.
6. Push the unitized wheel end straight IN. Note the reading. Pull the unitized wheel end straight OUT. Note the reading.
   - **If the total movement of the dial indicator is less than 0.003-inch (0.08 mm):** The inspection is complete. No adjustment is required.
   - **If the total movement of the dial indicator is 0.003-inch (0.08 mm) or greater:** Remove the outer bearing nut and tabbed washer. Tighten the inner wheel bearing nut to 500-700 lb-ft (679-949 N•m) while rotating the unitized wheel end a minimum of five rotations. Figure 3.12.

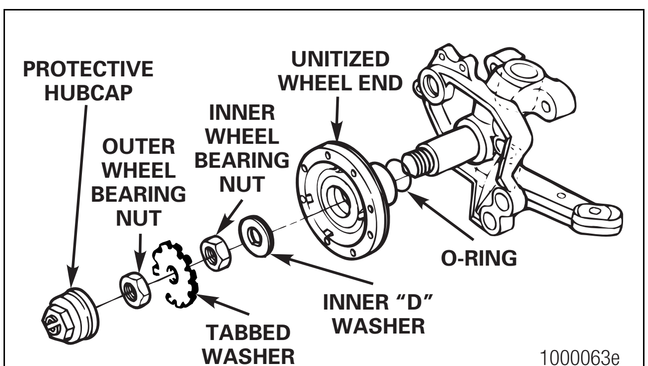


Figure 3.12

7. Install the tabbed washer and outer wheel bearing nut onto the spindle. Tighten the outer wheel bearing nut to 200-300 lb-ft (271-476 N•m).

   NOTE: The inner wheel bearing nut and the outer wheel bearing nut are identical, but the torque values are different.

8. Reattach the dial indicator. Set the dial indicator to ZERO. Do not rotate the wheel end. Place your hands at the nine and three o'clock positions.
9. Push the unitized wheel end straight IN. Note the reading. Pull the unitized wheel end straight OUT. Note the reading.
   - **If the total movement of the dial indicator is greater than 0.003-inch (0.08 mm) but less than 0.006-inch (0.15 mm):** Record the measurement in a maintenance log, and perform a basic inspection at the next regularly-scheduled maintenance interval, or not to exceed 50,000 miles (80 467 km), whichever comes first.
   - **If the total movement of the dial indicator is 0.006-inch (0.15 mm) or greater:** Replace the unitized wheel-end hub. You must inspect a replacement hub before you install it. Refer to Replacement Hub Inspection in this section.
10. After you've taken the measurement, bend the parts of the tabbed washer that protrude over the flats of the outer wheel bearing nut and the inner wheel bearing nut. Bend the washer a minimum of one flat edge to each nut.

    NOTE: If a ticking sound is detected during rotation, this does not indicate a hub problem. It is a normal occurrence.

11. Verify that the unitized wheel end rotates smoothly and without noise. While rotating the wheel, grasp the brake chamber to feel for unitized wheel-end hub vibration.
    - **If the tire and unitized wheel-end assembly does not rotate smoothly, or you hear noise (such as wheel bearing grind) or feel wheel-end hub vibration during rotation:** Replace the unitized wheel-end hub. You must inspect a replacement hub before you install it. Refer to Replacement Hub Inspection in this section.
    - **If the wheel end rotates smoothly:** The inspection is complete. Reinstall the wheel-end equipment. Return the vehicle to service.

Inspection with an Optional Meritor Hub Bearing Analyzer Kit

After the initial 200,000-mile (321 800 km) inspection, perform the inspection at each scheduled preventive maintenance interval, not to exceed 50,000-mile (80 467 km) intervals.

The Meritor hub bearing analyzer kit, TP0306K, is available from Archway Marketing Services. To obtain this kit, call 248-435-8689, send a fax to 248-435-1495 or send an e-mail to arvinmeritororders@archway.com.

The following tools are required for the hub bearing analyzer inspection.

- A jack, wheel blocks and safety stands
- A torque wrench with 700 lb-ft (949 N•m) capability

The Meritor Hub Bearing Analyzer kit contains the following tools.

- Digital tachometer, Shimpo or equivalent
- Reflective tape
- Hand crank
- Tripod stand
- Hub bearing analyzer, SKF SecuriCheck™

The SKF SecuriCheck™ hub bearing analyzer is a hand-held inspection tool for checking wheel bearings. Figure 3.13. The analyzer collects and processes vibration data. The on/off button toggles the analyzer on and off. When toggled on, a five-minute timer starts. If no buttons are pressed within five minutes, the analyzer automatically turns itself off. The battery low indicator on the analyzer LCD display illuminates when battery power is low. When the indicator illuminates, immediately replace or recharge both AA batteries. If the analyzer's internal sensor is overloaded, the LED on the remote unit will show an orange light, or no light.

If this occurs, wait for the LED to turn green, which indicates that the sensor is no longer overloaded. The up/down arrow buttons are used to change operating modes. Operate the analyzer in the remote data collection mode.

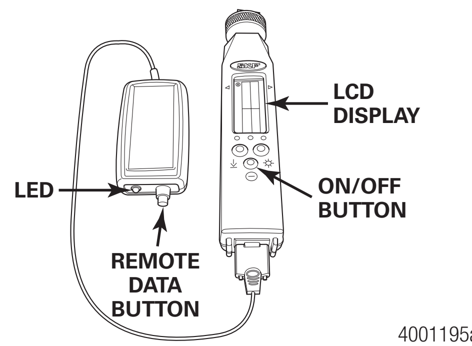


Figure 3.13

1. Park the vehicle on a level surface. Block the rear wheels to prevent the vehicle from moving.
2. Raise the vehicle so that the front wheels are off the ground. Support the vehicle with safety stands. Do not use a jack to support the vehicle. Position the safety stands to allow steering lock-to-lock movement.
3. At the initial 200,000-mile (321 800 km) inspection only, check the torque on the two wheel nuts (50,000-mile [80 467 km] interval inspections do not require a wheel-end nut torque check).

   A. Remove the hubcap.

   NOTE: The outboard and inboard seals may purge small amounts of grease that are visible during inspection. Figure 3.10. This is a normal occurrence.

   B. Remove the outer bearing nut and tabbed washer. Tighten the inner wheel bearing nut to 500-700 lb-ft (679-949 N•m) while rotating the unitized wheel end a minimum of five rotations. Figure 3.12.

   C. Install the tabbed washer and outer wheel bearing nut onto the spindle. Tighten the outer wheel bearing nut to 200-300 lb-ft (271-476 N•m).

   D. Bend the parts of the tabbed washer that protrude over the flats of the outer wheel bearing nut and the inner wheel bearing nut. Bend the washer a minimum of one flat edge to each nut. Install the hubcap.

4. Grasp the tire and wheel-end assembly at the nine and three o'clock positions. Check for vertical and horizontal movement. With your hands, apply approximately 50 lb (23 kg) of force to the assembly. You should not feel or see any looseness or movement.

   If you feel or see any movement or looseness in the tire and wheel-end assembly, follow the procedure below to determine the cause.

   A. Check the wheel-to-hub mounting. Verify that the wheel is mounted correctly and all wheel-end fasteners and hardware are tightened to the correct specification.

   B. Apply the service brake to lock the hub and spindle together.

      - **If you detect looseness or movement:** The king pin or king pin bushings should be inspected. Refer to procedure in this section.
      - **If applying the service brake eliminates looseness or movement:** Proceed to Step 5.

5. Turn the tire to provide access to the king pin cap. Remove one wheel stud nut and use a wrench to install the hand crank, included in the kit, onto the wheel stud. Figure 3.14.

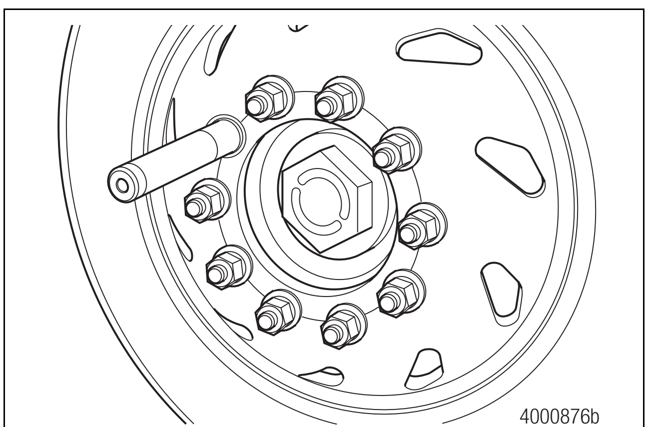


Figure 3.14

6. Position the tripod and digital tachometer to read the tape as the tire turns. Locate the tape position with the red light by pressing and holding the side switch on the digital tachometer. Apply reflective tape to the tire. Figure 3.15.

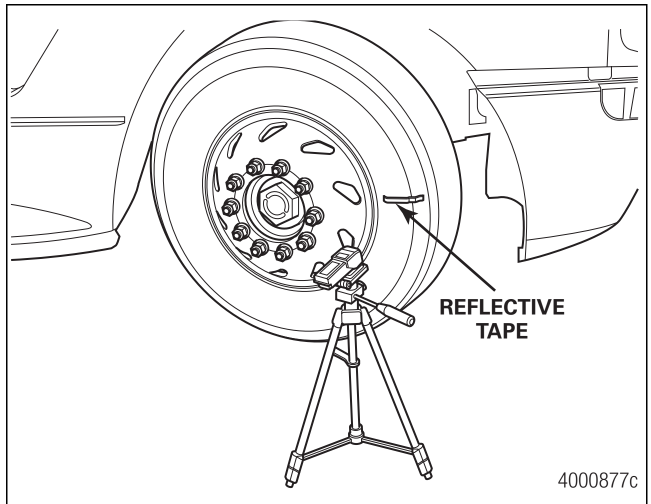


Figure 3.15

7. Use a rag and wire brush to clean the king pin cap. Attach the magnetic base of the hub bearing analyzer to the king pin cap. Position the analyzer so that both magnets are on the cap. Figure 3.16.

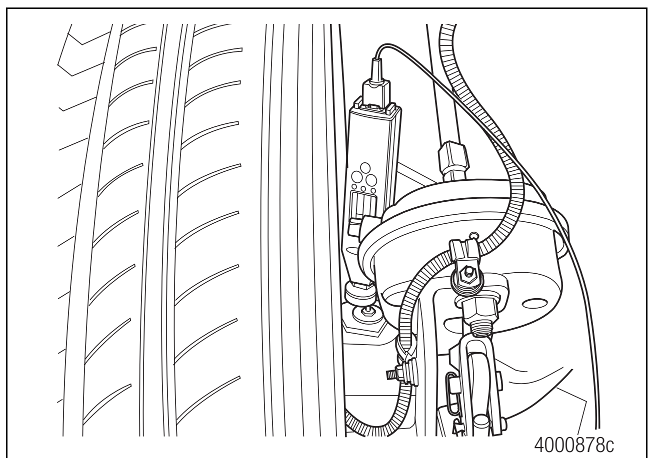


Figure 3.16

8. Turn on the hub bearing analyzer. A green light will illuminate on the tool. Operate the analyzer in remote data collection mode. Figure 3.13.

9. Position the remote control with the cable routed on a rubber hood mount. The remote control cable must not be affected by floor vibrations, vehicle component vibrations or tire movement.

10. Use the hand crank to rotate the wheel and tire assembly CLOCKWISE between 80 and 82 rpm. Figure 3.17.

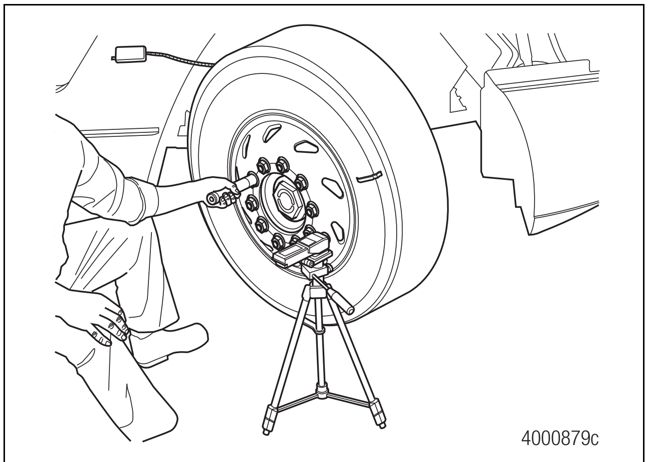


Figure 3.17

11. When the digital tachometer reads 80 rpm, release the hand crank and push the button on the hub bearing analyzer remote control. Figure 3.18.

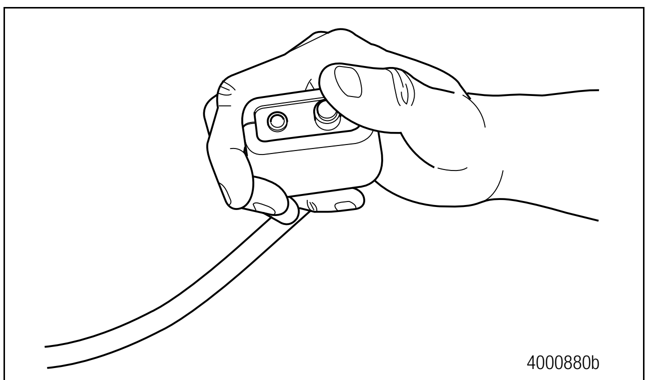


Figure 3.18

- **If the light is green:** The unitized wheel-end hub is good.
- **If the light is red:** Repeat the test after verifying the following conditions.
  - — The brakes are backed-off.
  - — The king pin cap and analyzer magnets are clean.
  - — The cable is not pinched or rubbing.
  - — There is no vehicle component, such as hood, movement during remote triggering.
  - — Actuation of remote control is smooth, not jerky.
  - — Wheel RPM is between 80-82.
  - — Wheel balancing devices are not causing a vibration.
  - — The king pin is thoroughly greased to dampen vibration.

- **If the light is red:** Replace the unitized wheel-end hub. You must inspect a new hub before you install it. Refer to Replacement Hub Inspection in this section.
- **If the light is green:** The unitized wheel-end hub is good.

Replacement Hub Inspection

1. Remove the replacement hub from the box and place it onto a clean surface.
2. Examine the interior of the hub to verify the following.
   - A. The inner clip ring has not become dislodged in shipment and is in correct alignment with the inner and outer bearings. The gap between the inner and outer bearing sets and the clip ring must be equal. Figure 3.19.
   - B. The gap between the ends of the clip ring must be equal and not exceed 0.25-inch (6 mm). If necessary, adjust by hand. Figure 3.19.
   - C. The bearing face must be clean with no seal coating, dirt or dust.

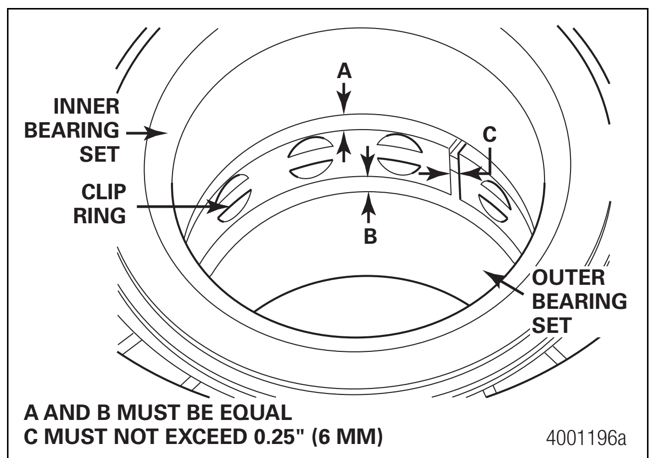


Figure 3.19

3. Examine the exterior of the hub to verify the following.
   A. There is no visible damage to the inboard or outboard seals and the bearings have not become unseated. Figure 3.20 and Figure 3.21.
   B. The tone ring teeth are not damaged and there are no broken or missing teeth on the tone ring. Figure 3.21.

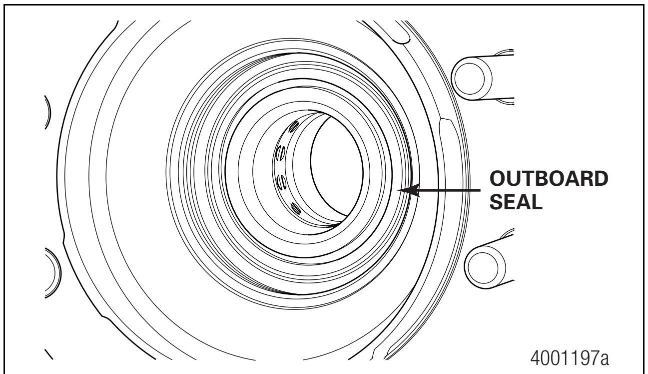


Figure 3.20

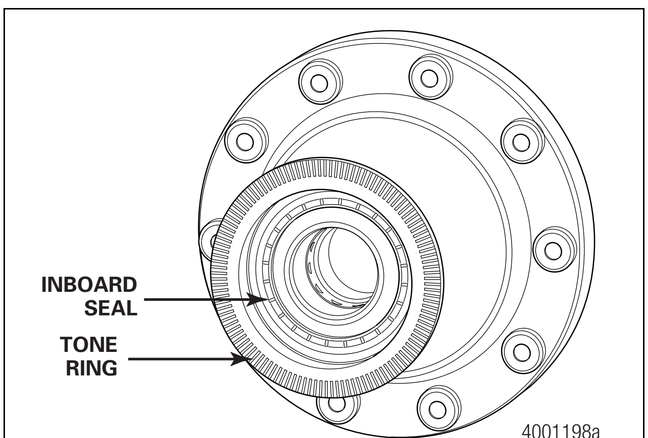


Figure 3.21

Tie Rod and Cross Tube Assembly

NOTE: Do not grease the tie rod assembly before you perform the inspection.

You may not be able to detect loose or worn tie rod ends during operation. Under normal operating conditions, wear occurs over time. The preload bearings inside each tie rod end provide less resistance, which can affect steering control, front tire wear and other axle components.

Regularly-scheduled inspection and maintenance helps to minimize the effects of tie rod end wear on the vehicle. Refer to Table L for inspection intervals. Figure 3.22.

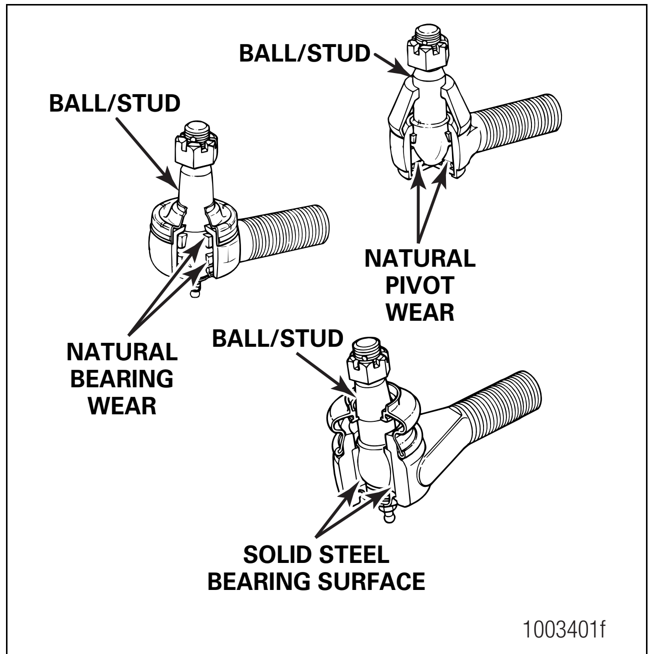


Figure 3.22

1. Park the vehicle on a level surface with the wheels STRAIGHT. Block the wheels to prevent the vehicle from moving. Set the parking brake. Figure 3.23.

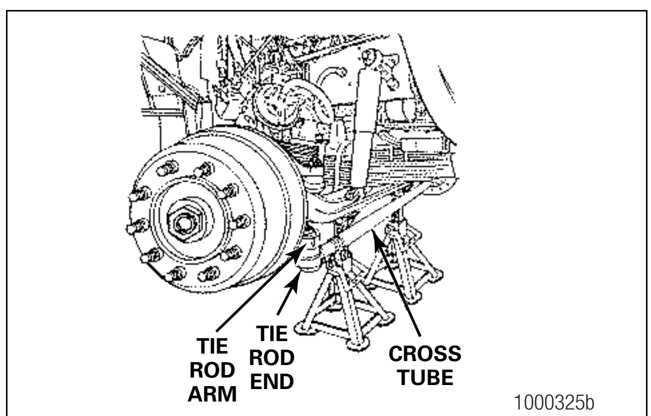


Figure 3.23

2. Raise the vehicle so that the front wheels are off the ground. Support the vehicle with safety stands. Do not use a jack to support the vehicle.

3. With the engine off, turn the wheels from full left to full right. Return to the straight-ahead position. This step will require more force for vehicles with the power steering off.
4. Check the tie rod boot for cracks, tears or other damage. Also check the boot seals for damage. Replace the entire tie rod end if the boot is damaged or missing. Figure 3.24.

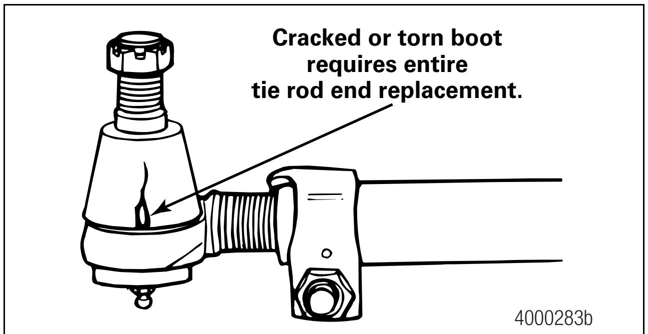


Figure 3.24

⚠ WARNING

Verify that a cotter pin is installed through the tie rod end, and the tie rod end nut is tightened to the correct torque specification. Replace a missing cotter pin and tighten a loose tie rod end nut. A missing cotter pin or loose tie rod end nut can cause loss of steering control. Serious personal injury and damage to components can result.

5. Check that the tie rod nut is installed and secured with a cotter pin.
   - **If the cotter pin is missing:** Tighten the tie rod end nut to the correct specification. Install a new cotter pin. Always tighten the tie rod nut to the specified torque when setting the cotter pin. Refer to Section 10. Do not back-off the nut to insert the cotter pin. Figure 3.25.

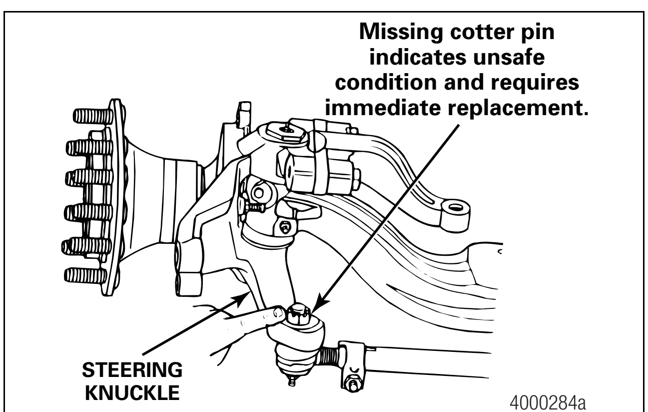


Figure 3.25

6. Check that the tie rod end is threaded correctly into the cross tube and installed deeper than the end of the cross tube slot. The tie rod end must be visible the entire length of the cross tube slot. Figure 3.26.

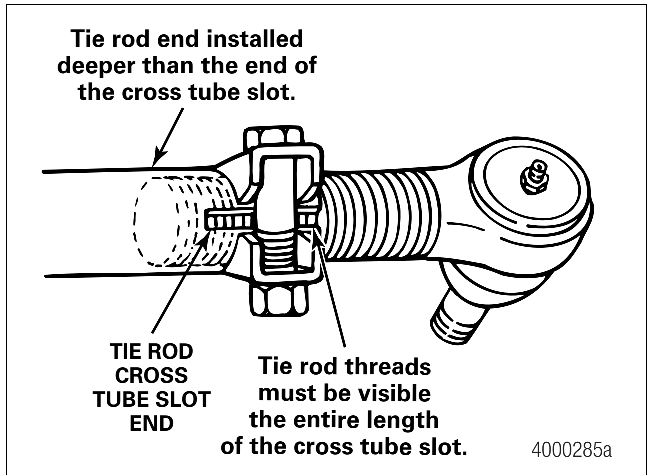


Figure 3.26

7. Check that the grease fittings are installed. Replace a damaged grease fitting.
   - **If the tie rod ends are non-greaseable:** Do not install a grease fitting. Figure 3.27.

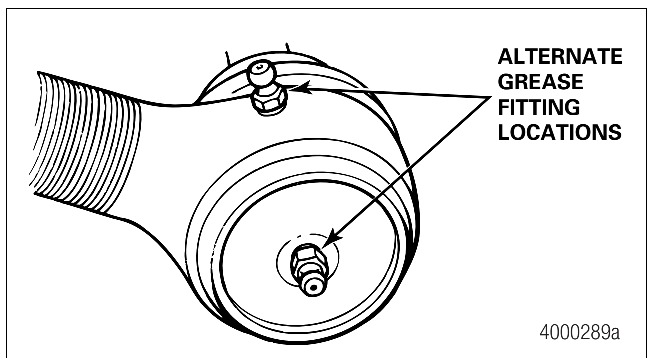


Figure 3.27

8. By hand or using a pipe wrench with jaw protectors to avoid gouging the cross tube, rotate the cross tube toward the FRONT of the vehicle and then toward the REAR. After rotating, center the cross tube between the stop positions.
   - **If the cross tube will not rotate in either direction:** Replace both tie rod ends.

9. Position yourself directly below the ball stud socket. Using both hands, grasp the assembly end as close to the socket as possible, no more than 6-inches (152.4 mm) from the end.

⚠ CAUTION

Only use your hands to check for movement or looseness of the tie rod assembly. Do not use a crow bar, pickle fork or two-by-four. Do not apply pressure or force to tie rod assembly ends or joints. Do not rock the tires with the vehicle on the ground or with the wheels raised. Damage to components can result.

10. Apply hand pressure of approximately 100 pounds in a vertical PUSH and PULL motion several times. Check for any movement or looseness at both tie rod ends. Figure 3.28.
    - **If there is any movement in the tie rod assembly:** Replace both tie rod ends.

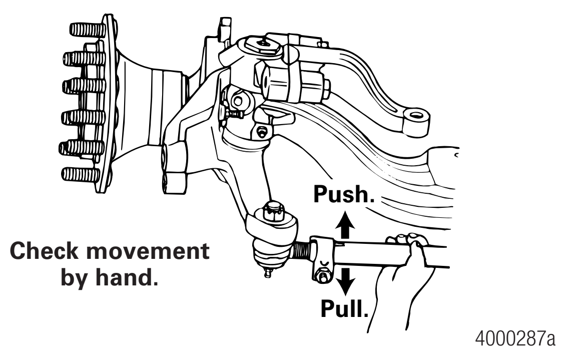


Figure 3.28

⚠ CAUTION

Replace bent or damaged cross tubes with original equipment parts of the same length, diameter and threads. Do not attempt to straighten a bent cross tube. Damage to components can result.

11. Inspect the cross tube and clamps for damage. Figure 3.29.
    - **If the cross tube is bent or cracked:** Replace it. Use original equipment parts of the same length, diameter and threads.
    - **If the clamps are damaged:** Replace them.
    - **If either clamp has become welded to the cross tube:** Replace the entire cross tube assembly. Use original equipment parts of the same length, diameter and threads.

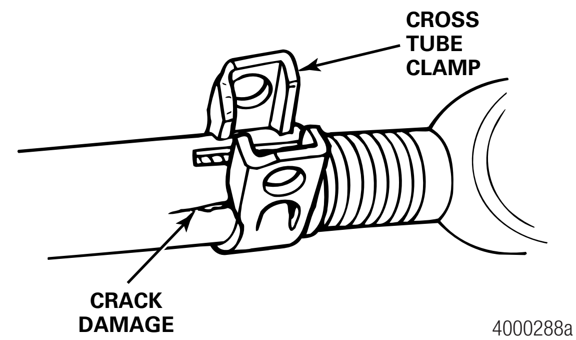


Figure 3.29

Department of Transportation Roadside Tie Rod Assembly Replacement Criteria

When the roadside check indicates tie rod movement of 1/8-inch (3 mm) or more, immediately remove the vehicle from service to replace the tie rod. Figure 3.29.

- **If the roadside check is less than 1/8-inch (3 mm) tie rod end movement:** The vehicle does not need to be immediately removed from a service run. Schedule a major out-of-service inspection and maintenance as soon as possible.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off. Serious personal injury and damage to components can result.

Removal

Wheel Ends

Axles with Conventional Wheel Ends

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Set the parking brake.
2. Raise the front of the vehicle until the front wheels are off the floor. Support the vehicle with safety stands.
3. Use the correct size socket to remove the capscrews that fasten the cap to the hub. Remove the cap and the gasket.
4. Remove the fasteners for the wheel bearings. Refer to the appropriate procedure.
   A. For double nut and lock fasteners, bend the tabs of the flattened lock washer away from the wheel bearing nut and the adjusting nut. Figure 4.1.
   B. Remove the wheel bearing nut, the lock washer, the pierced lock ring and the adjusting nut from the knuckle. Figure 4.1.

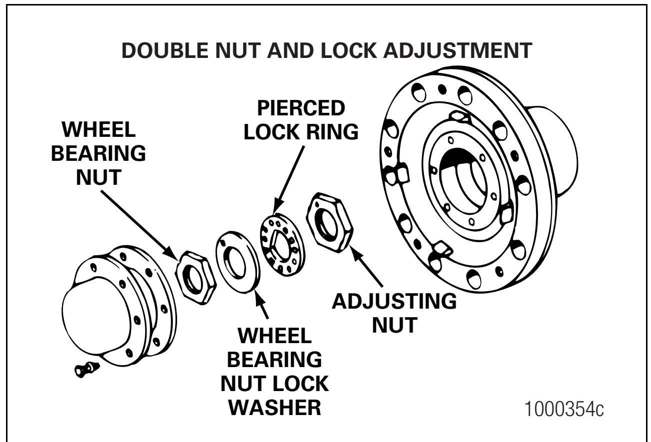


Figure 4.1

   A. For single nut fasteners, remove the cotter pin from the adjusting nut. Figure 4.2.
   B. Remove the adjusting nut and the "D" washer from the spindle. Figure 4.2.

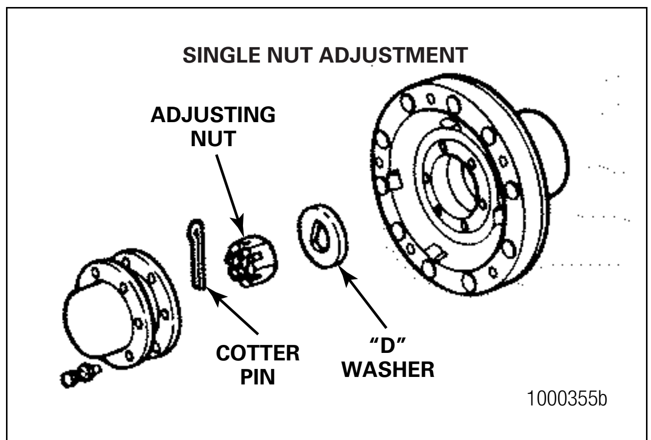


Figure 4.2

5. Remove the outer wheel bearing cone from the hub. Remove the wheel, tire, hub and drum as an assembly.
6. Remove the brake components. Refer to the brake manufacturer's procedures.
7. Remove the oil seal from the hub. Remove the inner wheel bearing cone.
8. Inspect the wheel bearings. Refer to Section 5.

Axles with Unitized Wheel Ends

NOTE: You may have to remove the unitized wheel end when servicing the king pin, brake cam shaft or when replacing the studs on the unitized wheel end. Unitized wheel end removal is not typically required for servicing the brakes, the tie rod assembly or the steering arms.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Set the parking brake.
2. Remove the hubcap.
   A. For threaded hubcaps, use the correct size socket to turn the hubcap COUNTERCLOCKWISE. Figure 4.3.
   B. Remove the threaded protective hubcap from the hub.

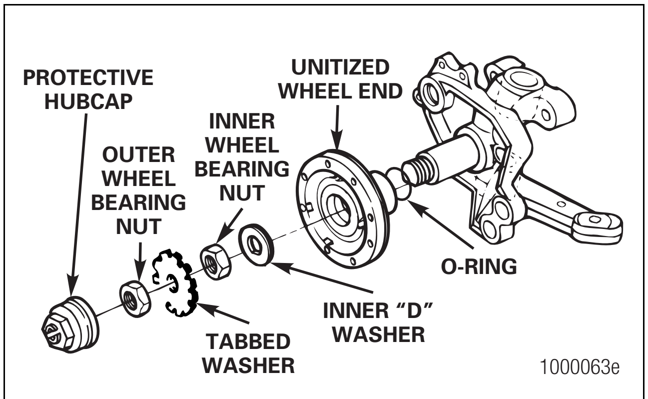


Figure 4.3

   A. For snap-ring hubcaps, insert a screwdriver into the notched end of the snap ring. Figure 4.4.
   B. Remove the snap ring by moving the screwdriver around the circumference of the ring.
   C. Remove the snap-ring hubcap.
3. Use a jack to raise the vehicle so that the front tires are off the ground. Support the front axle with safety stands.
4. Remove the tire and wheel assembly.
5. Bend back and flatten the washer tab folded against the flat edge of the outer wheel bearing nut.

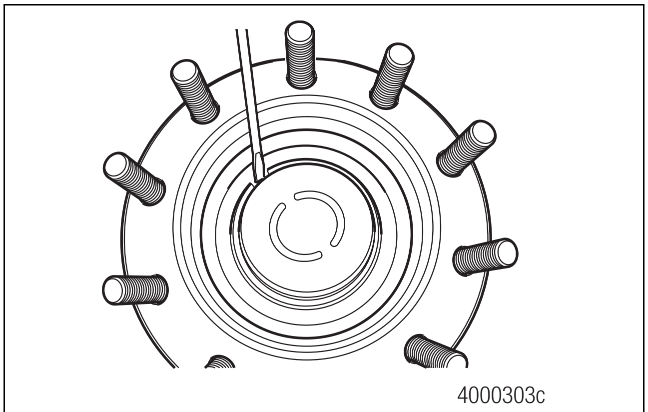


Figure 4.4

6. Remove the outer wheel bearing nut and the tabbed washer from the spindle.
7. Remove the inner wheel bearing nut and the inner washer from the spindle.

⚠ CAUTION

Align the unitized wheel end STRAIGHT onto the spindle. Do not allow the assembly to misalign and contact the spindle threads. Bearing damage can occur that requires replacement of the entire unitized wheel end.

Hub bearings are not serviceable. Do not remove bearings from the unitized wheel end. Damage to components can result.

8. Remove the unitized wheel end STRAIGHT from the spindle. Figure 4.3.
9. Remove and discard the spindle O-ring. Replace it during assembly.

   NOTE: The spindle O-ring enables you to remove the unitized wheel-end hub from the spindle more easily, because it helps to prevent contaminants from entering the assembly.

   When you remove the unitized wheel-end hub, install a new O-ring.

10. If the unitized wheel end is difficult to remove from the spindle, use the following procedure.
    A. Use a brass hammer to remove two studs from opposite sides of the unitized wheel end.
    B. Install a 17.5-ton cross block puller with two 8 x 7/8-inch Grade 8 bolts. Figure 4.5.
    C. Use a wrench to gradually tighten the forcing nut and washer against the cross block to separate the unitized wheel end from the knuckle spindle. Figure 4.6.
       - **If you've applied force and the part has not moved:** Use a cross block puller with a larger capacity
    D. Repeat this procedure to remove the unitized wheel end on the opposite side of the axle, if required.

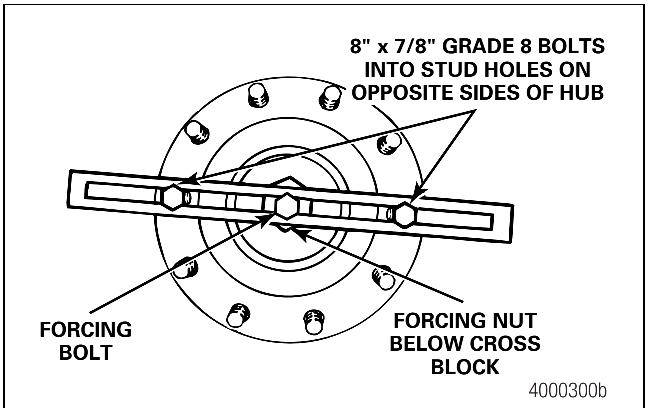


Figure 4.5

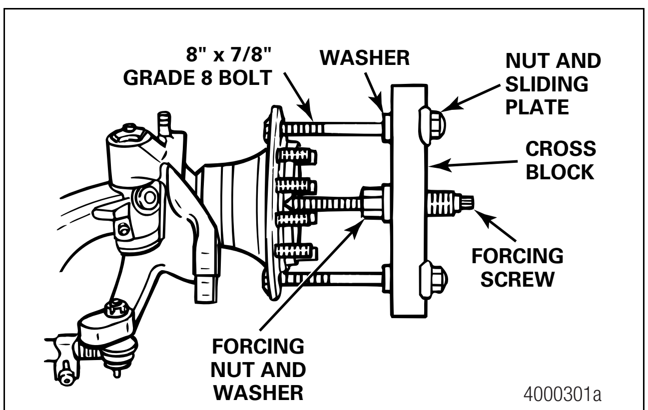


Figure 4.6

Drag Link

Refer to the vehicle manufacturer's procedures. Figure 4.7

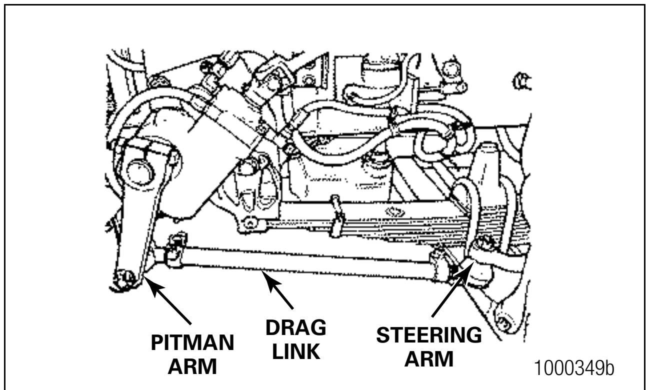


Figure 4.7

Steering Arm

Axles with a Keyed Steering Arm

1. Remove the cotter pin and nut that fasten the steering arm to the drag link. Disconnect the steering arm from the drag link. Figure 4.7.
2. Remove the cotter pin and nut that fasten the steering arm to the knuckle. Figure 4.8.

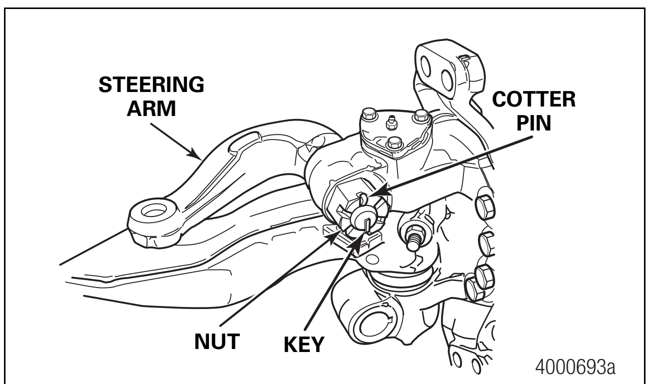


Figure 4.8

3. Remove the steering arm from the knuckle. If necessary, use a leather or plastic mallet to tap on the end of the arm and separate the arm from the knuckle.
4. Remove the key from the steering arm. Inspect the steering arm. Refer to Section 5.

Axles with a Bolt-On Steering Arm

1. Remove the two steering-arm-to-knuckle capscrews from the knuckle assembly. Figure 4.9.

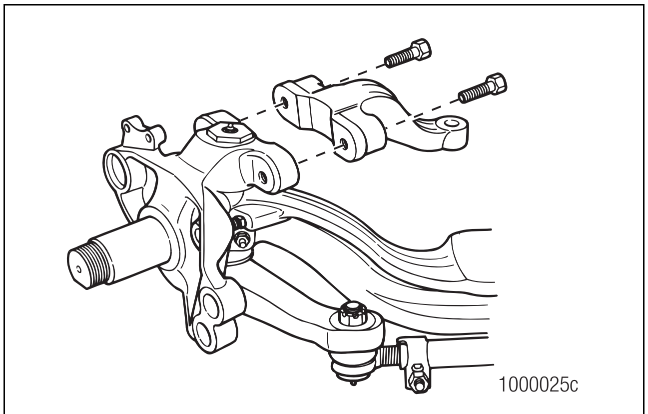


Figure 4.9

2. Remove the steering arm from the knuckle. If necessary, use a leather or plastic mallet to tap the outside of the arm and separate the arm from the knuckle.
3. Remove the steering arm. Inspect the steering arm. Refer to Section 5.

Tie Rod Arms, Tie Rod Ends and Cross Tube

⚠ WARNING

Support the tie rod assembly during maintenance and service to prevent serious personal injury and damage to components. If the cross tube clamps are tack-welded, do not remove the tack weld during tie rod assembly removal. If you remove the tack weld, clamp force is reduced. Replace the cross tube if the weld is broken. Loss of steering control, serious personal injury and damage to components can result.

⚠ CAUTION

Do not heat the arm to remove the tie rod assembly. Heating the tie rod arm will soften parts. Damage to components will result.

Axles with Removable Tie Rod Arms

1. Remove the cotter pins and nuts that fasten each tie rod end to the tie rod arms. Figure 4.10.

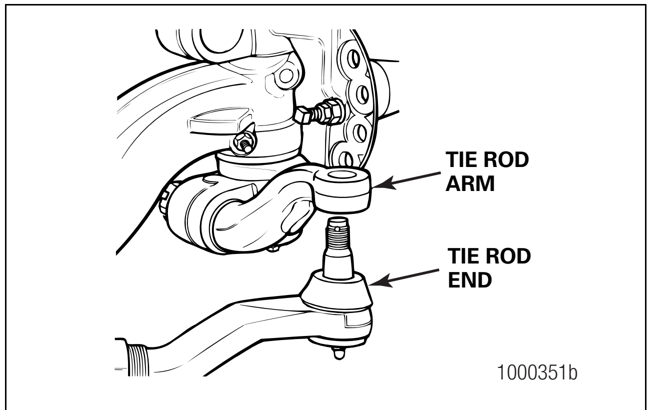


Figure 4.10

2. Disconnect the cross tube assembly from the tie rod arms. If available, use a tie rod end puller to separate the tie rod end from the tie rod arm. Figure 4.10.
3. Remove the cotter pin and nut that fastens the tie rod arms in the knuckle.
4. Remove the tie rod arms from the knuckle. If necessary, use a leather or plastic mallet to tap on the end of the rod. Remove the key.
5. If necessary, use this procedure to remove the tie rod ends.
   A. Mark the position of each tie rod end in the cross tube. Count and record the number of threads that appear outside of the cross tube. Figure 4.11.
   B. Remove the bolts and nuts from the clamp on the cross tube. Rotate the cross tube clamp to remove the nuts and bolts from the clamp. Figure 4.12.
   C. Remove the tie rod ends from the cross tube.

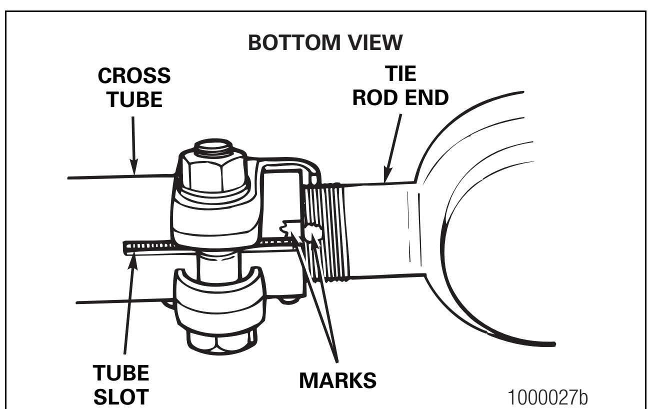


Figure 4.11

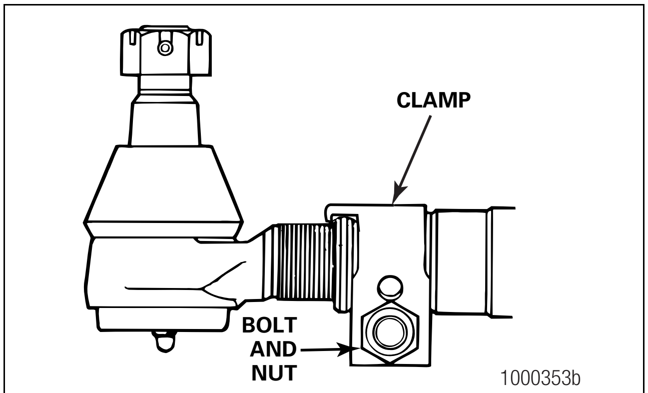


Figure 4.12

6. Inspect the parts. Refer to Section 5.

Axles with Integral Tie Rod Arms

1. Remove the cotter pins and nuts that fasten each tie rod end to the tie rod arms.
2. Disconnect the cross tube assembly from the tie rod arms. If available, use a tie rod end puller to separate the tie rod end from the tie rod arm. Figure 4.13. If necessary, use a leather or plastic mallet to tap on the tie rod end to loosen and remove it.

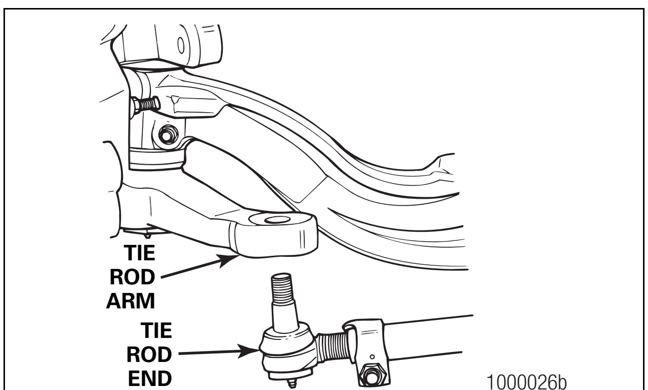


Figure 4.13

3. If necessary, use this procedure to remove the tie rod ends.
   A. Mark the position of each tie rod end in the cross tube. Count and record the number of threads that appear outside of the cross tube. Figure 4.11.
   B. Remove the bolts and nuts from the clamp on the cross tube. Rotate the cross tube clamp to remove the nuts and bolts from the clamp. Figure 4.12.
   C. Remove the tie rod ends from the cross tube.
4. Inspect the parts. Refer to Section 5.

Draw Keys, King Pin Caps, King Pins and Steering Knuckle

Axles with Bolt-On King Pin Caps

1. Remove the wheel ends as described in this section.
2. Vent the air from the brake system. Disconnect the air lines from the brakes.
3. Remove the brake components. Refer to the brake manufacturer's procedures.
4. Remove the tie rod arms and the steering arm from the knuckle. Refer to the procedure in this section.
5. Remove the capscrews that fasten the king pin caps to the top and the bottom of the knuckle. Remove the caps and the gaskets. Figure 4.14.

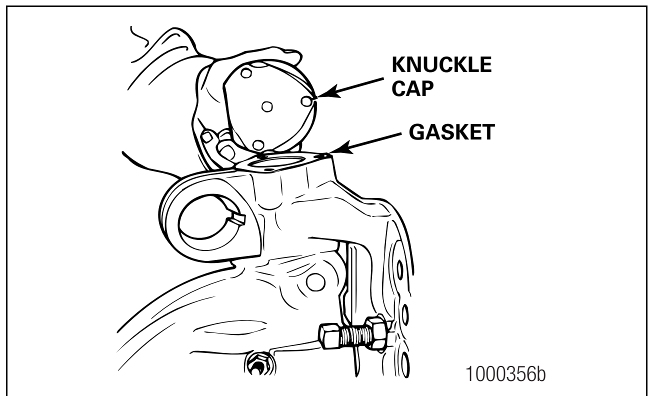


Figure 4.14

6. Remove the plain or the threaded draw keys. Refer to Table C.

Table C: Threaded or Plain Draw Keys

Threaded Draw Keys	Plain Draw Keys
All other axle models	FC-901, FC-921, FE-970, FF-971 and FL-901

- **For plain draw keys:** Use a brass hammer and a steel drift to remove the draw key. Place the drift onto the small, "D"-shaped end of the key. Figure 4.15.
- **For threaded draw keys:** Perform the following procedure.

A. Loosen the threaded draw key lock nut until the top of the lock nut is even with the end of the draw key.

B. Use a brass drift and a hammer to hit the end of the draw key. Figure 4.16.

C. Remove the nut from the draw key. Remove the draw key from the knuckle.

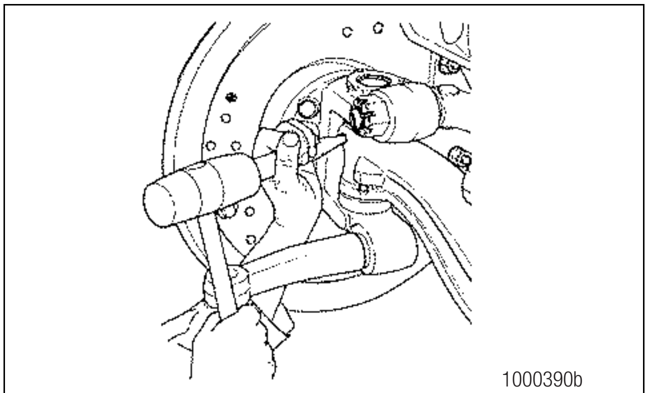


Figure 4.15

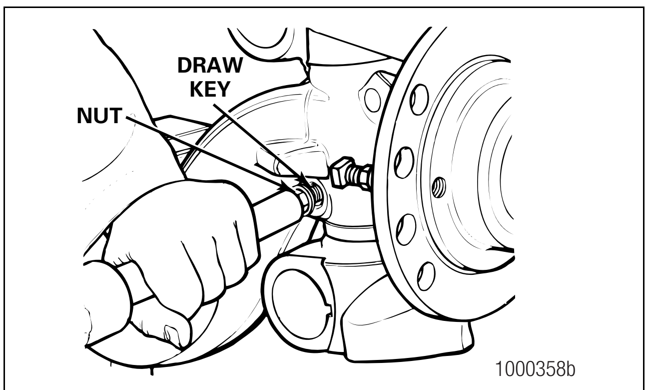


Figure 4.16

7. If you're not replacing the bushings, use the following procedure to prevent damaging the bushings during king pin removal.

   A. Use a brass drift and a hammer to remove the king pins from the knuckle. Figure 4.17.

   B. Remove any flaring on the drift that touches the bushings.

   C. Wrap tape to a thickness of 1/16-inch (1.5 mm) onto the end of the drift.

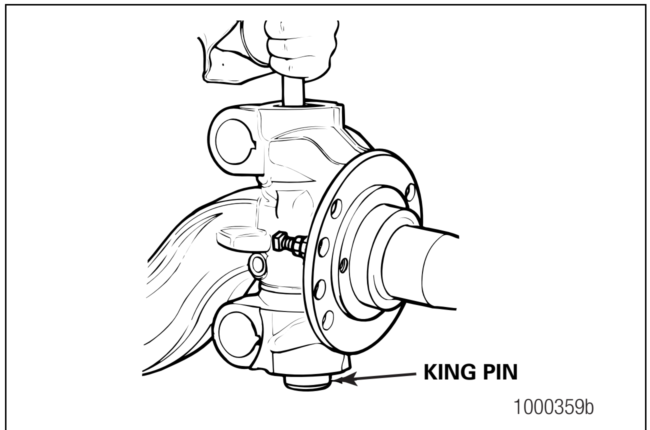


Figure 4.17

8. If the king pin is hard to remove, use a hydraulic king pin remover. Refer to Section 11. To obtain this tool, refer to the Service Notes page on the front inside cover of this manual.

9. Remove the knuckle from the axle beam.

⚠ WARNING

Wear gloves when you remove or install shims. Shims have sharp edges that can cause serious personal injury.

10. While wearing gloves, remove the shims, the thrust bearing and the seal from the beam and knuckle. Figure 4.18.

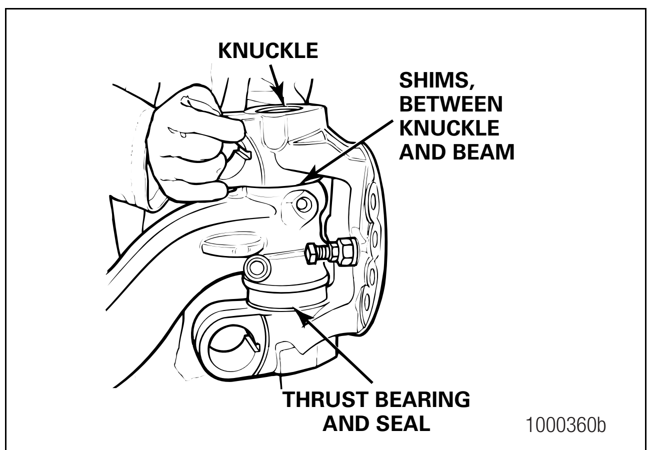


Figure 4.18

11. Inspect the parts. Refer to Section 5.

Axles with Threaded King Pin Caps

1. Remove the wheel end as described in this section.
2. Vent the air from the brake system. Disconnect the air lines from the brakes.
3. Remove the brake components. Refer to the brake manufacturer's procedures.
4. Remove the steering arm from the knuckle, if applicable.
5. Remove the top and bottom king pin caps. Figure 4.19.

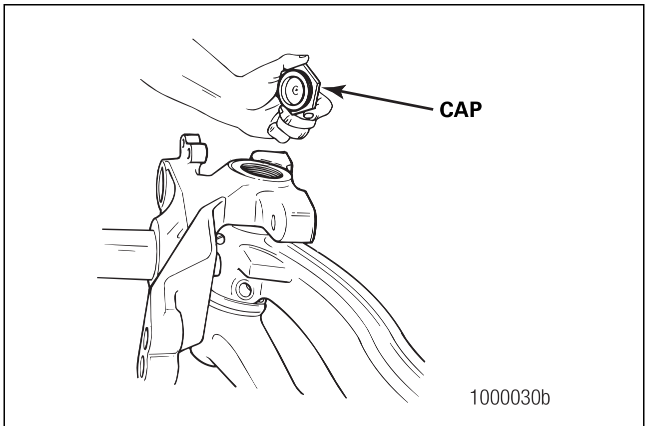


Figure 4.19

6. Use the following procedure to remove the upper and lower draw keys from the knuckle.
   A. Loosen the draw key nut. Use a brass drift and a hammer to hit the end of the draw key. Figure 4.20.
   B. Remove the nut from the draw key. Figure 4.21. Remove the draw key from the knuckle.

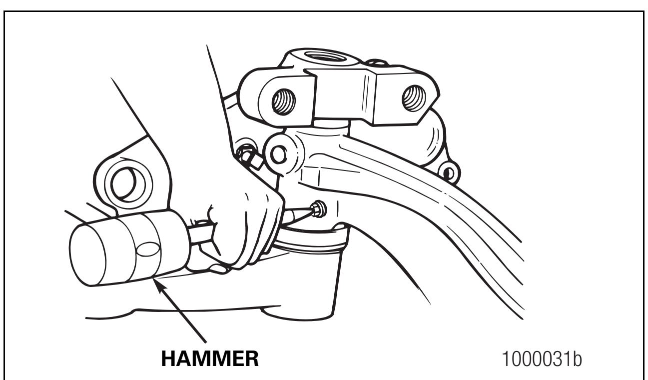


Figure 4.20

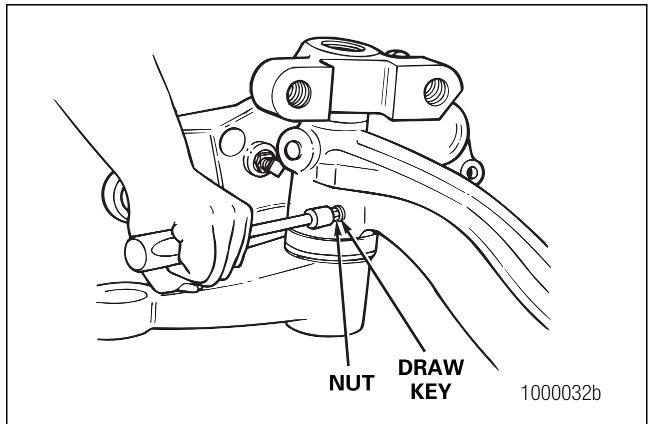


Figure 4.21

7. If you're not replacing the bushings, use the following procedure to prevent damage to the bushings during king pin removal.
   A. Use a hammer and brass drift to remove the king pins from the knuckle. Figure 4.22.
   B. Remove any flaring on the drift that touches the bushings.
   C. Wrap tape to a thickness of 1/16-inch (1.5 mm) onto the end of the drift.

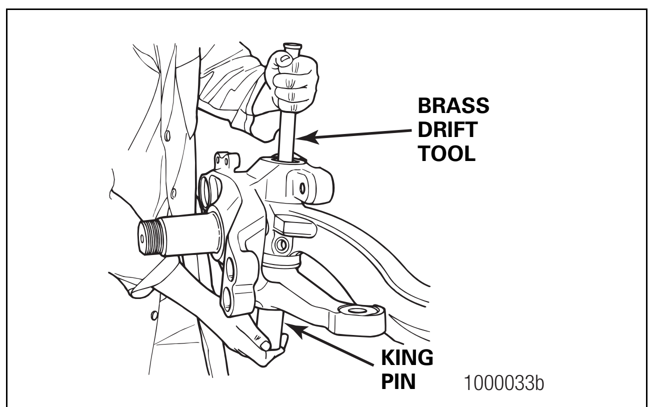


Figure 4.22

8. If the king pin is hard to remove, use a hydraulic king pin remover. Refer to Section 11. To obtain this tool, refer to the Service Notes page on the front inside cover of this manual.

⚠ WARNING

Wear gloves when you remove or install shims. Shims have sharp edges that can cause serious personal injury.

9. While wearing gloves, remove the integral thrust bearing and seal, and the shims from the beam and knuckle. Figure 4.23.

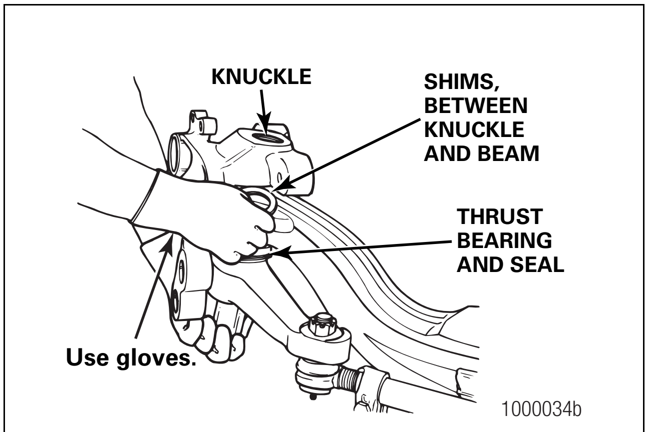


Figure 4.23

10. Remove the knuckle from the axle beam. Figure 4.24. Inspect the parts. Refer to Section 5.

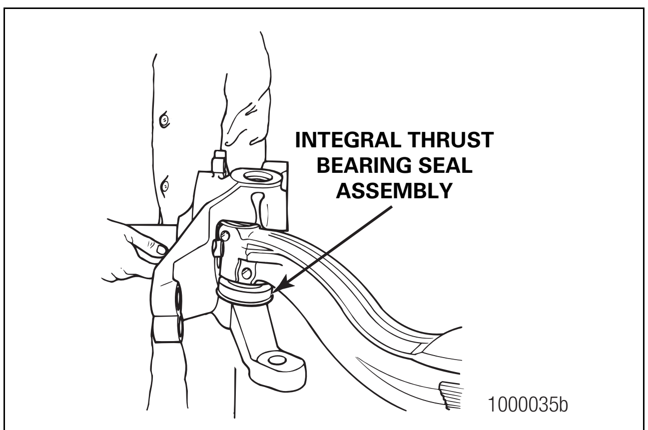


Figure 4.24

King Pin Bushings

⚠ WARNING

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

Axles with Conventional Wheel Ends — Nylon Bushings

1. Remove and discard the lower king pin seal. Figure 4.25.

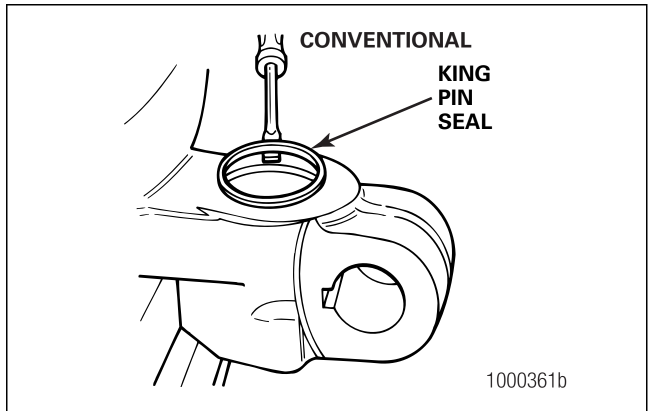


Figure 4.25

2. Turn the knuckle upside down and remove the upper king pin seal. Remove the old bushings.
3. Remove the top and the bottom bushings from the knuckle bore. Figure 4.26.

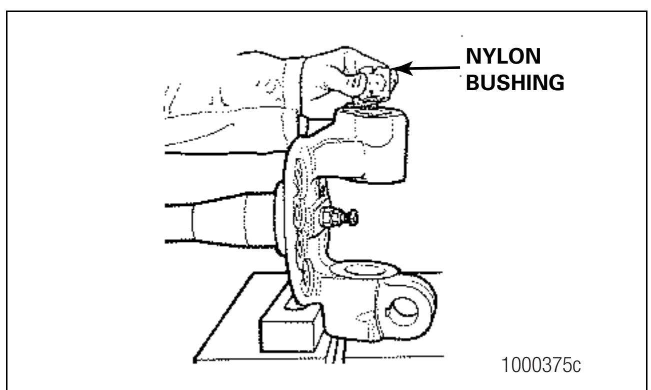


Figure 4.26

Axles with Conventional Wheel Ends — Easy Steer™ and Bronze Bushings

1. Remove and discard the lower king pin seal. Figure 4.25.
2. Turn the knuckle upside down and remove the upper king pin seal. Remove the old bushings.

   NOTE: For some axles, you can remove the bushings with a bushing service kit. Refer to Section 11.

3. Make a tool to remove the bushings. Refer to Section 11.
4. Place the knuckle in a vise. Use a press with a five-ton capacity. The knuckle must not move when the bushings are removed.
5. Install the tool into the upper king pin bushing. Press the upper king pin bushing from the knuckle bore. Figure 4.27.
6. Turn the knuckle upside down and install the tool into the lower king pin bushing. Press the lower bushing from the knuckle bore. Figure 4.27.

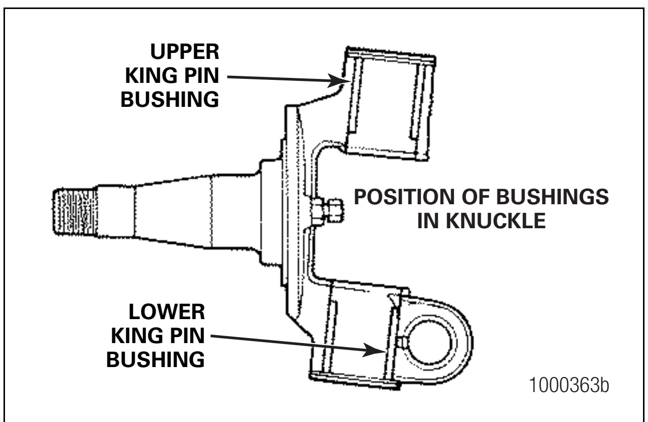


Figure 4.27

Axles with Unitized Wheel Ends — Easy Steer™ Bushings

1. Remove and discard the lower king pin seal. Figure 4.28.
2. Turn the knuckle over. Remove the upper king pin seal.

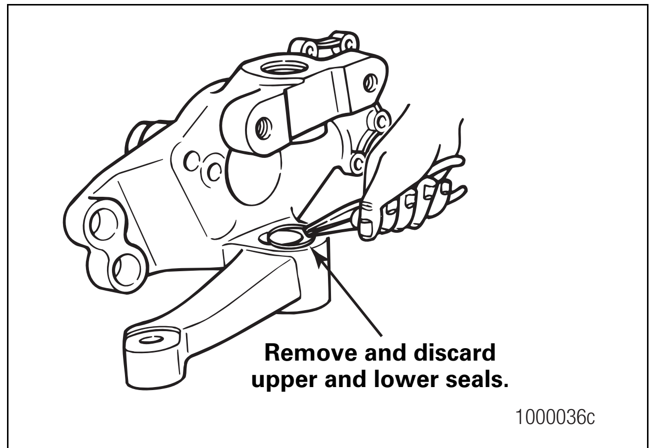


Figure 4.28

3. Use the following procedure to remove the old bushings.
   - A. Make a tool to remove the bushings. Refer to Section 11.
   - B. Place the knuckle into a vise. Use a press with a five-ton capacity. The knuckle must not move when the bushings are removed.
   - C. Install the tool into the upper king pin bushing and press it from the knuckle bore. Figure 4.29.
   - D. Turn the knuckle upside down. Install the tool into the lower king pin bushing and press it from the knuckle bore. Figure 4.30.

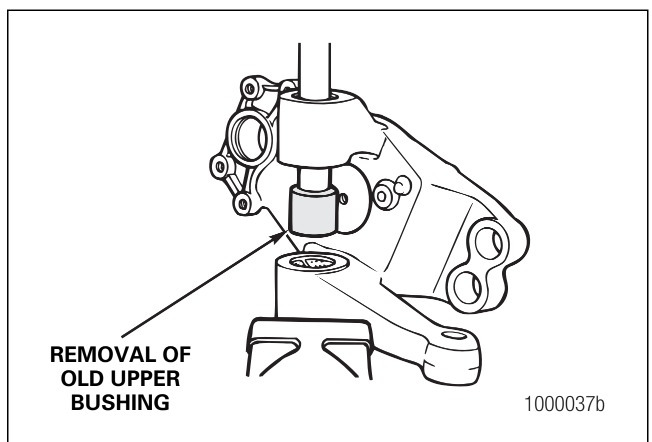


Figure 4.29

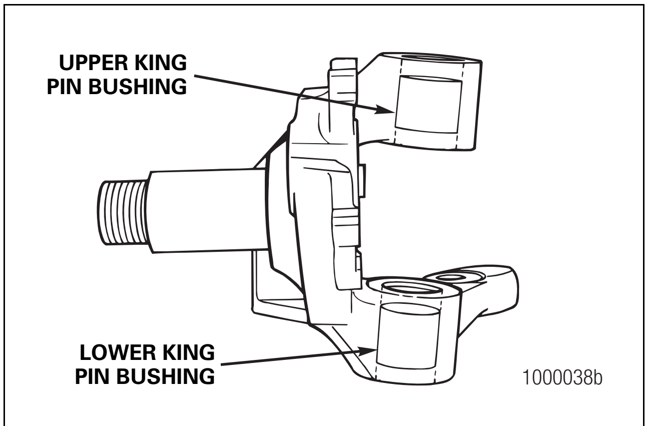


Figure 4.30

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Replace damaged or out-of-specification axle components. Do not bend, repair or recondition axle components by welding or heat-treating. A bent axle beam reduces axle strength, affects vehicle operation and voids Meritor's warranty. Serious personal injury and damage to components can result.

Replace

Worn or Damaged Parts

Do not repair or recondition front axle components. Replace damaged or out-of-specification components. All major components are heat-treated and tempered.

Do not perform the following operations on front axle components.

- Weld steering arms, tie rod arms, knuckles, king pins, axle beams, tie rod assemblies, hubs, drums or brakes.
- Hot- or cold-bend the knuckles, steering arms, tie rod arms, ball studs, axle beams or tie rod assemblies.
- Drill holes in the axle beam for the king pins.
- Drill draw key holes in the knuckle.
- Spray-weld bearing diameters onto the knuckles or into the machined bores.
- Disassemble the unitized wheel end.
- Mill or machine any components.

WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

CAUTION

Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts can result.

Clean, Dry and Inspect Parts

Ground or Polished Parts

Use a cleaning solvent to clean the ground or polished parts and surfaces. Kerosene or diesel fuel can be used for this purpose. DO NOT USE GASOLINE.

Do NOT clean ground or polished parts in a hot solution tank or with water, steam or alkaline solutions. These solutions will cause corrosion of the parts.

Rough Parts

Rough parts can be cleaned with the ground or polished parts. Rough parts also can be cleaned in hot solution tanks with a weak alkaline solution. Parts must remain in the hot solution tanks until they are completely cleaned and heated.

Dry Cleaned Parts

Parts must be dried immediately after cleaning. Dry parts with clean paper or rags, or compressed air. Do not dry bearings by spinning with compressed air.

Prevent Corrosion on Cleaned Parts

Apply a light oil to cleaned and dried parts that are not damaged and are to be immediately assembled. Do NOT apply oil to the brake linings or the brake drums.

If the parts are to be stored, apply a good corrosion preventative to all surfaces. Do NOT apply the material to the brake linings or the brake drums. Store the parts inside special paper or other material that prevents corrosion.

NOTE: All tapered joints must be clean and dry with no lubrication or corrosion preventative applied to the mating surfaces.

Installation

New Fasteners with Pre-Applied Adhesive Patches

1. Clean the oil and dirt from the threaded holes. Use a wire brush to remove the old patch material. There is no special cleaning required.

⚠ CAUTION

Do not apply adhesives or sealants onto new fasteners with pre-applied adhesive patches or into the threaded holes. If other adhesives or sealants are used, the new adhesive will not function correctly. Damage to components can result.

2. Assemble the parts using the new pre-applied adhesive fasteners.

   NOTE: There is no drying time required for fasteners with pre-applied adhesive.

3. Tighten the fasteners to the required torque value for that size fastener. Refer to Section 10.

Original or Used Fasteners Using Meritor Specification 2297-C-7049 Liquid Adhesive, Loctite® 680 Adhesive or Equivalent

⚠ WARNING

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions to prevent irritation to the eyes and skin. If Loctite® adhesive material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

1. Clean the oil, dirt and old adhesive from all threads and threaded holes. Use a wire brush.

⚠ CAUTION

Do not apply adhesive to the fastener threads. Air pressure in the hole will push the adhesive out as the fastener is installed. Damage to components can result.

   NOTE: There is no drying time required for Meritor specification 2297-C-7049 liquid adhesive, Loctite® 680 adhesive or equivalent.

2. Apply four or five drops of Meritor liquid adhesive, Loctite® 680 adhesive or equivalent into each threaded hole or bore only. Figure 5.1 and Figure 5.2.

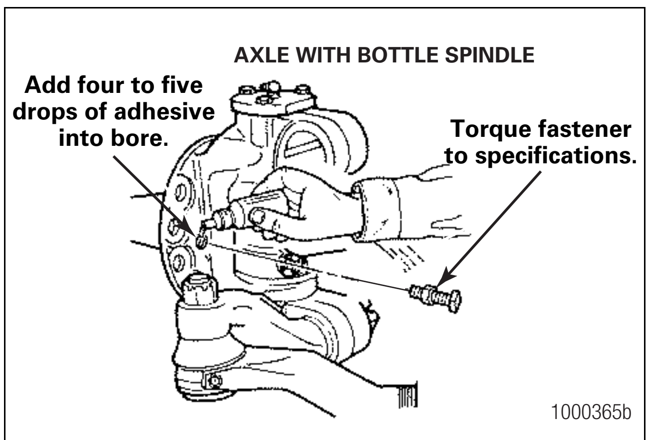


Figure 5.1

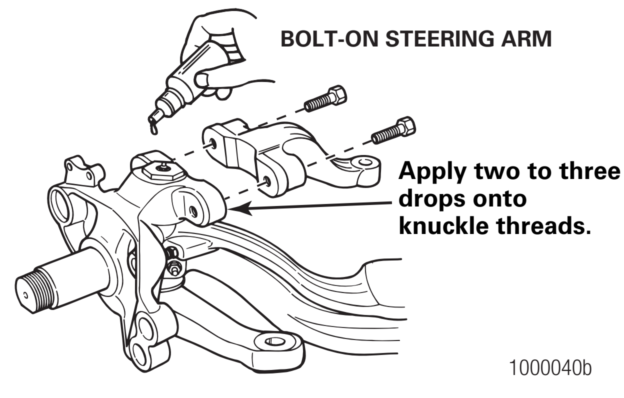


Figure 5.2

3. Tighten the fasteners to the required torque value for that size fastener. Refer to Section 10.

Check the Torque Values of Dri-Loc® Fasteners Not Requiring Removal

If Dri-Loc® fasteners do not require removal from components, use the following procedure to check the fasteners for the correct torque value.

Apply the minimum amount of torque required for that size fastener. Refer to Section 10. The fastener must not rotate.

- **If the fastener rotates:** Remove the fastener from the component. Inspect the fastener and the hole for wear and damage. Repair as necessary.
- **If the fastener and the hole are in good condition:** Apply adhesive into the threaded hole. Follow the procedure to install old Dri-Loc® fasteners.

Inspection

Parts

Axles with Conventional and Unitized Wheel Ends

WARNING

Use only dye penetrant inspection techniques on unitized wheel-end hub units. Be careful not to get penetrant fluids into the bore of the hub unit. Do not use fluid immersion-based crack inspection techniques. The fluids can enter the joint between the inner bearing cones through the bore of the hub unit and damage the lubricant. Serious personal injury and damage to components can result.

Refer to the following guidelines to carefully inspect all disassembled parts before assembly.

1. Inspect and replace any parts that are worn, cracked or damaged. Check for cracks using dye penetrant, magnetic flux or fluorescent particle testing methods. Follow the inspection product manufacturer's procedures.
2. Remove the old bushing from the knuckle. Measure the upper knuckle bore inside diameter at two locations. Always use a micrometer and a telescoping gauge when taking knuckle bore measurements. Some rounding of the top and bottom bore edges is acceptable.
3. Measure the bore in four positions and at two locations. The two locations must be 90 degrees opposite each other. Figure 5.3.
   - **If the average measurement is more than the knuckle bore maximum diameter specification in Table D:** Replace the knuckle.

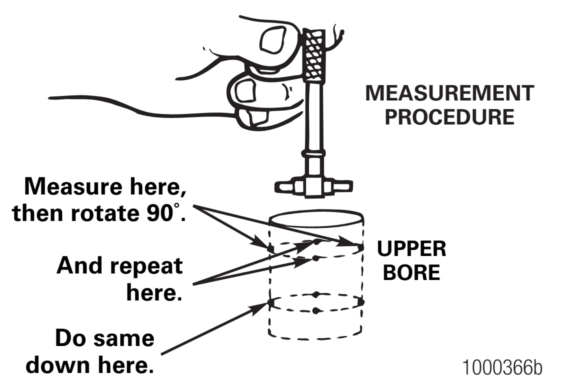


Figure 5.3

4. Repeat this procedure for measuring the lower knuckle bore. Figure 5.4 and Figure 5.5. Refer to the knuckle bore maximum diameter in Table D.
   - **If measurements at either the upper or lower knuckle bores exceed the knuckle bore maximum diameter in Table D:** Replace the knuckle.

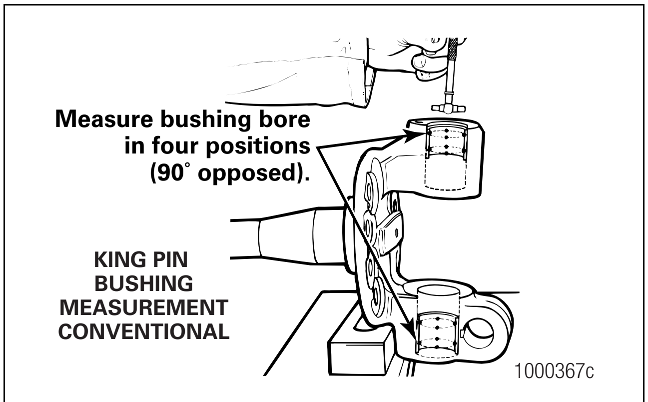


Figure 5.4

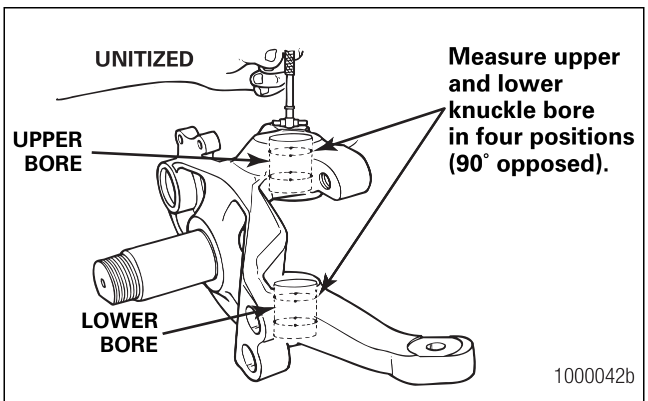


Figure 5.5

5. Measure the king pin bushing inside diameter using a micrometer and a telescoping gauge.
   - **If the average inside diameter measurement is greater than the king pin bushing maximum inner diameter in Table D:** Install a new bushing.

6. Measure the inner diameter of the new bushing after installation and reaming in four positions and at two locations. The two locations must be 90 degrees opposite each other. Figure 5.3.
   - **If the average measurement is more than the king pin bushing maximum inner diameter specification in Table D:** Replace the bushing.

7. Measure the inner bore diameter of the axle beam. Rounding at the top and bottom of the beam is acceptable. Measure the axle beam bore at four positions and at two locations. Figure 5.3. Refer to the guidelines below.

   A. 0.5-inch (12.7 mm) below the top of the bore. Figure 5.6.

   B. 0.5-inch (12.7 mm) above the bottom of the bore. Figure 5.6.

   - **If the average measurement is greater than the axle beam bore maximum diameter in Table D:** Replace the entire axle beam.

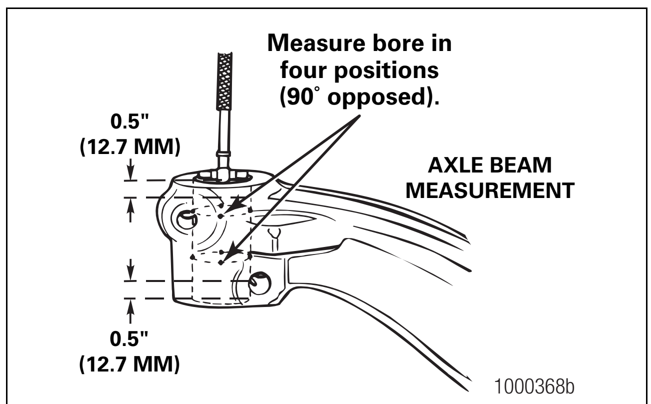


Figure 5.6

Table D: Axle Wear Limits Specifications

<table>
<tr><th>Model Number</th><th>Knuckle Bore Maximum Diameter</th><th>Axle Beam Bore Maximum Diameter</th><th>King Pin Bushing Maximum Inner Diameter</th></tr>
<tr><td>FC-901[1]</td><td rowspan="4">1.3610 in. (34.569 mm)</td><td rowspan="5">1.2380 in. (31.4450 mm)</td><td>1.2400 in. (31.4960 mm)</td></tr>
<tr><td>FC-901[2]</td><td>1.2380 in. (31.4420 mm)</td></tr>
<tr><td>FC-903[1]</td><td>1.2400 in. (31.4960 mm)</td></tr>
<tr><td>FC-903[2]</td><td>1.2380 in. (31.4420 mm)</td></tr>
<tr><td>FC-921</td><td>1.3615 in. (34.582 mm)</td><td>1.2365 in. (31.4070 mm)</td></tr>
<tr><td>FC-941</td><td>1.6295 in. (41.389 mm)</td><td>1.5040 in. (38.2020 mm)</td><td>1.5020 in. (38.1510 mm)</td></tr>
<tr><td>FD-901</td><td>1.5630 in. (39.700 mm)</td><td>1.4375 in. (36.5125 mm)</td><td>1.4380 in. (36.5250 mm)</td></tr>
<tr><td>FD-931</td><td rowspan="2">1.7360 in. (44.094 mm)</td><td rowspan="2">1.6110 in. (40.9194 mm)</td><td rowspan="2">1.6105 in. (40.9067 mm)</td></tr>
<tr><td>FD-933</td></tr>
<tr><td>FD-961</td><td>1.9220 in. (48.818 mm)</td><td>1.7980 in. (45.6692 mm)</td><td>1.7960 in. (45.6180 mm)</td></tr>
<tr><td>FE-970</td><td>1.7360 in. (44.094 mm)</td><td>1.6110 in. (40.9194 mm)</td><td>1.6105 in. (40.9067 mm)</td></tr>
<tr><td>FF-921</td><td rowspan="23">1.9220 in. (48.818 mm)</td><td rowspan="12">1.7980 in. (45.6692 mm)</td><td rowspan="5">1.7975 in. (45.6565 mm)</td></tr>
<tr><td>FF-931</td></tr>
<tr><td>FF-932</td></tr>
<tr><td>FF-933</td></tr>
<tr><td>FF-934</td></tr>
<tr><td>FF-941</td><td rowspan="7">1.7960 in. (45.6180 mm)</td></tr>
<tr><td>FF-942</td></tr>
<tr><td>FF-943</td></tr>
<tr><td>FF-944</td></tr>
<tr><td>FF-961</td></tr>
<tr><td>FF-966</td></tr>
<tr><td>FF-967</td></tr>
<tr><td>FF-971</td><td>1.6105 in. (40.9067 mm)</td><td>1.6105 in. (40.9067 mm)</td></tr>
<tr><td>FF-981</td><td rowspan="10">1.7980 in. (45.6692 mm)</td><td rowspan="6">1.7960 in. (45.6180 mm)</td></tr>
<tr><td>FF-982</td></tr>
<tr><td>FF-983</td></tr>
<tr><td>FF-984</td></tr>
<tr><td>FF-986</td></tr>
<tr><td>FF-987</td></tr>
<tr><td>FG-931</td><td rowspan="2">1.7975 in. (45.6565 mm)</td></tr>
<tr><td>FG-933</td></tr>
<tr><td>FG-941</td><td rowspan="2">1.7960 in. (45.6180 mm)</td></tr>
<tr><td>FG-943</td></tr>
<tr><td>FL-931</td><td rowspan="5">2.1270 in. (54.025 mm)</td><td rowspan="5">2.0030 in. (50.8762 mm)</td><td rowspan="2">2.0030 in. (50.8767 mm)</td></tr>
<tr><td>FL-933</td></tr>
<tr><td>FL-941</td><td rowspan="2">2.0010 in. (50.8250 mm)</td></tr>
<tr><td>FL-943</td></tr>
<tr><td>FL-951</td><td>2.0030 in. (50.8767 mm)</td></tr>
</table>

Table D: Axle Wear Limits Specifications (cont'd.)

Model Number	Knuckle Bore Maximum Diameter	Axle Beam Bore Maximum Diameter	King Pin Bushing Maximum Inner Diameter
FU-910	2.1900 in. (55.626 mm)	2.0655 in. (52.4637 mm)	2.0645 in. (52.4383 mm)
FU-935			
MFS 6	1.3615 in. (34.582 mm)	1.2380 in. (31.4450 mm)	1.2365 in. (31.4070 mm)
MFS 7	1.6295 in. (41.389 mm)	1.5040 in. (38.2020 mm)	1.5020 in. (38.1510 mm)
MFS 8			
MFS 10	1.9220 in. (48.818 mm)	1.7960 in. (45.6180 mm)	1.7980 in. (45.6692 mm)
MFS 12			
MFS 13			
MFS 14			
MFS 16	2.1270 in. (54.025 mm)	2.0030 in. (50.8762 mm)	2.0010 in. (50.8250 mm)
MFS 18			
MFS 20			

[1] Knuckles with nylon bushings.

[2] Knuckles with bronze bushings.

Wheel Bearings

Axles with Conventional Wheel Ends

Inspect the wheel bearings when the hub is removed from the knuckle spindle.

Remove all lubricant from the bearings, knuckle, hub and hubcap.

Inspect the cup, the cone and the rollers and cage of all bearings. If any of the following conditions exist, you must replace the bearing.

- The center of the large diameter end of the rollers is worn level or below the outer surface. Figure 5.7.
- The radius at the large diameter end of the rollers is worn to a sharp edge. Figure 5.7.
- There is a visible roller groove in the cup or the cone inner race surfaces. The groove can be seen at the small or large diameter end of both parts. Figure 5.8.
- There are deep cracks or breaks in the cup, the cone inner race or the roller surfaces. Figure 5.8.
- There are bright wear marks on the outer surface of the roller cage. Figure 5.9.
- There is damage on the rollers and on the surfaces of the cup and the cone inner race that touch the rollers. Figure 5.10.
- There is damage on the cup and the cone inner surfaces that touch the rollers. Figure 5.11.

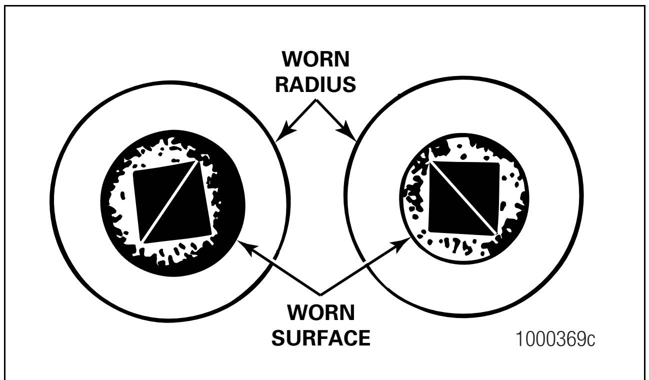


Figure 5.7

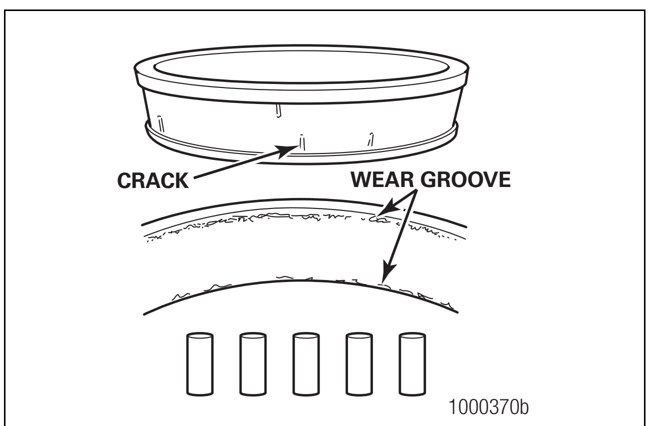


Figure 5.8

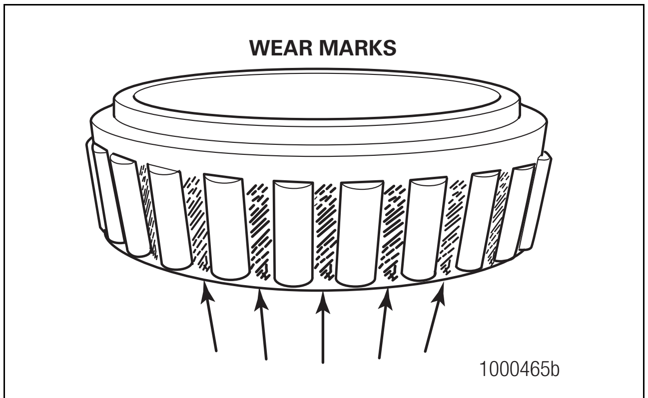


Figure 5.9

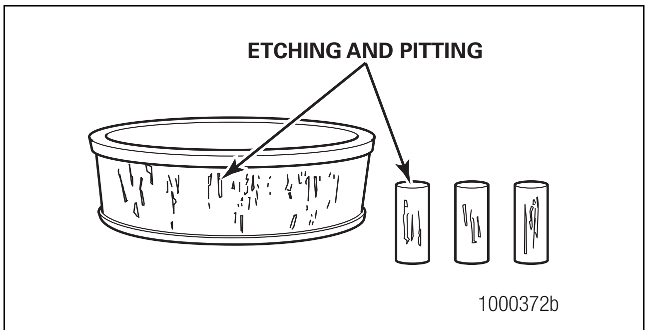


Figure 5.10

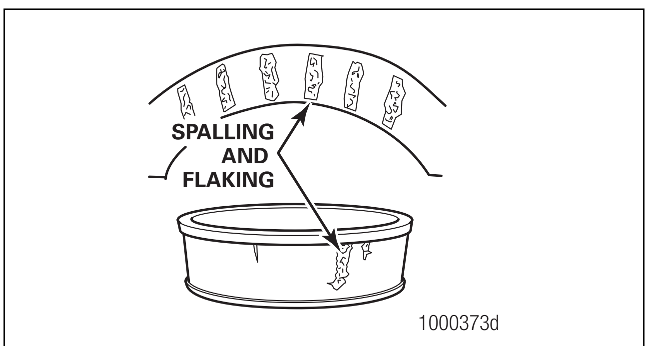


Figure 5.11

Tie Rod Grease Fittings

1. If a grease fitting is missing, install a new one. Do not install a fitting if the tie rod end is a non-greaseable design. Figure 5.12.

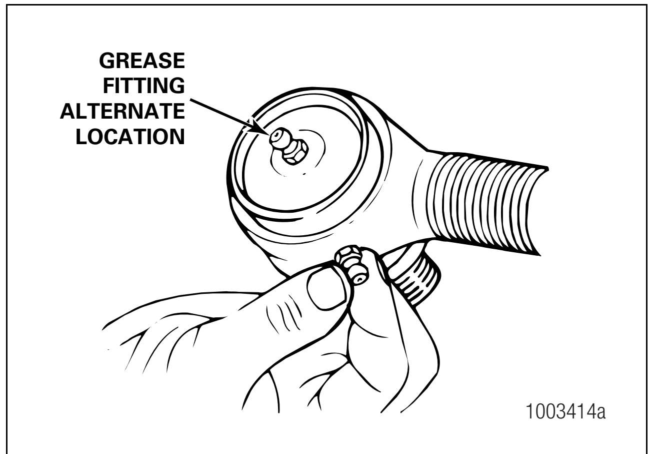


Figure 5.12

2. Tighten all grease fittings to 10 lb-ft (13.558 N•m). Figure 5.13.

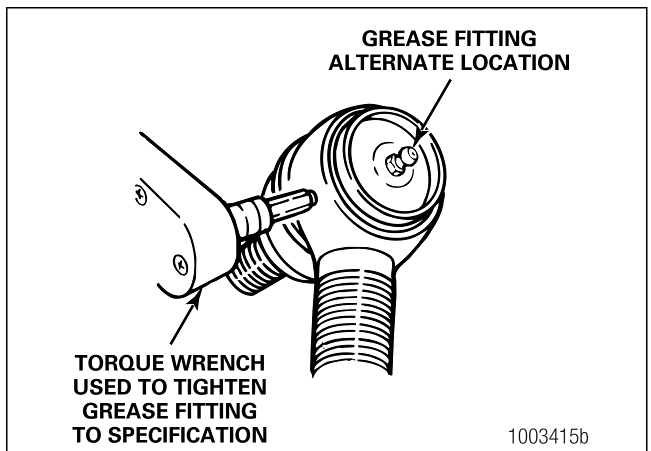


Figure 5.13

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Installation

King Pin Bushings

Nylon Bushings — Axles with Conventional Wheel Ends

1. Insert the nylon bushing into each knuckle bore by hand. The entire outer surface of the nylon bushing must be in contact with the knuckle bore.
2. Check the nylon bushing installation before attempting to install the knuckle onto the axle beam.
3. Pass the king pin through the upper and lower bores. Each nylon bushing must be fully seated in the knuckle bore.
4. The bushing lube slots must align with the grease ports in the knuckle. Figure 6.1.

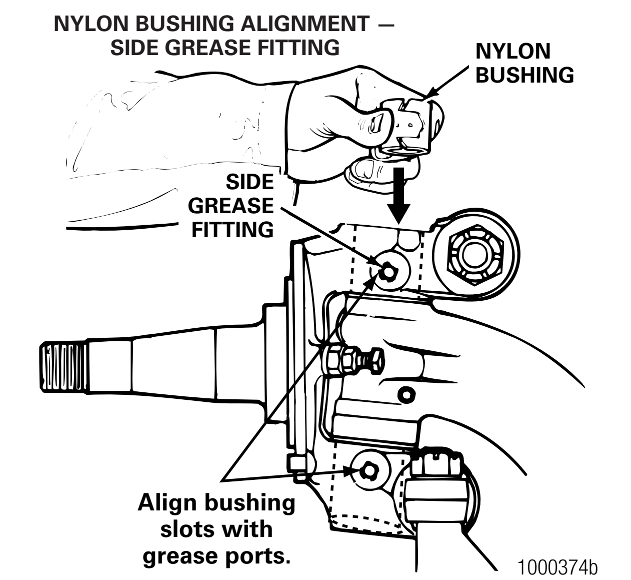


Figure 6.1

Bronze and Easy Steer™ King Pin Bushing Installation without a Press — Axles with Conventional and Unitized Wheel Ends

NOTE: For some axles you can install the bushings without a press. Use a bushing service kit to install and ream the bushings. Refer to Section 11.

Bronze and Easy Steer™ bushings have an interference fit in the knuckle bores and require a bushing installation tool. Refer to Section 11. To obtain this tool, refer to the Service Notes page on the front inside cover of this manual.

1. Place the new bushing into the upper knuckle bore. On MFS-7 and -8 front axles, the bushing hole must be aligned with the grease fitting hole in the knuckle bore. Figure 6.2.

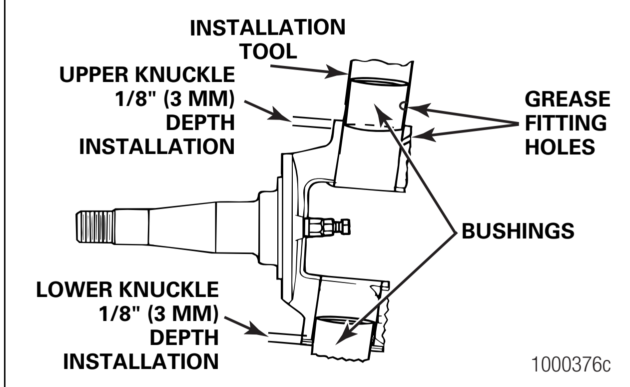


Figure 6.2

2. Use the installation tool to start the bushing 1/8-inch (3 mm) STRAIGHT into the upper bore. Figure 6.2.
   A. On Easy Steer™ bushings and for MFS axles, press the bushing to a depth of 0.352-0.382-inch (8.94-9.70 mm) below the top of the upper knuckle bore or until the grease fitting holes are aligned. Figure 6.3.
   B. On bronze bushings, press the bushing to a depth of 0.135-0.165-inch (3.5-4.0 mm) above the bottom of the upper bore. Figure 6.4.

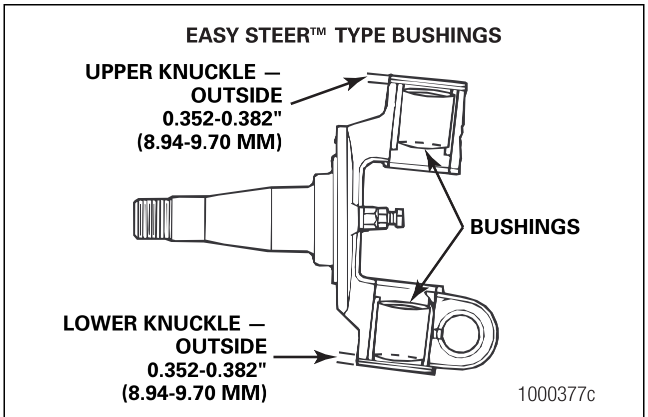


Figure 6.3

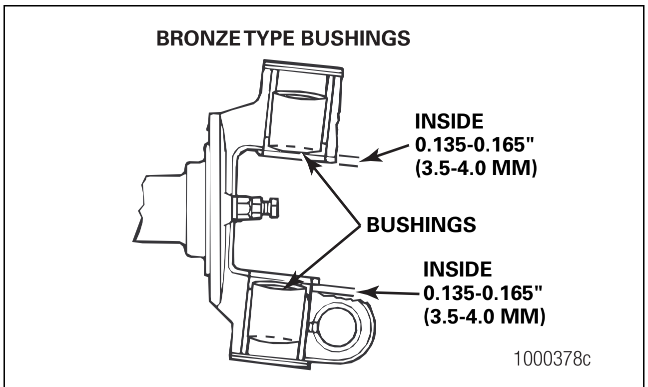


Figure 6.4

3. Turn the knuckle over so that the bottom of the knuckle is UP. The bore must be parallel to the top of the press.
4. Place the new bushing into the lower knuckle bore. On MFS-7 and -8 front axles, the bushing hole must be aligned with the grease fitting hole in the knuckle bore. Figure 6.2.
5. Use the installation tool to start the bushing 1/8-inch (3 mm) STRAIGHT into the lower bore. Figure 6.2.
   A. On Easy Steer™ bushings and for MFS axles, press the bushing to a depth of 0.352-0.382-inch (8.94-9.70 mm) below the top of the lower knuckle bore, as viewed with the knuckle upside down or until the grease fitting holes are aligned. Figure 6.3.
   B. On bronze bushings, press the bushing to a depth of 0.135-0.165-inch (3.5-4.0 mm) above the bottom of the lower bore, as viewed with the knuckle upside down. Figure 6.4.
6. Ream the bushings. Refer to procedure in this section.

Bronze and Easy Steer™ King Pin Bushing Installation with a Press — Axles with Conventional and Unitized Wheel Ends

1. Install the top king pin bushing first.

⚠ WARNING

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

2. Place the knuckle in a press with the top of the knuckle toward the top of the press. The top of the bores must be parallel to the top of the press.
3. Place the new bushing into the upper knuckle bore. On MFS-7 and -8 front axles, the bushing hole must be aligned with the grease fitting hole in the knuckle bore. Figure 6.2.
4. Use the installation tool to press the bushing 1/8-inch (3 mm) STRAIGHT into the upper bore. Release the pressure. Figure 6.2.
   A. On Easy Steer™ bushings and for MFS axles, press the bushing to a depth of 0.352-0.382-inch (8.94-9.70 mm) below the top of the upper knuckle bore or until the grease fitting holes are aligned. Figure 6.3.
   B. On bronze bushings, press the bushing to a depth of 0.135-0.165-inch (3.5-4.0 mm) above the bottom of the upper bore. Figure 6.4.
5. Turn the knuckle over so that the bottom of the knuckle is UP. The bore must be parallel to the top of the press.
6. Place the new bushing into the lower knuckle bore. On MFS-7 and -8 front axles, the bushing hole must be aligned with the grease fitting hole in the knuckle bore. Figure 6.2.
7. Use the installation tool to start the bushing 1/8-inch (3 mm) STRAIGHT into the lower bore. Release the pressure. Figure 6.2.
   A. On Easy Steer™ bushings and for MFS axles, press the bushing to a depth of 0.352-0.382-inch (8.94-9.70 mm) below the top of the lower knuckle bore, as viewed with the knuckle upside down or until the grease fitting holes are aligned. Figure 6.3.
   B. On bronze bushings, press the bushing to a depth of 0.135-0.165-inch (3.5-4.0 mm) above the bottom of the lower bore, as viewed with the knuckle upside down. Figure 6.4.
8. Ream the bushings. Refer to procedure in this section.

Ream the King Pin Bushings

Axles with Conventional and Unitized Wheel Ends — Bronze and Easy Steer™ Bushings

CAUTION

Use a fixed reamer to ream the king pin bushings. Do not hone or burnish the bushings. Damage to the bushings will result.

NOTE: Reamer tools are available from SPX Kent-Moore. Refer to Section 11. To obtain these tools, refer to the Service Notes page on the front inside cover of this manual.

1. Place the knuckle in a vise with brass jaws.
2. Slide the pilot of the reamer through the top bushing until the reamer blades touch the bushing. Figure 6.5 and Figure 6.6.

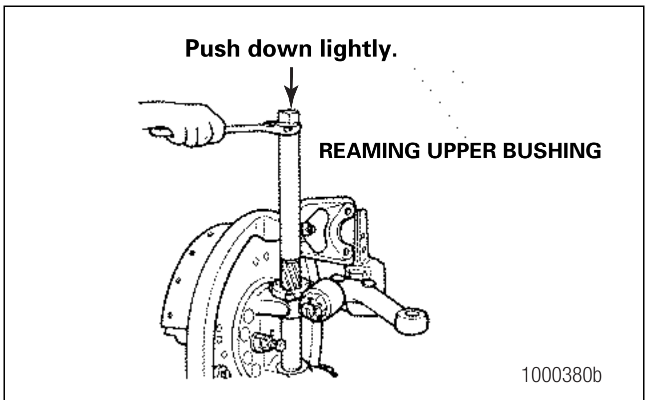


Figure 6.5

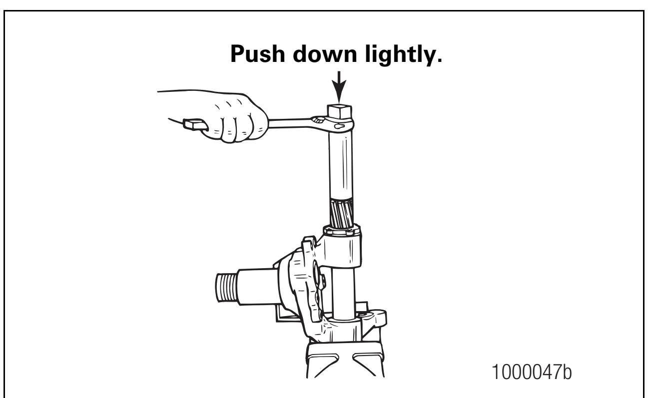


Figure 6.6

3. Rotate the reamer with a light DOWNWARD pressure. Do not apply too much force. Rotate the reamer smoothly.
4. After cutting the top bushing, guide the reamer into the bottom bushing. Do not allow the tool to drop to the bottom bushing. Repeat Step 2 and Step 3. Figure 6.7 and Figure 6.8.

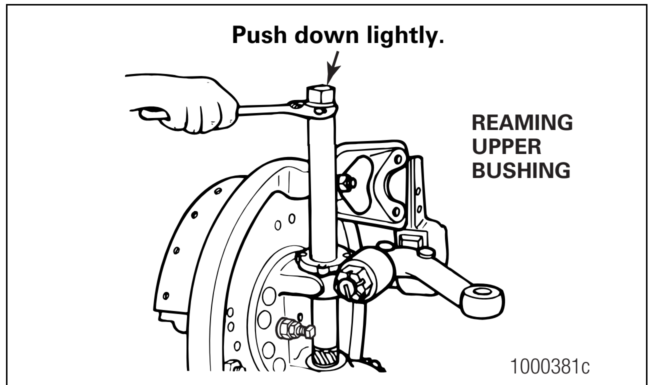


Figure 6.7

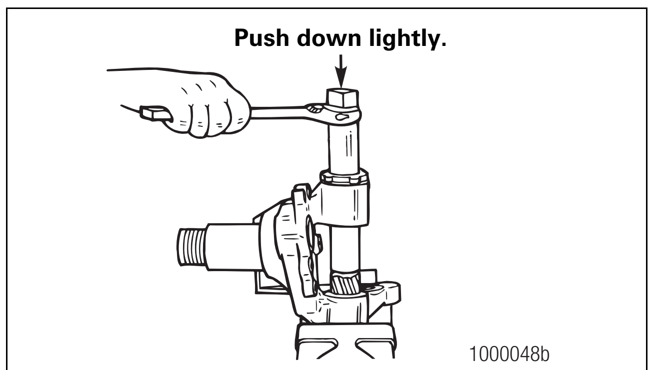


Figure 6.8

5. Slide the reamer out of the bottom bushing.
   - **If the reamer must be removed through the top bushing:** Rotate the tool in the opposite cutting direction.
6. Clean all material from the bushings.

Inner Knuckle Bore King Pin Seals

Axles with Conventional Wheel Ends

1. Place the top of the knuckle into a vise with brass jaws. The bottom of the knuckle must be TOWARD you.
2. Place the seal into the bottom of the top knuckle bore. The lip of the seal must be AWAY from the bore. Figure 6.9.

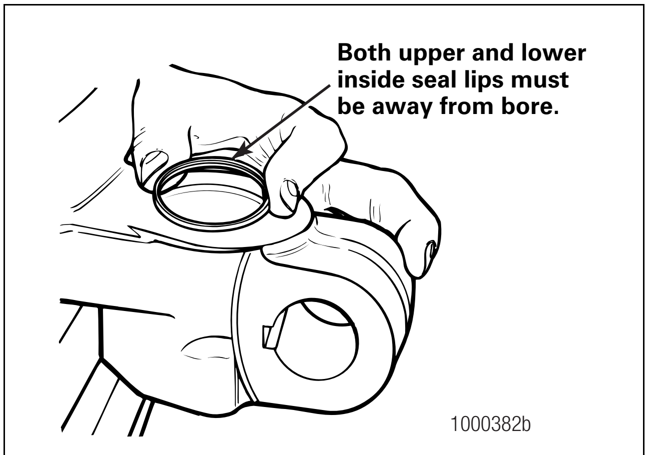


Figure 6.9

3. Place the end cap for the knuckle on top of the seal. Slide the king pin through the opposite knuckle bore. Use the king pin to install the seal. Figure 6.10.
   - **For bronze bushings:** The bottom of the seal must touch the bushing.
   - **For Easy Steer™ and nylon bushings:** The top of the seal must be even with the top of the knuckle. Figure 6.11.
4. Turn the knuckle over in the vise. The jaws of the vise must hold the bottom of the knuckle, and the top of the knuckle must be toward you.
5. Place the seal into the top of the bottom knuckle bore. The lip of the seal must be AWAY from the bore. Figure 6.9.
6. Repeat Step 3 of this procedure.

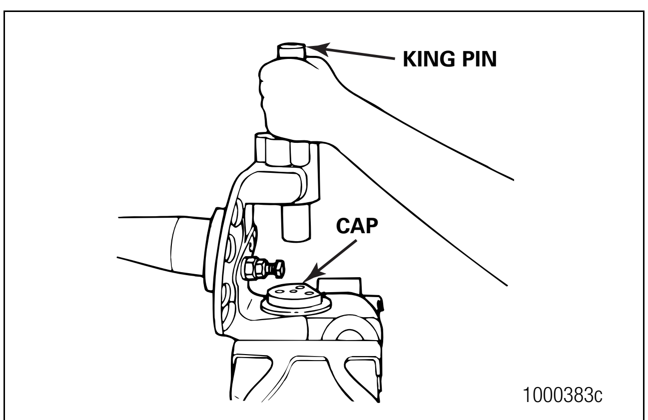


Figure 6.10

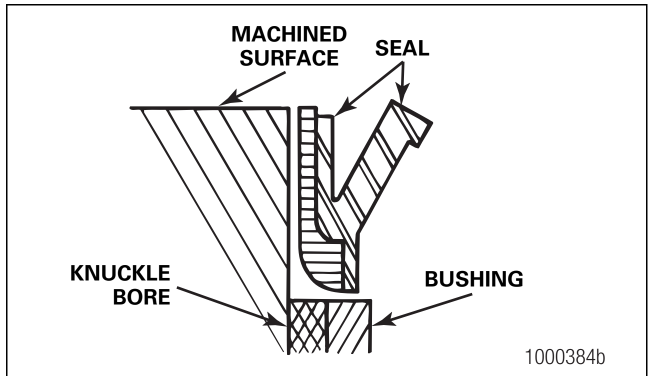


Figure 6.11

Axles with Unitized Wheel Ends

1. Turn the knuckle OVER. Place the seal lightly into the inner bore. The seal lip must be AWAY from the bore. Figure 6.11 and Figure 6.12.

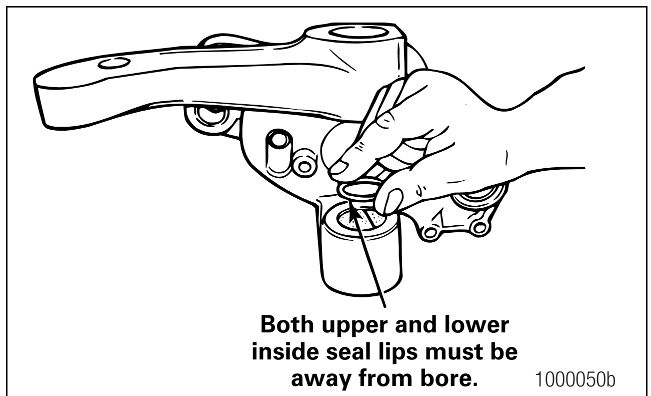


Figure 6.12

2. Use a seal installer tool to press the seal firmly into the knuckle bore. Figure 6.13.

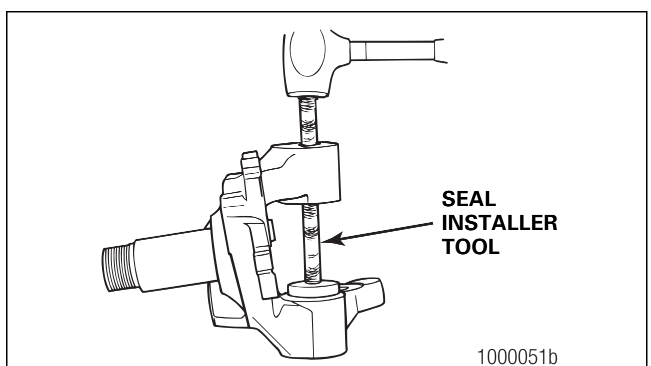


Figure 6.13

3. After installing the Easy Steer™ bushings, the top of the seal must be even with the inner machined surface of each knuckle bore. Figure 6.11.
4. Turn the knuckle over to the UP position. Place the seal lightly into the inner bore. The seal lip must be AWAY from the bore. Figure 6.11.
5. Use a seal installer tool to press the seal firmly into the knuckle bore. Figure 6.13. The top of the seal must be even with the inner machined surface of each knuckle bore. Figure 6.11.

Knuckle to the Axle Beam

⚠ WARNING

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off. Serious personal injury and damage to components can result.

Axles with Conventional Wheel Ends

1. Clean the bores of the knuckle and the axle beam.

   NOTE: The one-piece thrust bearing with an integrated grease seal is completely interchangeable with the two-piece design. It has a specified top and bottom orientation.

2. Install the seal onto the thrust bearing. Figure 6.14. The surface with the inner diameter seal must be on the top. The surface with the outer diameter seal must be on the bottom. Figure 6.15.
   A. On cover-type seals: Install the seal over the open end of the bearing.
   B. On flat-type seals: Install the seal over the closed part of the bearing.

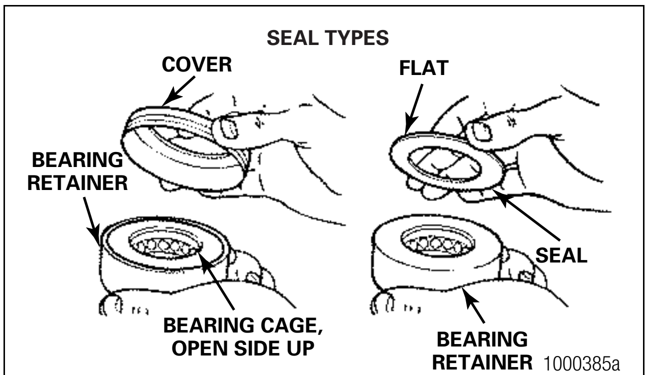


Figure 6.14

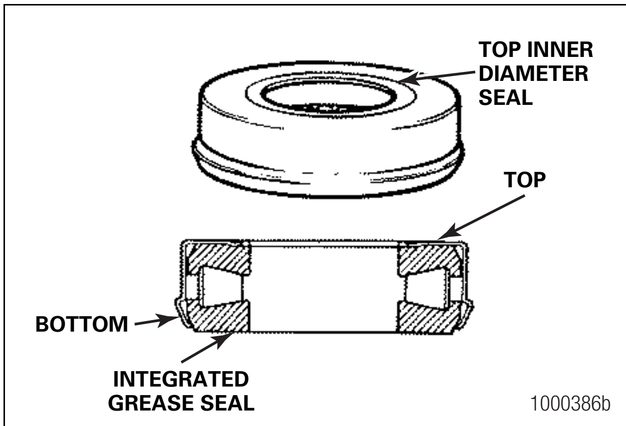


Figure 6.15

3. Install the seal and thrust bearing assembly on the inner knuckle. The seal must face UPWARD toward the beam. The top inner diameter will contact the bottom of the axle beam. Figure 6.16.

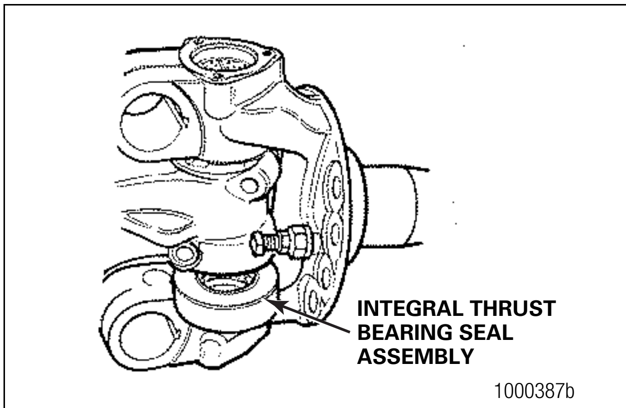


Figure 6.16

⚠ WARNING

Wear gloves when you install the shims. Shims have sharp edges that can cause serious personal injury.

4. Inspect the shims for damage before installation.
   A. Replace damaged shims with the same size shims, or in combination, that allow the least amount of knuckle end play.
   B. If a new shim pack is required, select the amount of shims that will give the least amount of end play.

5. After inspection, place the shims on top of the axle beam bore machined surface. Align the shims for king pin installation.
6. Place the knuckle onto the axle beam.
7. Place a pry bar between the steering arm boss and the axle beam. Lift the knuckle and slide the shim pack between the top of the beam and the knuckle. Figure 6.17.

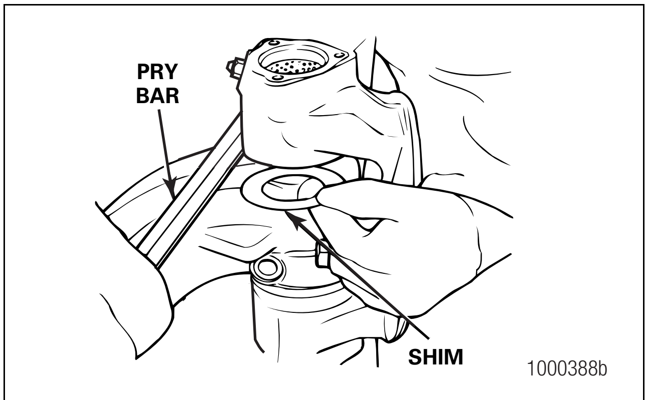


Figure 6.17

8. Align all the bores. If the bores are not aligned, the parts will be damaged when the king pin is installed.
9. Remove the pry bar.
10. Before installing the king pin into the top of the knuckle, apply the multi-purpose grease onto the bottom half of the king pin.
11. Verify that you can see the word "TOP," which is stamped on the king pin. Figure 6.18.

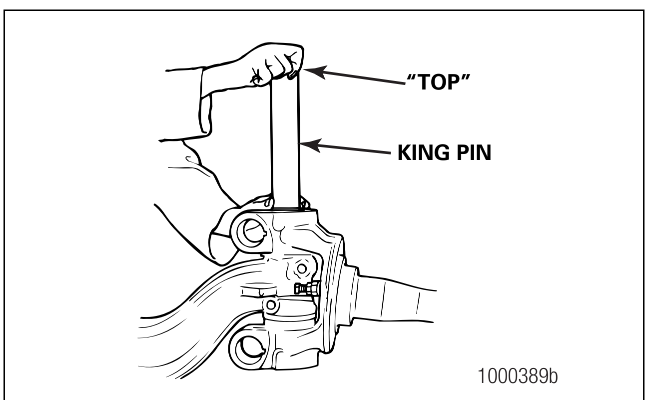


Figure 6.18

12. Rotate the king pin so that the two draw key slots of the pin correctly align with the draw key slots in the knuckle.
13. Install the king pin into the TOP of the knuckle and through the area where the shims are located. Do not force the pin through the top bushing.
14. If required, use a hammer and a brass drift to apply direct force to the king pin for seating it into the lower knuckle bore.
15. Seat the top draw key into the front of the beam. Refer to Table E. Seat the bottom draw key into the back of the beam by striking it with a hammer and drift. The keys must align with the slots of the king pin. Do not install or tighten the locknuts before checking the knuckle end play. Figure 6.19.

Table E: Threaded or Plain Draw Keys

Threaded Draw Keys	Plain Draw Keys
All other axle models	FC-901, FC-921, FE-970, FF-971 and FL-901

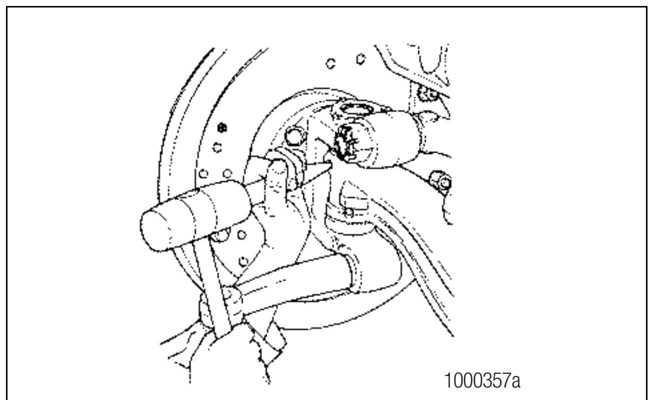


Figure 6.19

Axles with Unitized Wheel Ends

1. Clean the bores of the knuckle and axle beam.

⚠ WARNING

Wear gloves when you install the shims. Shims have sharp edges that can cause serious personal injury.

2. Inspect the shims for any damage before installation.
   A. Replace damaged shims with same size shims, or in combination, that allow the least amount of knuckle end play.
   B. If a new shim pack is required, select the amount of shims that will give the least amount of end play.

3. After inspection, place the shims on top of the axle beam bore machined surface. Align the shims for king pin installation. Figure 6.20.

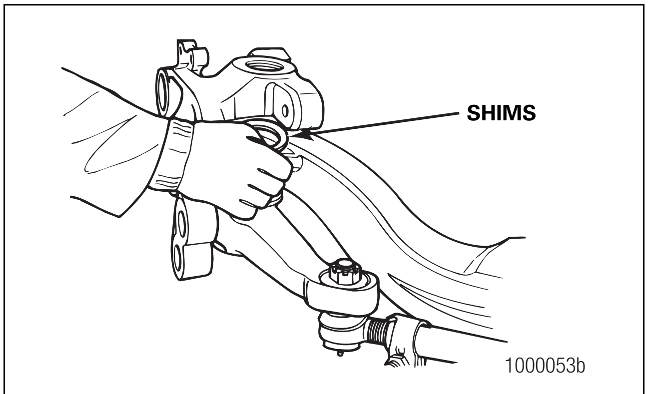


Figure 6.20

4. Place the knuckle onto the axle beam.

NOTE: The one-piece bearing with an integrated grease seal is completely interchangeable with the two-piece design. It has a specific top and bottom orientation.

5. Slide the thrust bearing and seal assembly between the bottom knuckle bore and the bottom of the axle beam. The surface with the inner diameter seal must be on the top. The surface with the outer diameter seal must be on the bottom. Figure 6.21 and Figure 6.22.
   - The shims must not move out of position above the axle beam bore.
   - The integral thrust bearing seal assembly must be positioned with the inner diameter seal on top and the flanged bottom down.
   - All the bores must be aligned with the king pin area. If the bores are not aligned, the parts will be damaged when the king pin is installed.

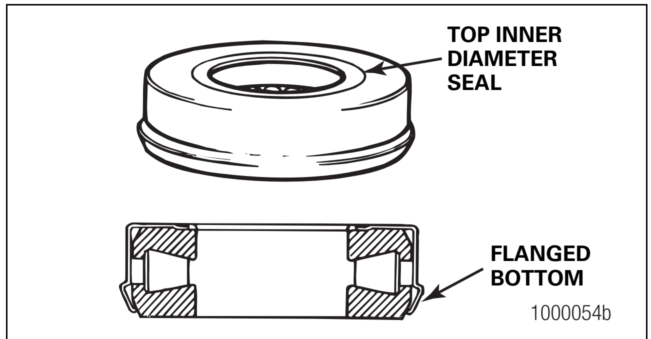


Figure 6.21

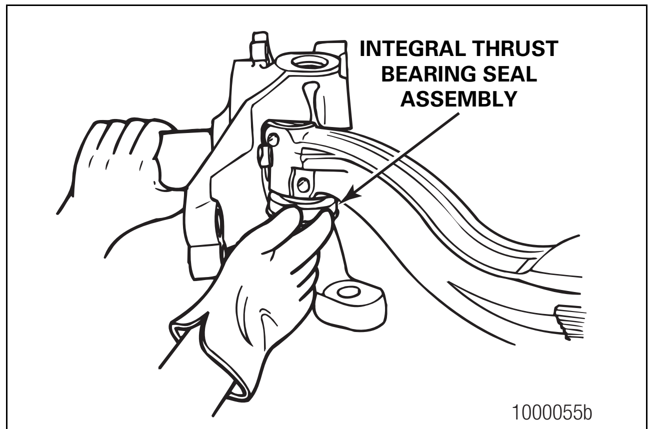


Figure 6.22

6. Before installing the king pin into the top of the knuckle, apply the multi-purpose grease onto the bottom half of the king pin.
7. Verify that you can see the word “TOP,” which is stamped on the king pin. Figure 6.23.

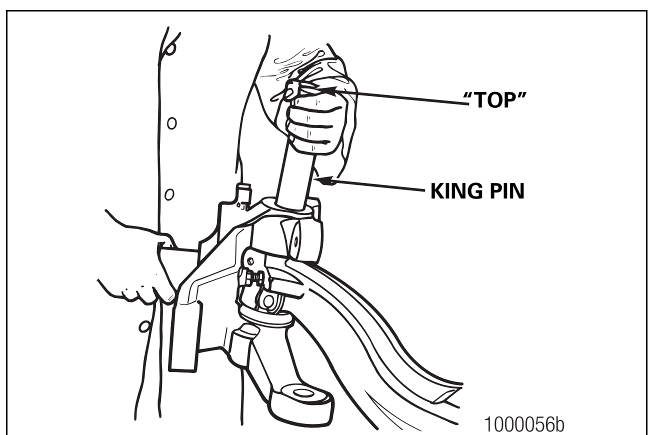


Figure 6.23

8. Rotate the pin so that the two draw key slots of the pin correctly align with the draw key holes in the knuckle.
9. Install the king pin into the top of the knuckle and through the area where the shims are located.
10. Use a hammer and a brass drift to apply direct force to the king pin for seating it into the lower knuckle bore.
11. Seat the top draw key into the front of the beam. Seat the bottom draw key into the back of the beam by striking it with a hammer and drift. The keys must align with the slots of the king pin. Do not install or tighten the locknuts.
12. Check the knuckle end play. Refer to procedure in this section.

Check Steer Knuckle Vertical End Play

Table F: End Play Specifications

New or Rebuilt Axles	0.001-0.010-inch (0.025-0.254 mm)
In-Service Axles	0.001-0.030-inch (0.025-0.762 mm)

Axles with Conventional Wheel Ends

1. Strike the boss of the knuckle with a rubber mallet to move the parts into position. Figure 6.24.

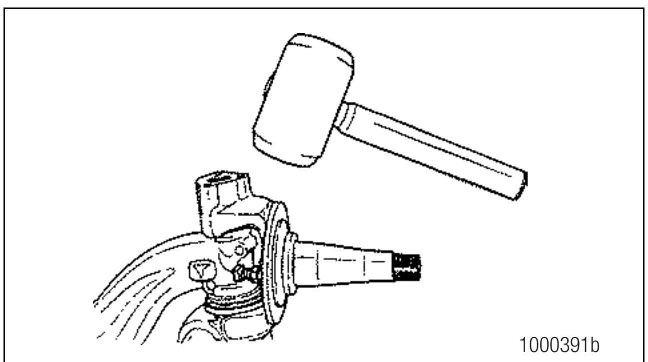


Figure 6.24

2. Turn the knuckle to the straight-ahead position.
3. Attach a dial indicator. Place the base onto the knuckle. Place the tip onto the center of the king pin. Set the dial indicator to ZERO. Figure 6.25.

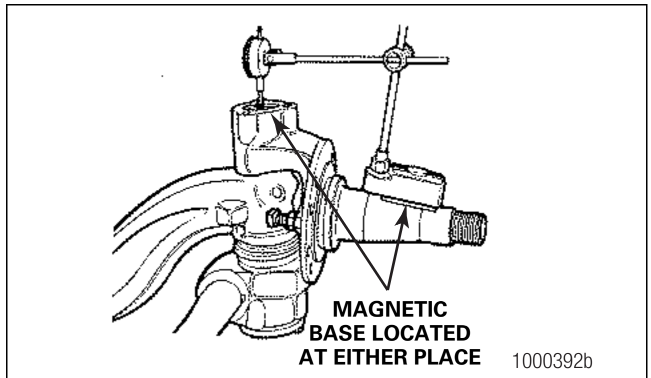


Figure 6.25

4. Use one of the following methods to measure the end play.
   - Place a pry bar between the knuckle and the top of the axle center. Push the knuckle up and measure the end play. Figure 6.26.
   - Place a block of wood and a hydraulic jack under the bottom of the knuckle. Raise the knuckle until the pointer on the dial indicator stops. Figure 6.27.

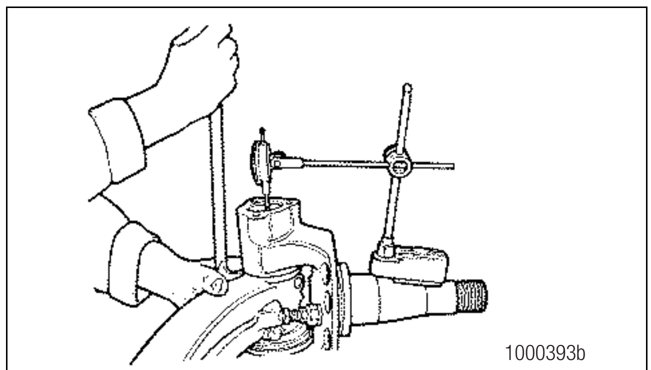


Figure 6.26

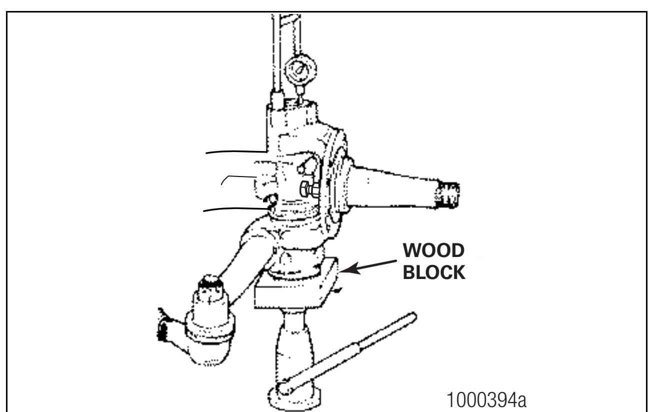


Figure 6.27

5. Repeat Step 3 and Step 4 with the axle in the full RIGHT and full LEFT positions.
6. Record the reading on the dial indicator.
   - **If the knuckle binds or ZERO end play is measured:** Remove the shims from the shim pack.
   - **If the reading is more than the correct specification shown in Table F:** Add shims to the shim pack.

Axles with Unitized Wheel Ends — Curbside Knuckle End Play

1. Turn the wheels to the STRAIGHT position. Secure the dial indicator base onto the axle beam.
2. Place the dial indicator tip onto the upper king pin cap.
3. Place a jack and a wood block, with a hole that allows clearance for the lower king pin grease fitting, under the lower king pin cap area.
4. Set the dial indicator to ZERO.
5. Raise the jack until the axle beam is slightly raised from the safety stands. Measure and record the dial indicator reading. Figure 6.28.

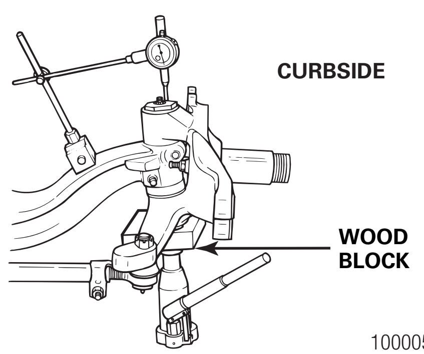


Figure 6.28

Axles with Unitized Wheel Ends — Driver Side Knuckle End Play

1. Turn the wheels to the STRAIGHT position. Remove the king pin cap.
2. Install a dial indicator with the base on the steering arm. Place the dial indicator tip onto the exposed king pin top.
3. Set the dial indicator to ZERO.
4. Raise the jack until the axle beam is slightly raised from the safety stands. Measure and record the dial indicator reading. Figure 6.29.
   - **If the end play is within allowable specifications:** Install the draw key lock nuts.
   - **If the reading is ZERO:** Excessive stress is placed on the bearing. Remove the knuckle and remove shims from the shim pack. Determine a thinner shim pack.
   - **If the reading is more than the correct end play specifications shown in Table F:** Remove the knuckle. Add shims to the shim pack.

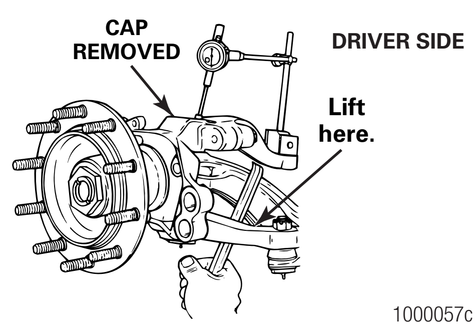


Figure 6.29

Draw Key Lock Nuts

⚠ WARNING

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off. Serious personal injury and damage to components can result.

⚠ CAUTION

Verify that the draw key is installed completely or the lock nut is tightened to 30-45 lb-ft (41-61 N•m). If not installed correctly, the king pin and the axle beam will be damaged.

Table G identifies the axles equipped with plain draw keys.

Table G: Threaded or Plain Draw Keys

Threaded Draw Keys	Plain Draw Keys
All other axle models	FC-901, FC-921, FE-970, FF-971 and FL-901

Plain Draw Keys — Axles with Conventional and Unitized Wheel Ends

Use a hammer and a brass drift to install the draw key into the axle beam and knuckle. The key must be installed 1/32-1/8-inch (1-3 mm) below the outer surface of the beam. Figure 6.30.

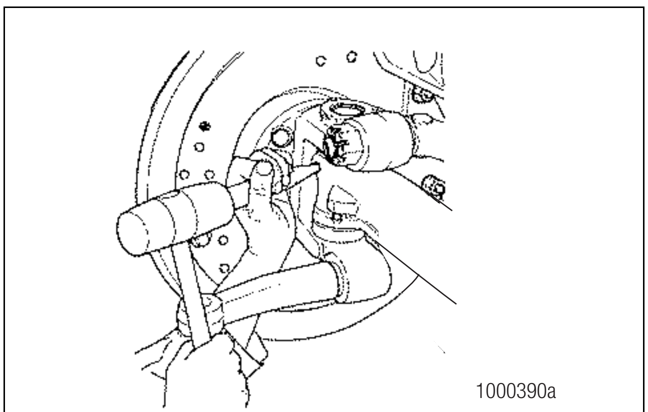


Figure 6.30

Threaded Draw Keys — Axles with Conventional and Unitized Wheel Ends

Install the lock nut and tighten it to 30-45 lb-ft (41-61 N•m). Figure 6.31 and Figure 6.32.

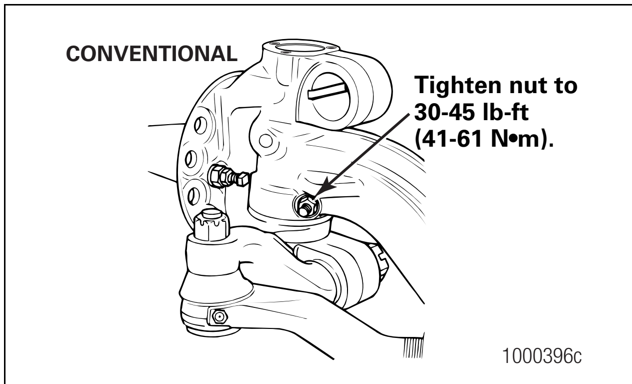


Figure 6.31

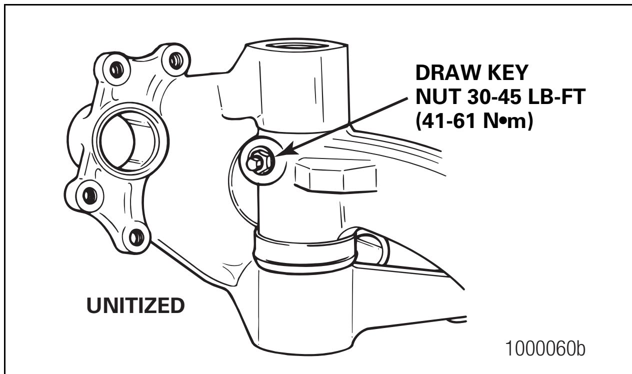


Figure 6.32

King Pin Caps

Bolt-On King Pin Caps

1. Install new gaskets and the caps onto the top and the bottom of the knuckle. Install the capscrews and the washers and tighten to 20-30 lb-ft (28-40 N•m). Figure 6.33.

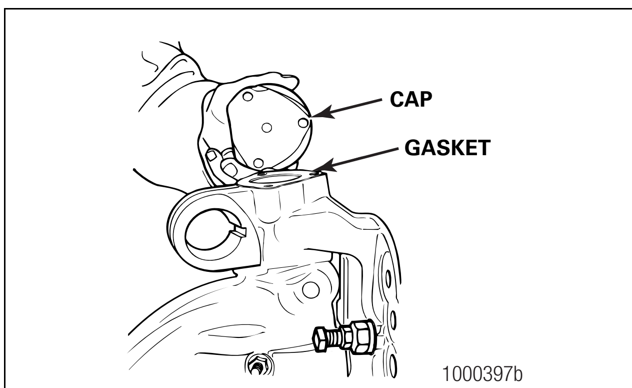


Figure 6.33

2. Connect the tie rod arm to the knuckle. Refer to procedure in this section.

Threaded King Pin Caps

⚠ WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

1. Apply the sealant, part number 2297-D-7076, onto the threads. To obtain these supplies, refer to the Service Notes page on the front inside cover of this manual.
2. Install the threaded king pin caps onto the top and the bottom of the knuckle.
3. Tighten the king pin caps to 70-90 lb-ft (95-120 N•m). Figure 6.34.

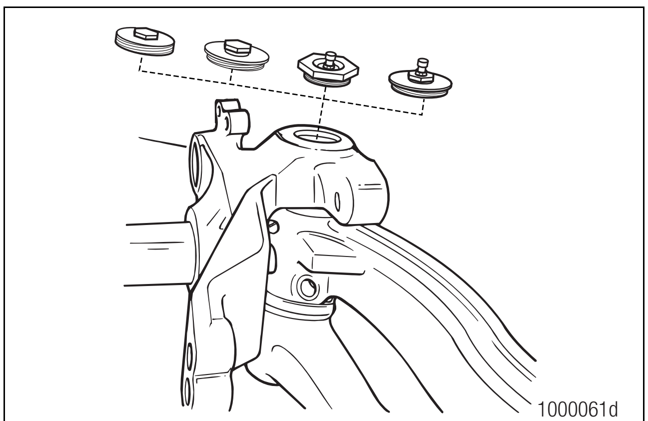


Figure 6.34

4. Connect the tie rod end assembly to the integral knuckle arm. Refer to procedure in this section.

Steering Arm

Axles with Keyed Steering Arm

1. Press the key into the slot in the arm. Install the steering arm into the knuckle. Figure 6.35.

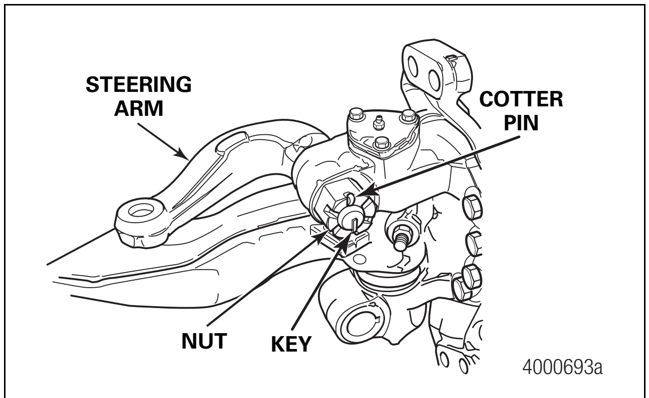


Figure 6.35

2. Install the nuts. Tighten to the specified torque. Refer to Section 10.
3. Install the cotter pins. If necessary, tighten the nut until the holes are aligned. Do not loosen the nut to install the cotter pin.
4. Lubricate the drag link end that connects to the steering arm. Refer to Section 9.
5. Check for correct operation.

Axles with Bolt-On Steering Arm

⚠ WARNING

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin. If Loctite® adhesive material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

1. Use a wire brush to remove old Loctite® adhesive from capscrew bolts and internal threads of the knuckle. Reapply Meritor specification 2297-C-7049 liquid adhesive or Loctite® 680 adhesive. At least half of the thread area must be covered.
2. Insert the bolts through the steering arm. Hand-start the bolts into the knuckle assembly. Figure 6.36.
3. Tighten the arm bolts to the following specification.
   - **MFS-6 axles:** 215-265 lb-ft (290-360 N•m)
   - **MFS-7 or MFS-8 axles:** 360-470 lb-ft (490-638 N•m)
   - **All other axles:** 300-450 lb-ft (406-610 N•m)

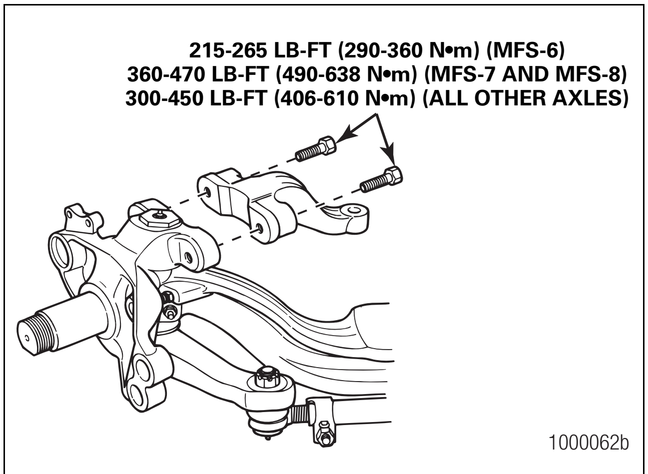


Figure 6.36

Install the Tie Rod Ends Into the Cross Tube

NOTE: The cross tube has right-hand threads on the right side of the vehicle and left-hand threads on the left side of the vehicle.

The replacement cross tube must be the same length and diameter as the original tube. Use the thread count as a guide. Install the tie rod ends into the threaded cross tube ends to the approximate depth marked during the tie rod assembly removal. Figure 6.37.

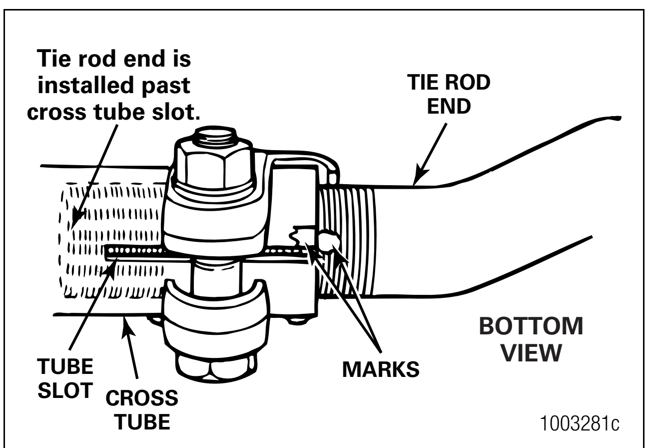


Figure 6.37

If you are installing new tie rod ends, thread the tie rod ends to the approximate original depth inside the cross tube. Figure 6.38.

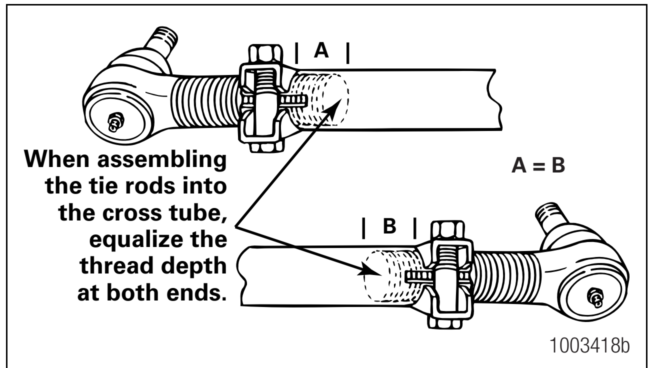


Figure 6.38

Both tie rod ends must be installed into the cross tube deeper than the end of the cross tube slot. Figure 6.37.

1. Verify that the tab on the clamp is firmly seated against the end of the cross tube.
2. Install the nuts and the bolts into the clamps. Tighten to the specified torque. Refer to Section 10.
   - **If the tab on the clamp is tack-welded:** Do not remove the tack weld. If you remove the tack weld, you will reduce the clamping force.

Tie Rod Arms, Tie Rod Ends and Cross Tube Assembly

Axles with Removable Tie Rod Arms

NOTE: If a different size tie rod arm is installed, the steering geometry is changed and may cause tire wear. Contact the ArvinMeritor Customer Service Center at 800-535-5560.

1. Press the key into the slot in the arm. Install the tie rod arm into the knuckle. Figure 6.39.

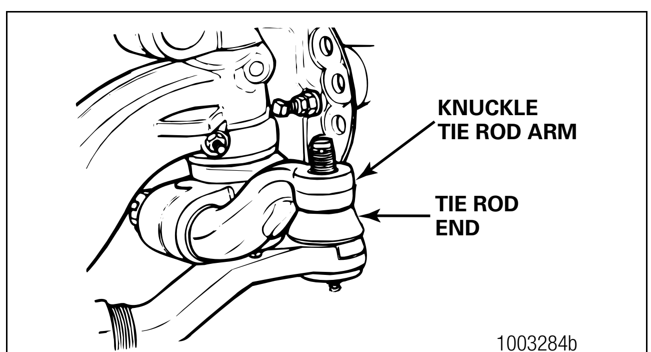


Figure 6.39

2. Install the nut onto the tie rod arm. Tighten to the specified torque. Refer to Section 10.
3. Install the cotter pins. If necessary, tighten the nut slightly, increasing the final torque value until the holes are aligned. Do not loosen the nut to install the cotter pin.

NOTE: The cross tube has right-hand threads on one end and left-hand threads on the other end.

4. If removed, install the tie rod ends into the cross tube to the position marked during removal. Figure 6.40. Thread the ends equally into the cross tube to the required length.

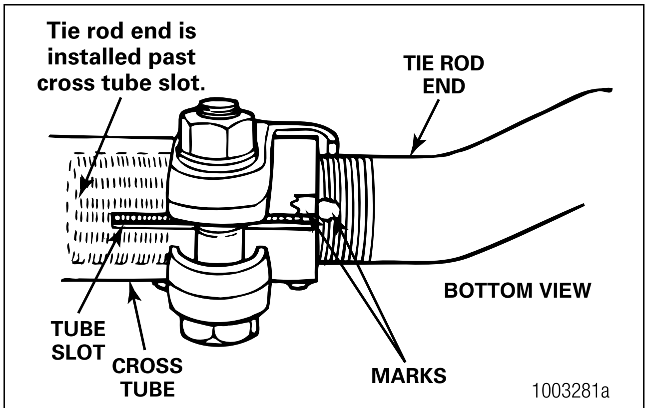


Figure 6.40

5. Install the nuts and the bolts into the clamps. Tighten to the specified torque. Refer to Section 10. Figure 6.40.
6. Rotate the cross tube clamp to remove the nuts and bolts from the clamp. Tighten the nut to engage the locking element of the nut with the bolt. The clamp and tie rod end must be free to rotate. The clamp tab must be firmly seated against the cross tube. Figure 6.41.
7. Check the tie rod boot for cracks, tears or other damage. Also check the boot seals for damage. Replace the entire tie rod end if the boot is damaged or missing.
8. Clean and dry the tie rod taper and the tie rod arm taper hole.
9. Install the tie rod ends into the tie rod arms. The threaded portion of the tie rod end must be installed into the cross tube beyond the end of the slot. The clamp tab must be firmly seated against the cross tube.
10. Install the nuts onto the tie rod ends. Tighten to the specified torque. Refer to Section 10.

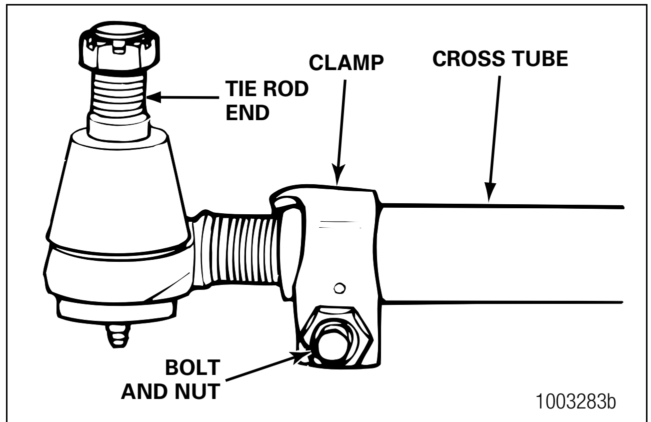


Figure 6.41

11. Install the cotter pins. If necessary, tighten the nut until the holes are aligned. Do not loosen the nut to install the cotter pin.
12. Check and, if necessary, adjust the toe. Refer to Section 7.

Cross Tube and Tie Rod Ends

Axles with Integral Tie Rod Arms

NOTE: The cross tube has right-hand threads on one end and left-hand threads on the other end.

1. If the tie rods have been removed, reinstall the tie rod ends into the cross tube to the position marked during removal. Thread the ends equally into the cross tube to the required length. Figure 6.42.

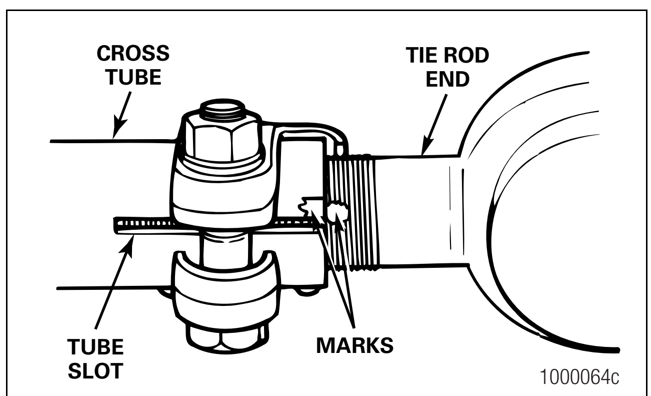


Figure 6.42

2. Install the nuts and the bolts into the clamps. Tighten to the specified torque. Refer to Section 10.

3. Rotate the cross tube clamp to remove the nuts and bolts from the clamp. Tighten the nut to engage the locking element of the nut with the bolt. The clamp and tie rod end must be free to rotate. The clamp tab must be firmly positioned against the cross tube. Figure 6.43.

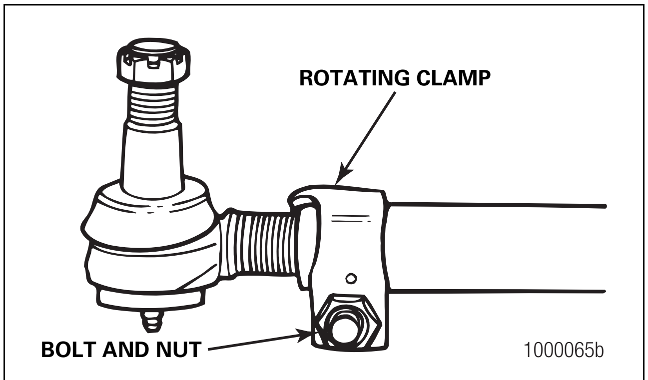


Figure 6.43

4. Clean and dry the tie rod end taper and the tie rod arm taper hole. Figure 6.44.

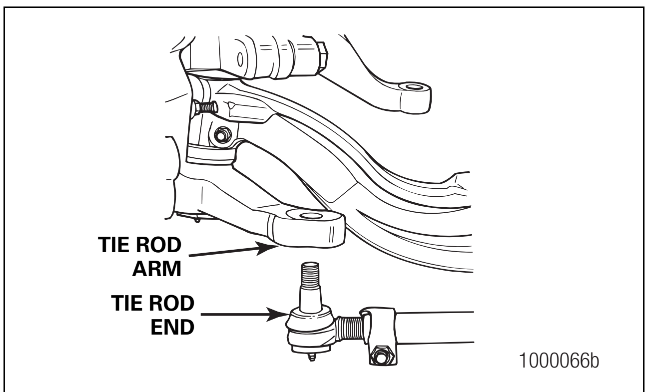


Figure 6.44

5. Install the tie rod ends into the tie rod arm. The threaded portion of the tie rod end must be installed into the cross tube beyond the end of the cross tube slot. Figure 6.42.
6. Install the nuts onto the tie rod ends. Tighten to the specified torque. Refer to Section 10.
7. Install the cotter pins. If necessary, tighten the nut until the holes are aligned. Do not loosen the nut to install the cotter pin.
8. Check and, if necessary, adjust the toe. Refer to Section 7.

Replace the Studs on a Unitized Wheel End

⚠ WARNING

Do not use a hammer to remove or install studs. A hammer can cause impact damage to the bearing raceway, which will reduce bearing life. Serious personal injury and damage to components can result.

Ensure that you do not damage stud threads during installation procedures. Damaged threads will not allow the stud to provide the required clamp to support the wheel retention system. The wheels can loosen and separate from the vehicle. Serious personal injury and damage to components can result.

NOTE: These procedures apply to axles with a barrel spindle, integral tie rod arms and sealed hub units.

If a stud is stripped and needs replacement, use one of the following procedures.

Preferred Method — Replacing Studs with the Hub Installed on the Vehicle

⚠ WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Raise the vehicle so that the front wheels are off the ground. Support the vehicle with safety stands.
3. Mark the wheel and hub relationship. Remove the wheel and tire assembly. Use a paint stick to mark the wheel studs you are removing. Figure 6.45. Do not reuse the studs.

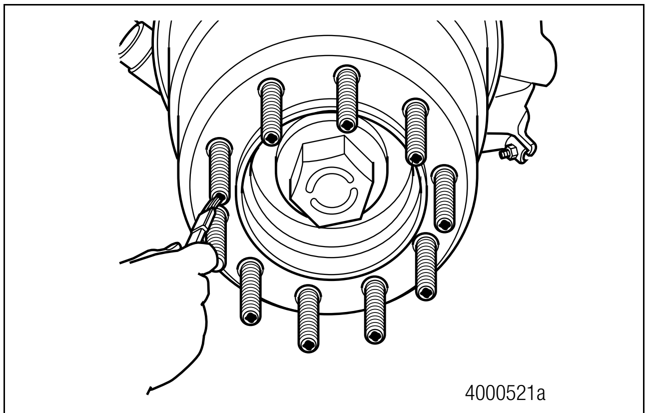


Figure 6.45

4. If necessary, back off the brake at the slack adjuster until the brake shoes retract and the drum clears the linings. Figure 6.46.

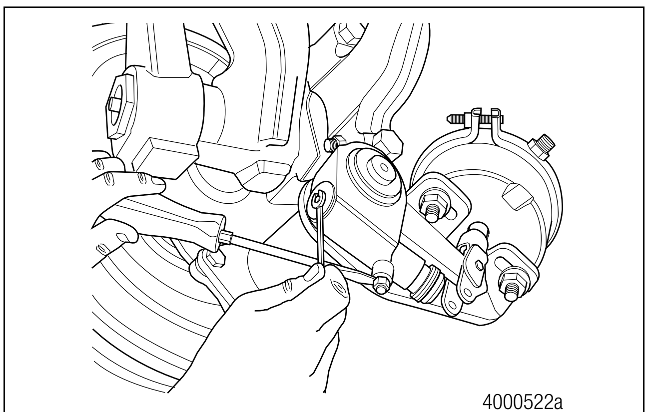


Figure 6.46

5. Remove the brake drum. Figure 6.47.

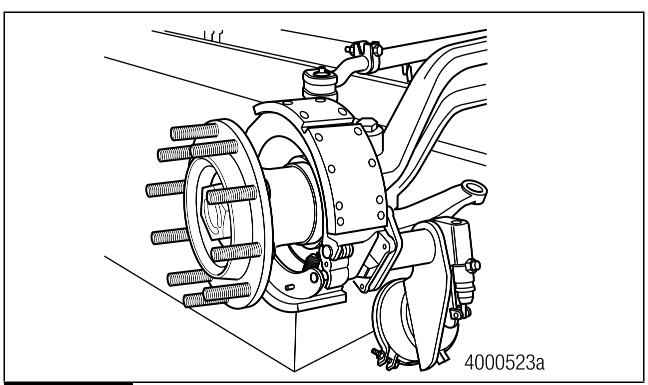


Figure 6.47

6. Use a 1/2-inch (12.7 mm) drive impact wrench and a ball joint removal kit to remove the studs. Figure 6.48.

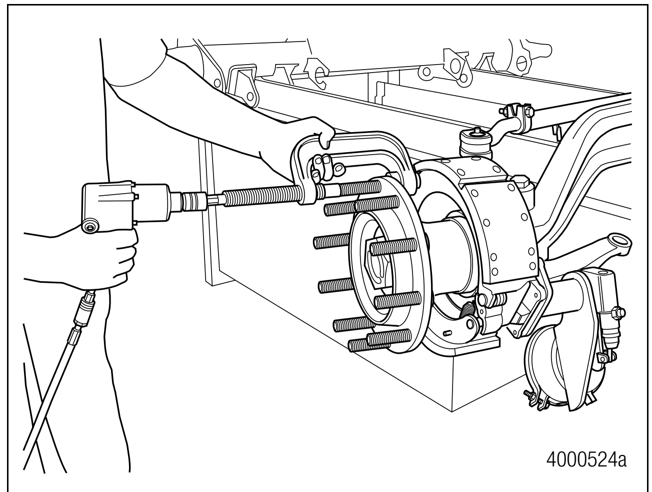


Figure 6.48

7. Use a crocus cloth to clean all the flat surfaces on the wheel and hub.

8. Position the new studs into the hub. Align the stud knurls with the impressions in the hub stud hole. Figure 6.49.

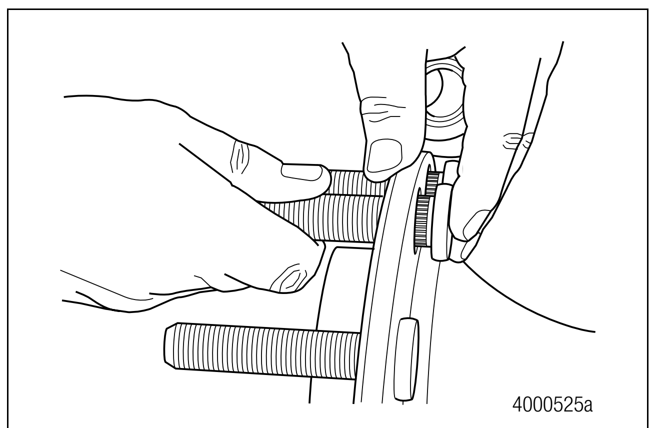


Figure 6.49

⚠ WARNING

Do not lubricate studs or nut threads. Lubricants will not enable you to tighten fasteners correctly, which causes excessive clamp load. Studs can break and cause wheels to loosen and separate from the vehicle. Serious personal injury can result.

9. Add two drops of oil between the body and flange on the stud nuts. Do not use more than two drops of oil. Figure 6.50.

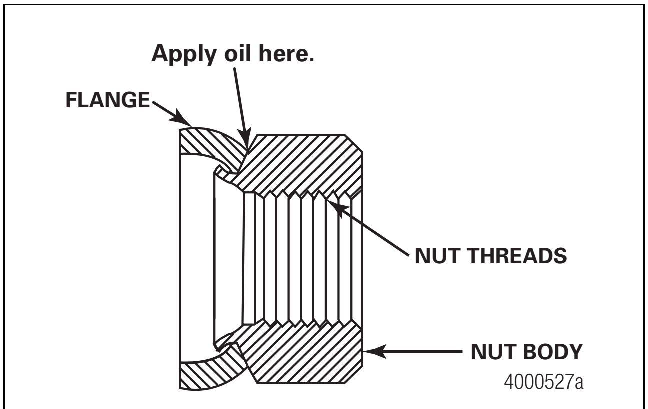


Figure 6.50

⚠ WARNING

Install nuts with the correct thread size on the studs. A nut with an incorrect thread size will not turn freely on the stud or will fit loosely on the stud. The thread can strip, which can cause loss of clamp load. The wheels can loosen and separate from the vehicle. Serious personal injury and damage to components can result.

10. Position the nuts onto the studs. Use a 1/2-inch (12.7 mm) drive impact wrench to draw the stud into the hub. Do not exceed 300 lb-ft (408 N•m). Figure 6.51 and Figure 6.52. Ⓣ

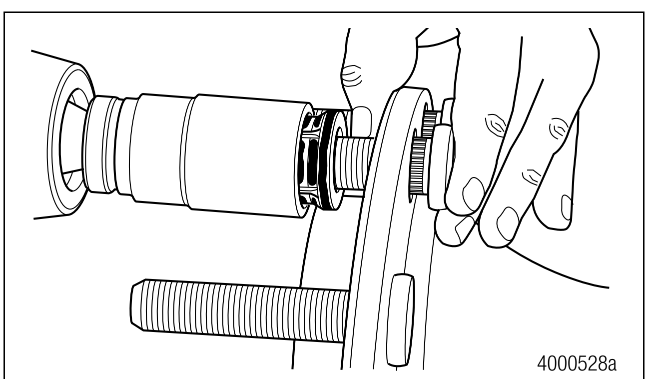


Figure 6.51

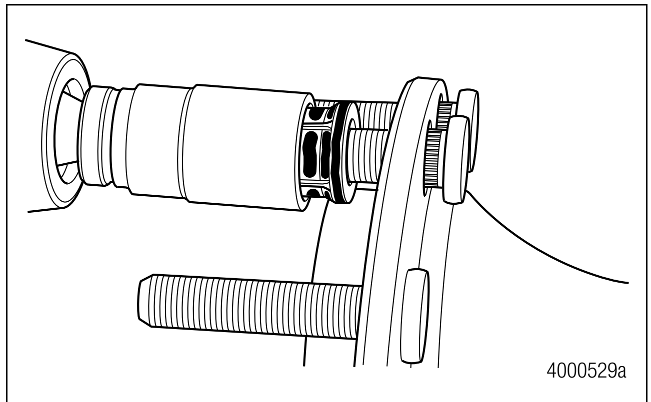


Figure 6.52

11. Use a 0.0015-inch (0.0381 mm) feeler gauge to check that the stud is correctly seated. Figure 6.53.
    - **If the stud is not correctly seated:** Remove the stud, clean all surfaces and install a new stud as described previously.
    - **If the stud is still not correctly seated:** Replace the hub.

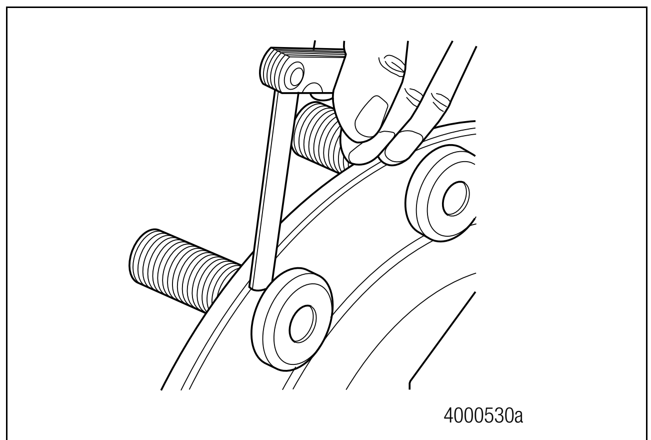


Figure 6.53

12. Remove all the nuts. Install the wheel and tire assembly.
13. Discard all removed studs.

Alternate Method — Replacing Studs with the Hub Removed from the Vehicle

1. Remove the unitized wheel end from the spindle. Refer to Section 4.
2. Support the inboard side of the flange adjacent to the stud head and perpendicular to the press cylinder.

⚠ WARNING
Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

3. Use a press on the threaded end of the stud to force the stud out of the flange. Discard all removed studs.
4. Turn over the unitized wheel end. Support the outboard side of the flange close to the stud hole and perpendicular to the press cylinder.
5. Use a press on the stud head applying no more than 10,000 pounds (4540 kg) of force to seat the new stud.
6. Install the unitized wheel end. Refer to procedure in this section.

Unitized Wheel End

⚠ WARNING
Use only dye penetrant inspection techniques on unitized wheel-end hub units. Be careful not to get penetrant fluids in the bore of the hub unit. Do not use fluid immersion-based crack inspection techniques. The fluids can enter the joint between the inner bearing cones through the bore of the hub unit and damage the lubricant. Serious personal injury and damage to components can result.

1. Inspect and replace any parts that are worn, cracked or damaged. Check for cracks using dye penetrant, magnetic flux or fluorescent particle testing methods. Follow the manufacturer's procedures.
2. Clean the unitized wheel-end inner bore and spindle with a clean, dry rag. Do not apply solvent.
3. Check the bore of the unitized wheel end for any obstructions and check the spindle for any nicks or burrs.

   NOTE: The spindle O-ring, Meritor part number 5X-1301 contained in Kit 1433, makes it easier for you to remove the unitized wheel-end hub from the spindle because it helps to prevent contaminants from entering the assembly. When you remove the unitized wheel-end hub, install a new O-ring.

4. Coat the new O-ring with a thin coat of Meritor part number 2297-C-8297 or Dow Corning Molykote D to assist in installing the O-ring.

⚠ WARNING
Do not apply anti-seize or anti-fretting compound to spindle threads. These compounds decrease a fastener assembly's capability to maintain clamp load, which can cause wheels to loosen and separate from the vehicle. Serious personal injury and damage to components can result.

5. Coat the inside of the unitized wheel end with anti-seize compound. Make certain to cover the inner and outer bearing races. Do not apply anti-seize or anti-fretting compound onto the spindle or threads. Wipe away any anti-seize or anti-fretting compound that may have dripped onto the spindle threads.
6. Slide a new O-ring, Meritor part number 5X-1301, onto the spindle. The O-ring must be positioned against the knuckle journal. Figure 6.54.

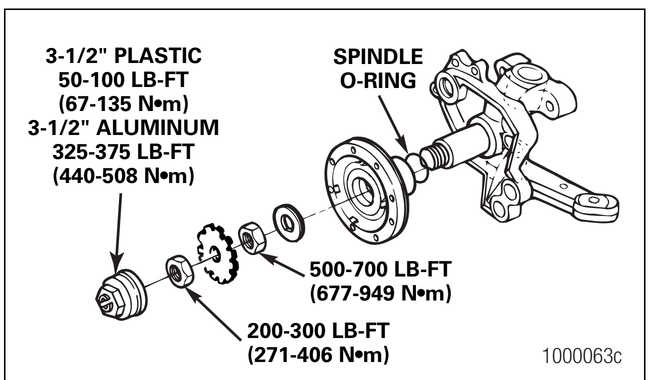


Figure 6.54

⚠ CAUTION

Align the unitized wheel end STRAIGHT onto the spindle. Do not allow the assembly to misalign and contact the spindle threads. Bearing damage can occur that requires replacement of the entire unitized wheel end.

7. Carefully align the unitized wheel-end bore with the spindle and slide the unitized wheel end STRAIGHT onto the spindle.
   - **If the unitized wheel end does not slide on easily:** Do not force it onto the spindle. The unitized wheel end can become jammed on the spindle if it is not aligned correctly with the spindle.
   - **If the unitized wheel end becomes jammed on the spindle:** Carefully remove the unitized wheel end from the spindle so that the inner bearings do not disassemble or loosen from the unitized wheel end.
8. Install the inner "D" washer and inner wheel bearing nut onto the spindle stud. Tighten the inner wheel bearing nut to 500-700 lb-ft (678-949 N•m) while rotating the unitized wheel end a minimum of five rotations. Figure 6.54.
9. Install the tabbed washer and outer wheel bearing nut onto the spindle. Tighten the outer wheel bearing nut to 200-300 lb-ft (271-406 N•m).

   NOTE: The inner wheel bearing nut and the outer wheel bearing nut are identical, but the torque values are different.

10. Bend the parts of the tabbed washer that protrude over the flats of the outer wheel bearing nut and the inner wheel bearing nut. Bend the washer a minimum of one flat edge to each nut.

Hubcaps

NOTE: Threaded plastic and metal hubcaps are interchangeable. Snap-ring and threaded hubcaps are not interchangeable.

Threaded Plastic Hubcaps

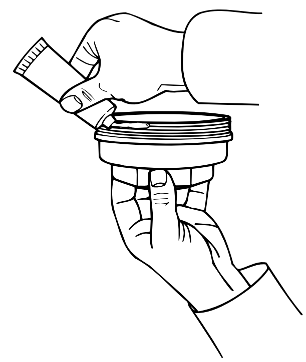
NOTE: It is not necessary to remove residual Loctite® sealant from the original hubcap installation.

1. Wipe the inner truck hub unit threads with a clean shop cloth. Do not use compressed air, solvents or power washers to clean the hub unit threads.
   - **To remove grease or mud from the exposed inner threads:** Use a wire brush to remove grease or mud from the inner hub unit threads. Wipe the inner threads with a clean shop cloth.

⚠ WARNING

Only use RTV sealant (Meritor part number 2297-Z-7098, Loctite® adhesive sealant number 5699) when you service a unitized wheel-end assembly. Do not use any other brand of RTV sealant, which can cause corrosion, damage and incompatibility between unitized wheel-end components. Serious personal injury and damage to components can result.

2. Apply a continuous 1/8-3/16-inch (3-5 mm) bead of RTV sealant to the outside first thread around the entire circumference of the hubcap. You must use Meritor part number 2297-Z-7098 RTV sealant, Loctite® adhesive sealant number 5699. Figure 6.55.



1003399b

Figure 6.55

3. Install the plastic hubcap into the unitized wheel end by hand.
4. Use a torque wrench with the correct size socket to tighten plastic hubcaps to 50-100 lb-ft (67-135 N•m). Disregard the torque value embossed on the hubcap. Refer to Table H.

Table H: Threaded Hubcaps

Threaded plastic hubcap	RTV sealant (Meritor part number 2297-Z-7098 RTV sealant, Loctite® adhesive sealant number 5699)	50-100 lb-ft (67-135 N•m)
Metal (aluminum) hubcap		325-376 lb-ft (440-508 N•m)

Metal (Aluminum) Hubcaps

1. Clean the INNER unitized wheel-end threads and threaded hubcap external threads with a wire brush. Apply Meritor part number 2297-Z-7098 RTV sealant, Loctite® adhesive sealant number 5699, to the hubcap threads.
2. Turn the hubcap by hand until it's seated.
3. Use a torque wrench with the correct size socket to tighten the hubcap to 325-375 lb-ft (440-508 N•m). Refer to Table H.

Reusing the Threaded Hubcaps

If you observe any of the following conditions while tightening a used hubcap, replace the hubcap with a new one.

- The hubcap "jumps" threads and makes a popping sound while you're tightening it.
- The hubcap begins to yield because threads are stripped.
- You cannot achieve the correct torque specification of 50-100 lb-ft (67-135 N•m) for plastic hubcaps or 325-375 lb-ft (440-508 N•m) for metal hubcaps.

Snap-Ring Hubcaps — Hub Puller and Screwdriver Method

There are two methods for installing a hubcap with a snap ring. You can either use a hub puller and flat-blade screwdriver, or a punch and mallet.

1. Install the hubcap into the hub unit by hand. Figure 6.56.

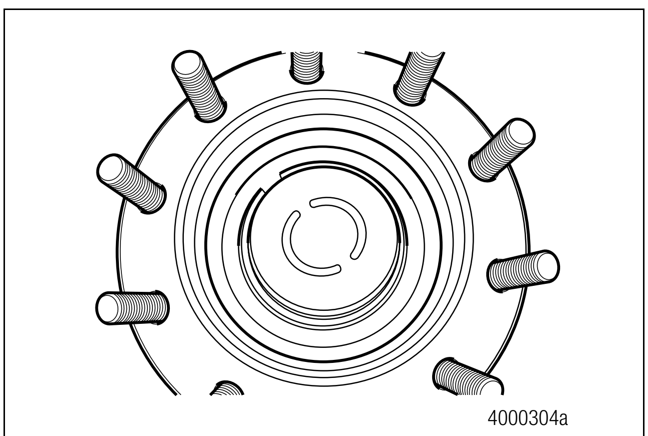


Figure 6.56

2. Insert the square end of the snap ring into the recess of the hubcap. Press the snap ring into position. This will seat the snap ring flat against the hubcap flange.
3. Use a wrench and the hub puller to install the hubcap into the hub unit. Figure 6.57.

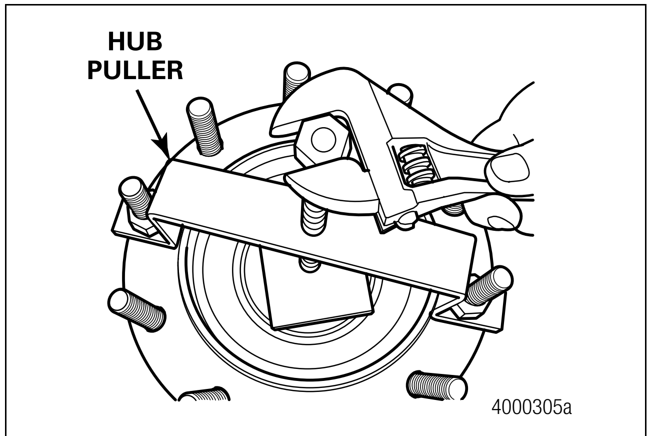


Figure 6.57

4. Position a hub puller over the hubcap. Use a steel spacer between the hubcap and the hub puller threaded stud to avoid scratching the hubcap surface.
5. Use a screwdriver to install the snap ring into the hub unit groove. Press the end of the snap ring and continue around the entire length of the snap ring. Figure 6.58.
6. Verify that the snap ring is correctly seated in the groove.

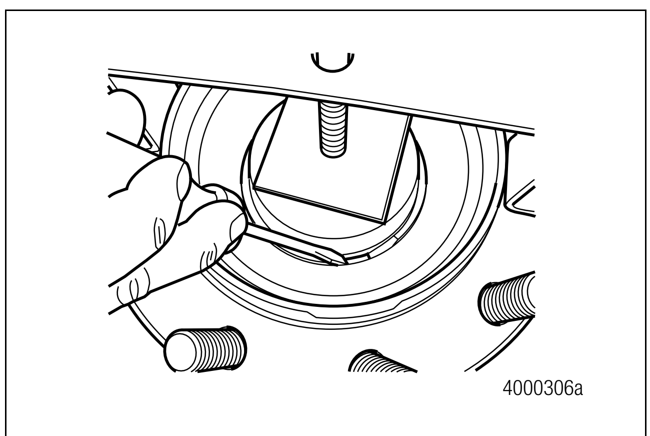


Figure 6.58

Snap-Ring Hubcaps — Punch and Mallet Method

1. If a hub puller is not available, install the hubcap into the hub unit by hand. Figure 6.56.
2. Insert the square end of the snap ring into the recess of the hubcap. Press the snap ring into position. This will seat the snap ring flat against the hubcap flange.

   NOTE: Don't use a steel hammer to install and seat the snap ring. You'll damage the hubcap. Use a dead-blow mallet.

3. Use a punch to apply pressure to the opening end of the snap ring. Strike the hubcap several times with a dead-blow mallet at the same time.
4. Move the punch CLOCKWISE around the snap ring to install it into the hub unit groove.
5. Strike the hubcap several times with a dead-blow mallet to fully seat the snap ring.

Drag Link

Refer to the vehicle manufacturer's procedures. Figure 6.59

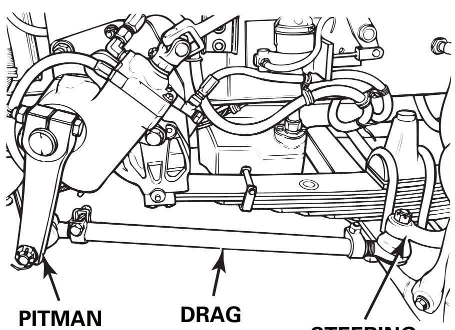


Figure 6.59

Brake Components and Wheel Ends

Axles with Conventional Wheel Ends

1. Install the brake assembly onto the knuckle. Refer to the vehicle manufacturer's procedures. Lubricate the wheel bearings. Refer to Section 9.
2. Install the outer wheel bearing cone into the hub. Install the adjusting nut.
3. Adjust the wheel bearings. Refer to Section 7. Refer to the wheel-end hardware manufacturer's procedures if necessary.
4. Install the cap and the gasket onto the hub. Install the capscrews and tighten to 20-30 lb-ft (27-41 N•m).
5. Install the wheel and tire assembly. Lower the vehicle to the ground. Check for correct operation.
6. Check and adjust the toe. Refer to Section 7.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Inspection

Inspection Before Alignment

Parts

Refer to Section 3 in this manual.

Wheels and Tires

1. Verify that the tires are inflated to the specified pressure.
2. Verify that the front tires are the same size and type.
3. Verify that the lug nuts are tightened to the specified torque.
4. Verify that the wheels are balanced.
5. Check for bent or damaged wheels.

Front Suspension

1. Verify that all fasteners are tightened to the specified torque.
2. Inspect the leaf springs for wear and damage.
3. Inspect the shock absorbers for wear and damage.

Rear Axle and Rear Suspension

Front tire wear can be caused by the rear axle. If the outer edge of one front tire is worn and the inner edge of the other front tire is worn, check the following.

1. All fasteners are tightened to the specified torque.
2. The leaf springs are not worn or damaged.
3. The bushings in the leaf springs are not worn or damaged.
4. The torque rods, if used, are correctly adjusted.
5. The frame is not bent.
6. The rear axle, especially a tandem axle, is correctly aligned. Refer to the vehicle or the suspension manufacturer's procedure.
7. Refer to any additional rear axle and suspension recommendations and specifications from the vehicle manufacturer.

Alignment

Front Wheel Alignment

Check the front wheel alignment:

1. Every 200,000 miles (320 000 km) or 24 months (normal maintenance).
2. When the vehicle does not steer correctly.
3. To correct a tire wear condition.

Minor Front Wheel Alignment

Perform a minor front wheel alignment for all normal maintenance conditions using the following procedure.

1. Inspect all systems that affect the wheel alignment. Refer to procedure in this section.
2. Check and adjust the wheel bearings or wheel bearing end play for the unitized wheel end.
3. Check and adjust the toe.

Major Front Wheel Alignment

Perform a major front wheel alignment to correct steering and tire wear conditions using the following procedure.

1. Inspect all systems that affect the wheel alignment. Refer to procedure in this section.
2. Check and adjust the wheel bearings. For models with unitized wheel ends, check wheel bearing end play for the unitized wheel end. Refer to Section 3.
3. Check and adjust the maximum turn angle.
   - **If the vehicle has power steering:** Check and adjust the pressure relief in the power steering system. Refer to procedure in this section.
4. Check and adjust the turning radius angle. Refer to procedure in this section.
5. Check the king pin, or steering axis, inclination. Refer to procedure in this section.
6. Check the camber angle. Refer to procedure in this section.

⚠ CAUTION

Replace damaged or out-of-specification axle components. Do not bend, repair or recondition axle components by welding or heat-treating. A bent axle beam reduces axle strength, affects vehicle operation and voids Meritor's warranty. Serious personal injury and damage to components can result.

7. Check and adjust the caster angle. Refer to procedure in this section.
8. Check and adjust the toe. Refer to procedure in this section.

Check and Adjust

Wheel Bearings

The most accurate bearing end play measurement is obtained with the brake drum and tires removed.

- **If the brake drum and tires are installed and the bearing end play is greater than 0.003-inch (0.0762 mm):** Remove the brake drum and the tire-wheel assembly. Recheck bearing end play.

⚠ WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Set the parking brake.
2. Raise the vehicle so that the wheels are off the floor. Support the vehicle with safety stands.
3. Remove the capscrews and remove the gasket and the cap from the hub.
4. Verify that the brake drum and the hub fasteners are tightened to the manufacturer's specifications.
5. Attach a dial indicator with the magnetic base at the bottom of the hub or the brake drum. Adjust the dial indicator so that the pointer is against the center of the knuckle. Set the dial indicator on ZERO. Figure 7.1.

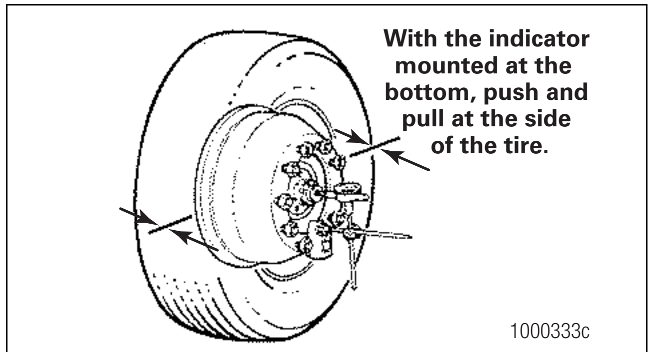


Figure 7.1

NOTE: Do not push or pull at the top and bottom of the hub or drum, which can affect the end play measurement.

6. Measure the end play by pushing and pulling on each side of the hub or drum while looking at the dial indicator. The end play is the total travel observed.
   - **If the end play is 0.001-0.005-inch (0.025-0.127 mm):** The bearings do not need adjustment.
   - **If the end play is not 0.001-0.005-inch (0.025-0.127 mm):** Adjust the wheel bearings. Figure 7.1.
7. **On double nut and lock fasteners:** Bend the lock washer off the wheel bearing nut. Remove the wheel bearing nut, the lock washer and the pierced lock ring. Figure 7.2.

   On single nut fasteners: Remove the cotter pin from the adjusting nut. Figure 7.3.

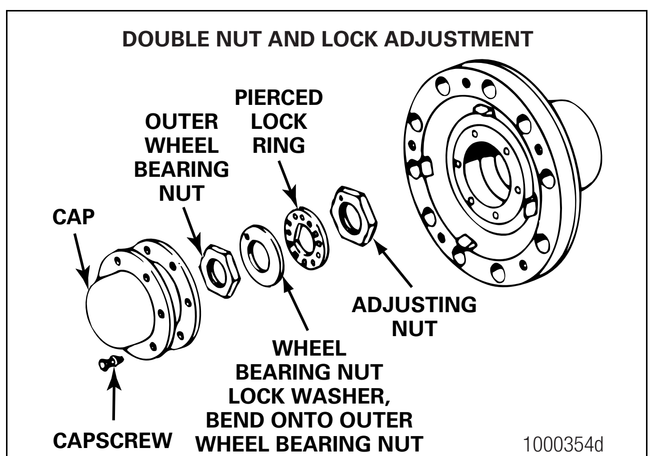


Figure 7.2

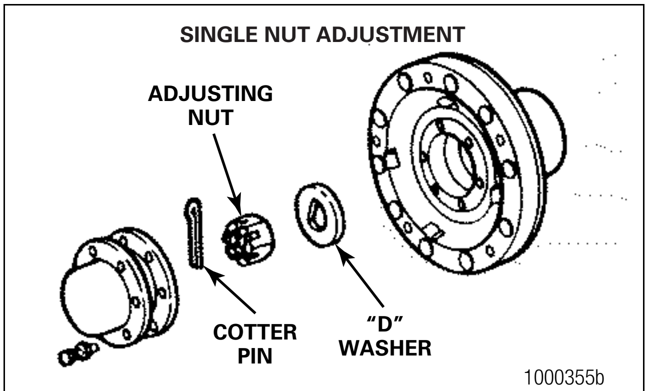


Figure 7.3

⚠ WARNING

Use a torque wrench to tighten or loosen adjusting nuts. Do not use a hammer to directly hit adjusting nuts, or to hit a chisel or drift placed against them. Damaged adjusting nuts can prevent you from obtaining correct wheel bearing end play, which can affect vehicle operation and cause the wheels to separate from the vehicle. Serious personal injury and damage to components will result.

8. Use a torque wrench to tighten the adjusting nut to 100 lb-ft (136 N•m) while rotating the tire in both directions. Figure 7.4.
9. Loosen the nut completely. Tighten the nut to 20 lb-ft (27 N•m) while rotating the tire. Figure 7.4.

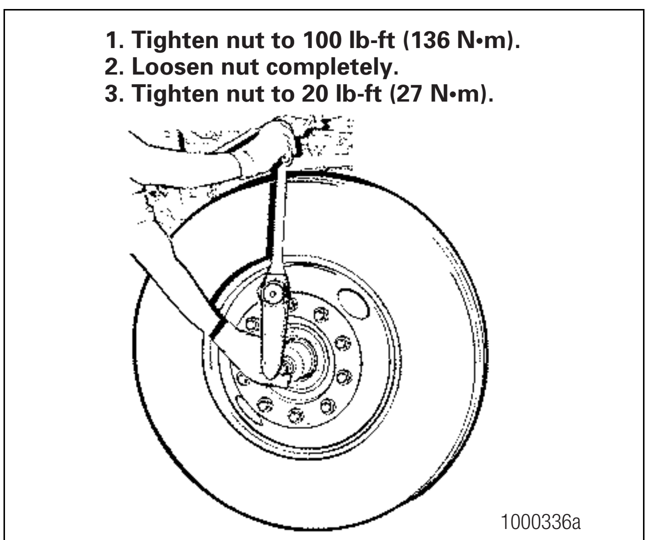


Figure 7.4

10. For axles with single nut fasteners, perform the following procedure.
    A. Back off the adjusting nut 1/8 turn. Figure 7.5.
    B. Rotate the nut in either direction to line up a slot with the closest cotter pin hole in the spindle.
    C. Install a new cotter pin into the nut.
    D. Measure the end play. The end play must be 0.001-0.005-inch (0.025-0.127 mm). Refer to Step 4 and Step 5. Readjust if necessary.

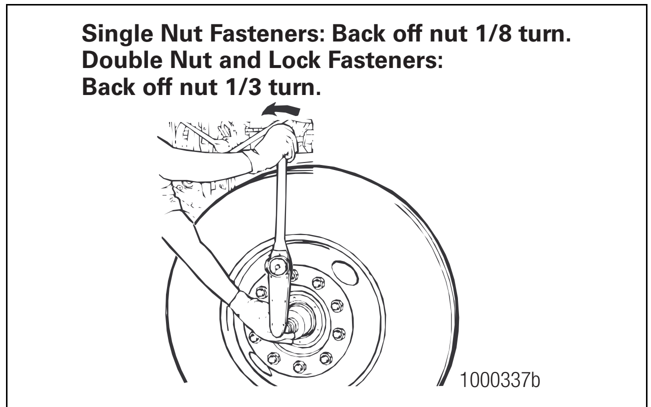


Figure 7.5

11. For axles with double nut and lock fasteners, perform the following procedure.
    A. Back off the adjusting nut 1/3 turn. Figure 7.5.
    B. Install the pierced lock ring, the lock washer and the wheel bearing nut.
       - **For 1-1/8-inch (2.86 cm) wheel bearing nuts used on MFS-06, MFS-07 and MFS-08 Series axles:** Tighten to 150-225 lb-ft (203-305 N•m).
       - **For wheel bearing nuts from 1-1/8-inches to 2-5/8-inches (2.86-6.67 cm):** Tighten to 200-300 lb-ft (271-407 N•m).
       - **For wheel bearing nuts 2-5/8-inches (6.67 cm) or more:** Tighten to 250-400 lb-ft (339-542 N•m).
    C. Measure the end play. The end play must be 0.001-0.005-inch (0.025-0.127 mm). Refer to Step 4 and Step 5. Readjust if necessary.
       - **If the end play is to specification:** Bend the washer to at least one flat edge of the outer wheel bearing nut. Figure 7.2.

12. Install the gasket and the cap onto the hub. Install the capscrews and tighten to 20-30 lb-ft (27-41 N•m).
13. Lower the vehicle to the ground. Check for correct vehicle operation.

Adjustment

Maximum Turn Angle

CAUTION

Do not exceed the maximum turn angle specified by the vehicle manufacturer. If the angle is exceeded, the steering arms, the cross tube and the tie rod ends will be damaged.

The stop bolt on the back of the knuckle controls the maximum turn angle. If the stop bolt is missing, bent or broken, the system requires adjustment. Use the mechanical stop in the steering system to adjust the pressure relief.

Check the angle if the front tires rub against the frame or if the steering gear has been serviced. Use an alignment machine to check the angle. Refer to the alignment equipment manufacturer's procedures.

- **For power steering systems:** The stop bolt should NOT touch the beam. The stop bolt should always have a minimum clearance of 1/8-inch (3 mm) when the knuckle is in the full-turn position as shown in Figure 7.6 and Figure 7.7.
- **For manual steering systems:** The stop bolt should always have a minimum clearance of 1/8-inch (3 mm). Stop bolt contact is acceptable if no other stops are used for the maximum turn angle of the steering knuckle.

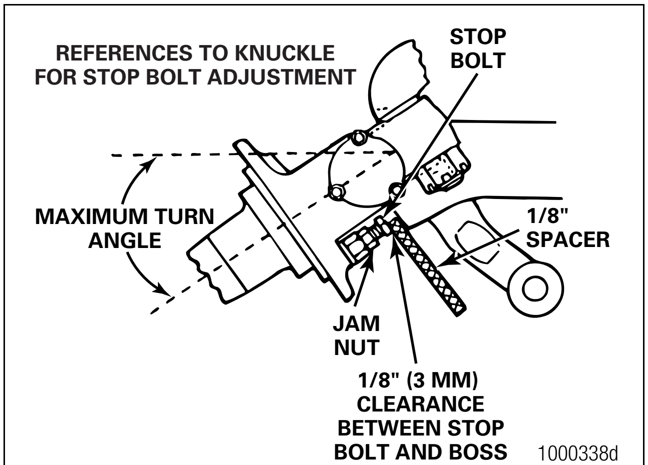


Figure 7.6

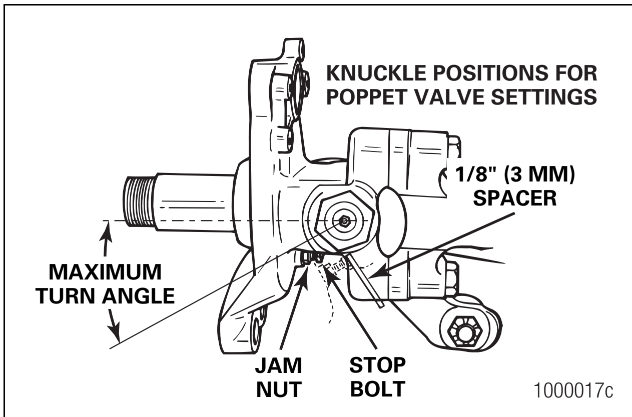


Figure 7.7

NOTE: If the steering system is out-of-adjustment, inspect the steering arm for damage. Use a magnetic particle or liquid dye penetrant inspection procedure to inspect the steering arm. Pay particular attention to the bend, the taper and the area near the ball stud. Refer to the vehicle manufacturer's manual for additional inspection procedures.

Two-Piece Steering 3/4-Inch Stop Bolt, Includes Unitized

1. Place a 1/8-inch (3 mm) spacer between the stop bolt and the boss on the axle beam.
2. Turn the steering wheel until the boss on the axle beam touches the spacer in front of the stop bolt. Measure the turn angle. Figure 7.8 and Figure 7.9.

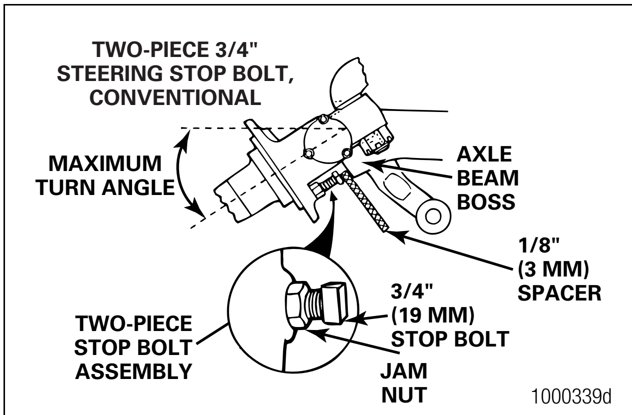


Figure 7.8

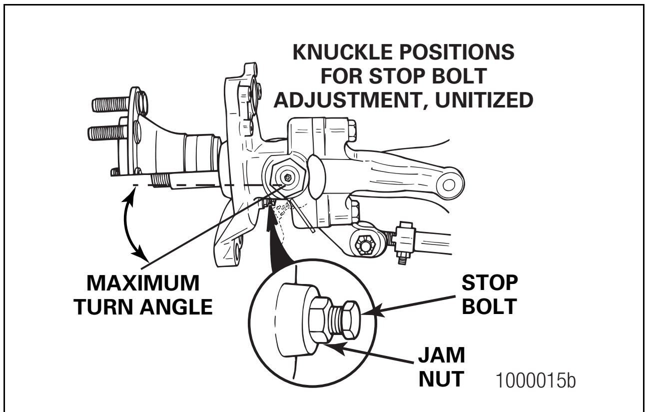


Figure 7.9

3. If the maximum turn angle does not meet vehicle manufacturer's specifications, correct the maximum angle.
   - **In a power steering system:** Adjust the pressure relief.
   - **In a manual steering system:** Follow the guidelines and specifications from the vehicle manufacturer.
4. When the maximum turn angle is correct:
   A. Loosen the stop bolt jam nut. Figure 7.8 and Figure 7.9.
   B. Insert a 1/8-inch (3 mm) spacer and adjust the stop bolt.
   C. Tighten the jam nut on conventional knuckles to 65-85 lb-ft (68-101 N•m).

Four-Piece Steering 1/2-Inch Stop Bolt, Conventional Only

1. Place the washer onto the adapter.
2. Apply adhesive patch material into the 3/4-inch (19 mm) knuckle bore stop screw adapter hole.
3. Install the adapter with the washer into the threaded knuckle cavity.
4. Tighten the adapter to 85-115 lb-ft (115-155 N•m).
5. Start the jam nut onto the 1/2-inch (12.7 mm) bolt, and install the bolt and jam nut assembly into the adapter.
6. Place a 1/8-inch (3 mm) spacer between the stop bolt and the boss on the axle beam.
7. Turn the steering wheel until the boss on the axle beam touches the spacer in front of the stop bolt. Measure the turn angle.
8. If the maximum turn angle does not meet vehicle manufacturer's specifications, adjust the maximum turn angle.
   - **In a power steering system:** Adjust the pressure relief.
   - **In a manual steering system:** Follow guidelines and specifications from the vehicle manufacturer.
9. Proceed to the following instructions when the maximum turn angle is correct.
   A. Loosen the stop bolt jam nut. Figure 7.10.
   B. Insert a 1/8-inch (3 mm) spacer between the stop bolt and the axle beam boss with the steering arm in the full-turn position.
   C. Tighten the jam nut 50-75 lb-ft (68-101 N•m).

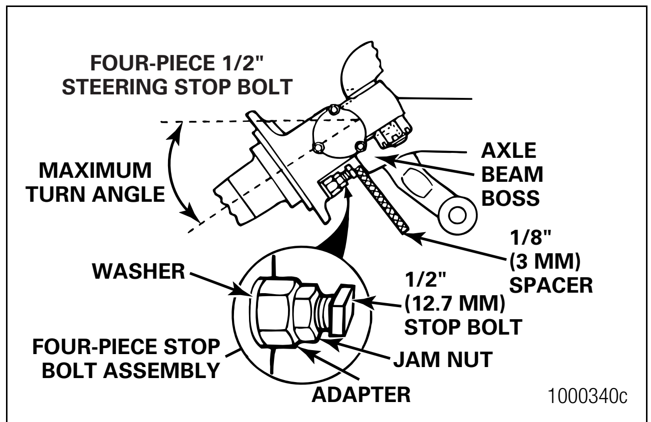


Figure 7.10

Adjust the Pressure Relief in the Power Steering System, Set the Maximum Turn Angle

⚠ CAUTION

In power steering systems, the hydraulic pressure should relieve or "drop off" at the end of the steering stroke, with 1/8-inch or 3 mm minimum clearance at the stop bolt. If the pressure does not relieve, the components of the front axle will be damaged.

The pressure relief in the power steering system stops or reduces forces applied to the axle when the wheel is moved in the full-turn position.

Check the pressure relief if the steering arm is damaged or the power steering gear is serviced.

Two types of systems are used to adjust the pressure relief.

- Mechanical stop on the Pitman arm or in the assist cylinder
- Hydraulic pressure relief in the power steering gear

⚠ CAUTION

Meritor does not recommend a power steering system that does not have mechanical stops or pressure relief before the maximum turn angle is obtained. Damage to the axle can result.

Mechanical Stop

Use the mechanical stop in the steering system to adjust the pressure relief. Do not use the stop bolt on the knuckle alone to adjust the poppet valve pressure relief.

NOTE: Refer to the vehicle manufacturer's procedures.

⚠ CAUTION

Use a pressure gauge to verify that the pressure drops from the maximum system delivery pressure to gear box manufacturing recommendation BEFORE the full turning angle is achieved. If the pressure does not drop, damage to the front axle components will result.

Steering systems with mechanical stops are adjusted when the wheels are turned to the full-right and full-left turn positions. The stop travel is set at 1/8-inch (3 mm) before the stop bolt contacts the axle beam boss. Figure 7.11 and Figure 7.12.

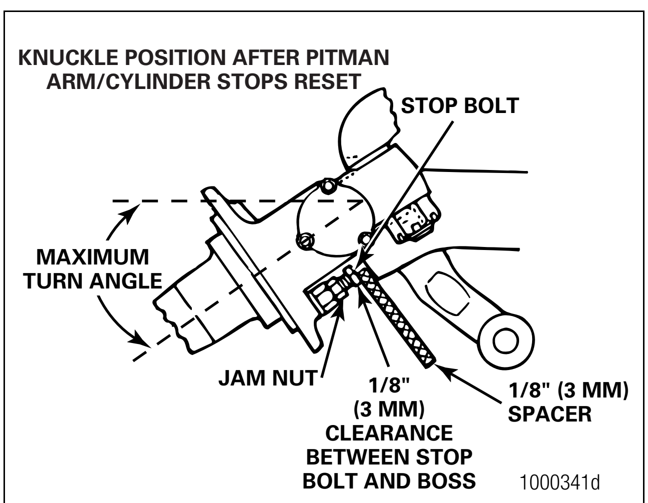


Figure 7.11

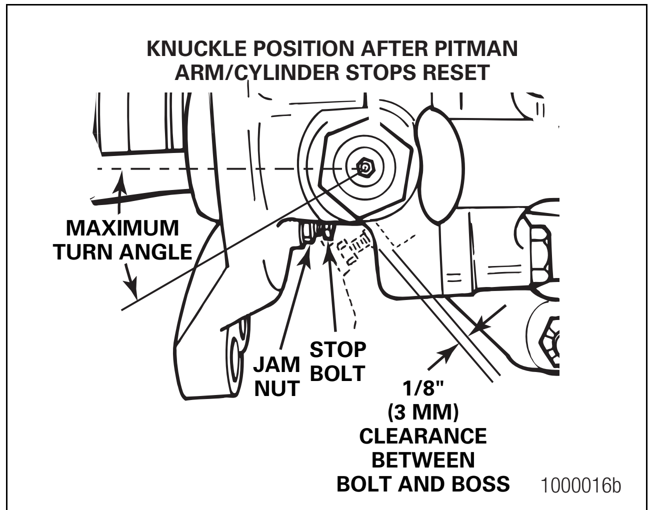


Figure 7.12

Hydraulic Pressure Relief in the Steering Gear

NOTE: Refer to the vehicle manufacturer's procedure. The stop bolt should always have a minimum clearance of 1/8-inch (3 mm) between the stop bolt and the axle beam boss.

Hydraulic steering gears with poppet valves are adjusted with a spacer between the stop bolt in the knuckle and the boss on the axle beam. The poppet valves are adjusted to stop or reduce steering forces from the 1/8-inch (3 mm) specified distance between the beam boss and the spacer. Figure 7.13 and Figure 7.14.

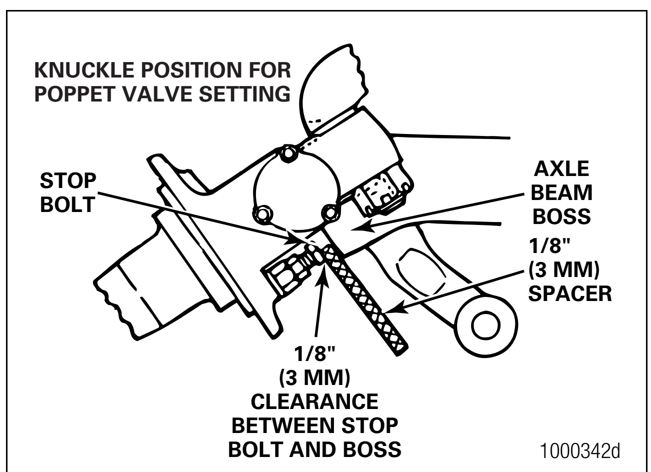


Figure 7.13

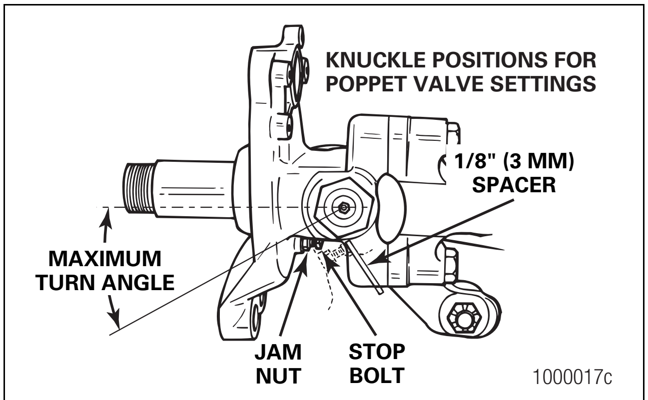


Figure 7.14

Turning Radius Angle

When turning, the inner wheel must turn at a greater angle than the outer wheel. This angle is the turning radius angle, often called the Ackerman angle. Figure 7.15.

Check the turning radius angle with the radius plates on the alignment equipment. To determine correct turning radius angle specification, refer to the vehicle manufacturer's manual.

- **If the angle is not within specifications:** Premature tire wear will occur. Inspect the knuckle, tie rod arms, tie rod ends and cross tube for wear or damage. Service as necessary.

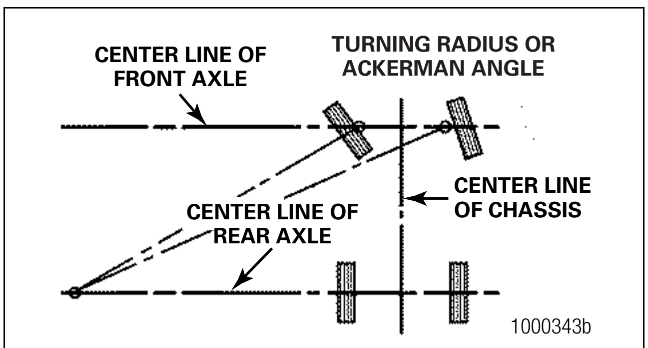


Figure 7.15

King Pin Inclination

NOTE: Refer to the vehicle manufacturer's king pin inclination specifications.

King pin, or steering axis inclination, is the angle measured between the center line of the king pin and the vertical position, as viewed from the front of the vehicle. Figure 7.16.

The king pin inclination and the camber angle are designed into the axle to place the tire tread center line in contact with the road. This reduces steering effort and improves directional stability.

Use an alignment machine to check the king pin inclination angle. Refer to the vehicle manufacturer's inclination angle specifications.

The king pin inclination is not adjustable. If the inclination is not at the specified angle, check the axle beam and knuckle for damage. Service as necessary.

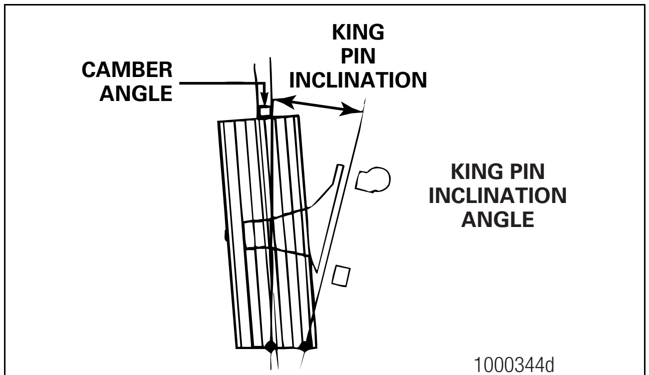


Figure 7.16

Recommended Camber, Caster and Toe Specifications

ArvinMeritor provides specific, recommended specifications for camber, caster and toe in this publication, Maintenance Manual 2, Front Non-Drive Steer Axles: All Meritor Conventional, Easy Steer Plus™ and MFS Series.

Refer to the Service Notes page on the front inside cover of this manual for information on Recommended Practices published by The Technology Maintenance Council (TMC) of the American Trucking Associations, Inc.

Camber Angle

⚠ WARNING

Replace damaged or out-of-specification axle components. Do not bend, repair or recondition axle components by welding or heat-treating. A bent axle beam reduces axle strength, affects vehicle operation and voids Meritor's warranty. Serious personal injury and damage to components can result.

Camber is the angle of the tire with respect to the ground. Camber is positive when the distance between the top of the wheels is greater than the distance at the ground. Figure 7.17.

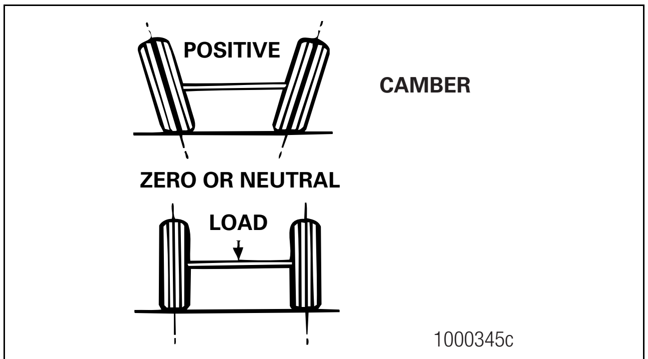


Figure 7.17

A small amount of positive camber is built into the knuckle, because camber changes with load. This results in a zero camber angle when the vehicle is operated at normal load.

If camber is out of specification by more than 1-1/2 degrees, rapid or uneven tire wear will occur. Bias ply tires will show excess camber easily, while with vehicles equipped with radial tires, excess camber will not be as evident.

The camber angle is not adjustable. The camber angle is machined into both the axle beam and the knuckle. If the camber angle is not at the specified angle, check the axle beam and the steering knuckle for damage. Service as necessary.

Use an alignment machine to check the camber angle. Refer to the alignment equipment manufacturer's procedure and vehicle manufacturer's manual to determine specifications for the correct camber setting. Table I gives the specification Meritor builds into the axle, but always use the specification from the vehicle manufacturer.

Table I: Camber Angle Recommendations

Vehicle Condition	Axles with Biased Camber	Axles with Unbiased Camber
Truck or Tractor on Alignment Rack	Left Side: +11/16° to –3/16° Right Side: +3/16° to –11/16°	+3/16° to –11/16°
Axle Not Installed in Vehicle	Left Side: +3/4° Nominal Right Side: +1/4° Nominal	+1/4° Nominal

Caster Angle

Caster is the FORWARD or REARWARD tilt of the king pin center line when viewed from the side of the vehicle. The caster angle is the angle from the vertical position to the center line of the king pin. If the top of the king pin axis is toward the rear of the vehicle, the caster is positive. A slight positive caster creates a self-aligning action that helps to stabilize the vehicle after turning and stabilizes it for driving straight ahead. Figure 7.18.

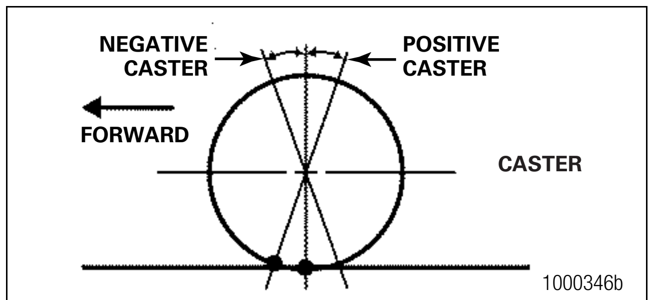


Figure 7.18

Always use an alignment machine to check the caster angle. When checking caster, refer to the alignment equipment manufacturer's procedures.

If the caster is greater than specification, steering effort can increase a shimmy condition.

The caster angle is controlled by tapered shims installed under the leaf springs. Adjust the caster according to the specifications and procedures of the vehicle manufacturer.

Caster specifications are set by the vehicle manufacturer. Refer to the vehicle manufacturer's specifications for the caster setting.

Measure and Adjust the Toe

Toe is the relationship of the distance between the front of the front tires and the rear of the front tires.

When the front distance is less than the rear distance, the wheels are "toed in." Toe-in is designed into the vehicle to counteract the tendency of the tires to toe-out when the vehicle is driven.

Incorrect toe will result in rapid tire wear.

⚠ WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Set the parking brake.
2. Use jacks to raise vehicle so that front tires are off the ground. Support the front axle with safety stands.
3. Use paint or chalk to mark the center area of both front tires around the complete outer surface of the tire.
4. Place the pointers of a trammel bar on the marks of each tire. Rotate the tires. Verify that a straight line is marked on the outer surface of the tire.
5. Lower the vehicle to the floor. Do not measure toe with the front axle in the raised position. The weight of the vehicle must be on the front axle when toe is measured. Move the vehicle FORWARD and BACKWARD 10 feet (3 meters).
6. Place the trammel bar at the back of the tires. Raise the pointers so that the pointers are level with the spindles. Align the pointers with the marks on the tires. Measure and record the distance between the pointers.
7. Repeat Step 6 for the front of the tires. Figure 7.19.

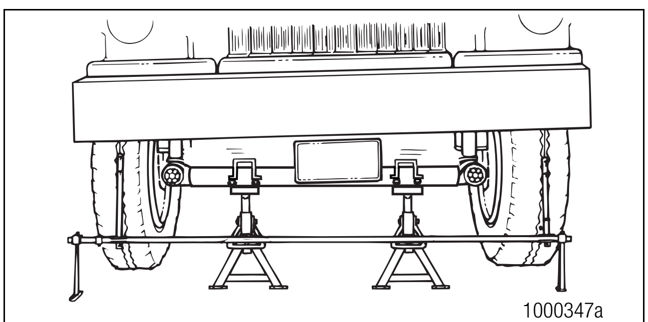


Figure 7.19

8. To obtain the toe measurement, subtract the distance reading between the front of the tires from the distance reading between the back of the tires. Figure 7.20.

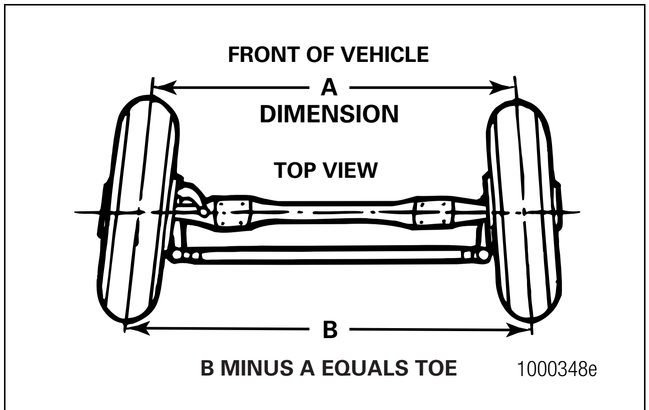


Figure 7.20

9. Use the following procedure if the toe measurement is not within the correct specifications shown in Table J.

Table J: Toe Specifications

Unloaded Vehicles	1/16-inch (1.587 mm) ± 1/32-inch (0.794 mm)
Loaded Vehicles	1/32-inch (0.794 mm) ± 1/32-inch (0.794 mm)

   A. Loosen the tube clamp nut and bolt on each end of the cross tube.

   B. Turn the cross tube until the specified toe distance is obtained.

   C. The threaded portion of the tie rod end must be installed into the cross tube beyond the point where the tube slot stops.

   D. Tighten the nut and bolt on each end of the cross tube to the specified torque. Refer to Section 10.

10. Repeat Step 1 through Step 8 to check the toe dimension.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING
To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Troubleshooting

Front Non-Drive Steer Axle Diagnostic Table

Table K

Condition	Cause	Correction
Tires wear out quickly or have uneven tire tread wear.	Tires have incorrect air pressure.	Place specified air pressure in tires.
	Tires out-of-balance.	Balance or replace tires.
	Incorrect tandem axle alignment.	Align tandem axles.
	Incorrect toe-in setting.	Adjust toe-in specified setting.
	Incorrect steering arm geometry.	Service steering system as necessary.
	Excessive wheel end play exists.	Readjust wheel bearings.
Vehicle is hard to steer.	Power steering system pressure low.	Repair power steering system.
	Steering gear linkage not assembled correctly.	Assemble steering gear correctly.
	Steering linkage needs lubrication.	Lubricate steering linkage.
	King pins binding.	Replace king pins.
	Incorrect steering arm geometry.	Service steering system as necessary.
	Caster out-of-adjustment.	Adjust caster as necessary.
	Tie rod ends hard to move.	Replace tie rod ends.
	Worn thrust bearing.	Replace thrust bearing.
Tie rod ends are worn and require replacement.	Tie rod ends require lubrication.	Lubricate ends of cross tube. Make sure lubrication schedule is followed.
	Severe operating conditions.	Increase frequency of inspection and lubrication intervals.
	Damaged boot on tie rod end.	Replace boot.

Table K (cont'd.)

Condition	Cause	Correction
Bent or broken cross tube, tie rod end ball stud, steering arm or tie rod end. Component requires replacement.	Too much pressure in the power steering system, pressure exceeds vehicle manufacturer's specification.	Adjust power steering system to specified pressure.
	Power steering system cut-off pressure, out of adjustment.	Adjust power steering system to specified pressure.
	Vehicle operated under severe conditions.	Verify that vehicle is operated correctly.
	Add-on type of power steering system not installed correctly.	Correctly install add-on power steering system.
	Steering gear overtravel poppets incorrectly set or malfunctioning.	Check for correct operation or adjust overtravel of poppets to vehicle manufacturer's specifications.
	Axle stops incorrectly set.	Set axle stops to vehicle manufacturer's specification.
Worn or broken steering ball stud.	Drag link fasteners tightened higher than vehicle manufacturer specified.	Tighten drag link fasteners to vehicle manufacturer's specified torque.
	Lack of lubrication or incorrect lubricant.	Lubricate linkage with specified lubricant.
	Power steering stops out-of-adjustment.	Adjust stops to specified dimension.
Worn king pins and king pin bushings.	Worn or missing seals and gaskets.	Replace seals and gaskets.
	Incorrect lubricant.	Lubricate axle with specified lubricant.
	Axle not lubricated at scheduled frequency.	Lubricate axle at scheduled frequency.
	Incorrect lubrication procedures.	Use correct lubrication procedures.
	Lubrication schedule does not match operating conditions.	Change lubrication schedule to match operating conditions.
Vibration or shimmy of front axle during operation.	Caster out-of-adjustment.	Adjust caster.
	Wheels and/or tires out-of-balance.	Balance or replace wheels and/or tires.
	Worn shock absorbers.	Replace shock absorbers.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Maintenance

NOTE: Refer to Section 3 for inspection procedures.

Refer to Table L and Table M for lubrication, inspection and maintenance schedules based on vehicle usage.

Table L: Vocational Groups

Group Number	Typical Vocations	Vehicle Build	Typical Operation Conditions
1 Light	On highway or turnpike, linehaul only	After July 1, 1996 Before July 1, 1996, use category 3	High mileage operation (more than 50,000 miles/year [80 500 km/year]) 95% on-highway/turnpike surface
2 Medium	Fire and rescue, city delivery, inner city coach, heavy haul, school bus, motor home, transit coach	After July 1, 1996 Before July 1, 1996, use category 3	Lower mileage operation (less than 50,000 miles/year [80 500 km/year])
3 Harsh	Logging, oil field, construction, heavy haul, yard tractor (highway licensed), residential refuse	All	Low mileage operation (less than 25,000 miles/year [40 250 km/year]) Heavy-duty service with substantial off-road operation
4 Severe	Mining, yard tractor (non-highway licensed), and land fill refuse		Heavy-duty service
5 Very Severe	Mining, logging and construction		Severe duty 80-100% off highway

Table M: Lubrication, Inspection and Maintenance Schedule

	Service Intervals									
	48 hours	5,000 miles/ 100 hours	First 6,000 miles of operation	10,000 miles	20,000 miles	36,000 miles	40,000 miles	50,000 miles	100,000 miles	200,000 miles
Component		8050 km	10 000 km	16 100 km	32 200 km	58 000 km	64 000 km	80 500 km	160 000 km	320 000 km
Tie Rod Ends[1]										
Group 1 Vocations								I	L[2]	
Group 2 Vocations					I		L[2]			
Group 3 Vocations				I,L[2]						
Group 4 Vocations		I,L[2]								
Group 5 Vocations	I,L[2]									
Inspect the Tie Rod Assembly for Movement										
Group 1 Vocations								I		
Group 2 Vocations					I					
Group 3 Vocations				I						
Group 4 Vocations		I								
Group 5 Vocations	I									
Ball Studs on Steering Arms									L[2]	
Easy Steer Plus™ Axle Ball Studs									I	
Sealed Axle Ball Studs									I	
King Pins and Bushings									L[2]	
Steering Arms Bolts										I
Thrust Bearings									L[2]	
Steering Knuckle Vertical End Play Inspection										
Group 1 Vocations								I		
Group 2 Vocations					I					
Group 3 Vocations				I						
Group 4 Vocations		I								
Group 5 Vocations	I									

I = Inspect L = Lubricate T = Tighten to specified torque

1 Tie rod ends with an anti-tilt style seal require lubrication every 10,000 miles (16 100 km).

2 If power washers are used during vehicle cleaning operations, lubrication intervals need to be adjusted. Frequent power washed vehicles will require more frequent lubrication.

Table M: Lubrication, Inspection and Maintenance Schedule (cont'd.)

	Service Intervals									
	48 hours	5,000 miles/ 100 hours	First 6,000 miles of operation	10,000 miles	20,000 miles	36,000 miles	40,000 miles	50,000 miles	100,000 miles	200,000 miles
Component		8050 km	10 000 km	16 100 km	32 200 km	58 000 km	64 000 km	80 500 km	160 000 km	320 000 km
Upper and Lower King Pin Bushings for Wear										
Group 1 Vocations								I		
Group 2 Vocations					I					
Group 3 Vocations				I						
Group 4 Vocations		I								
Group 5 Vocations	I									
Draw Key Nuts			T			T				
Sealed Hub Unit Inspection										I

I = Inspect L = Lubricate T = Tighten to specified torque

1 Tie rod ends with an anti-tilt style seal require lubrication every 10,000 miles (16 100 km).

2 If power washers are used during vehicle cleaning operations, lubrication intervals need to be adjusted. Frequent power washed vehicles will require more frequent lubrication.

Lubrication

Lubricant Specifications

Table N: Front-Non-Drive Axle Greasing Specifications

Grease[1]	Meritor Specification	NLGI Grade	Grease Classification	Outside Temperature
Multi-Purpose Grease[1]	O-617-A	1	Lithium 12-Hydroxyl Stearate	Refer to the grease manufacturer's specifications for the temperature service limits.
	O-617-B	2		

1 Meritor recognizes that industry trends are moving toward increased selection and usage of synthetic grease in vehicle maintenance. However, some seals are known to expand when in contact with synthetic grease. Consult your local Meritor representative for synthetic grease application references BEFORE using any synthetic grease when performing axle service and maintenance.

Hazard Alert Messages

Read and observe all Caution and Warning safety alerts below and those that precede instructions or procedures you will perform.

⚠ WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Lubrication

Tie Rod End

This procedure refers to all tie rod ends on Meritor non-drive steer axles.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Set the parking brake.
2. Turn the vehicle wheels to the STRAIGHT position. Figure 9.1.

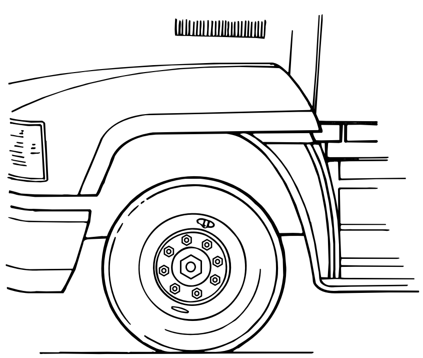


Figure 9.1

3. Wipe the grease fitting, seal and boot clean with shop towels. Figure 9.2.

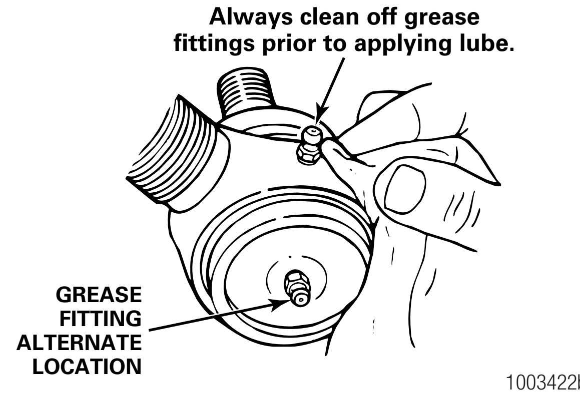


Figure 9.2

4. Attach either a hand or air pressure grease gun to the grease fitting. Figure 9.3. If using air pressure, do not exceed 150 psi (1035 kPa).

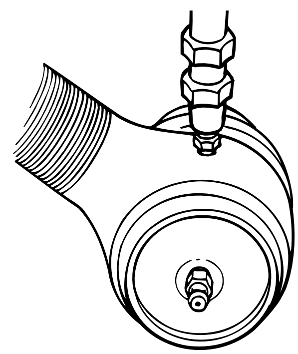


Figure 9.3

5. Apply grease into the grease fitting. Discolored old grease should come out of the purge holes near the boot crimp or bellows area, typically three or more places. Figure 9.4.
6. If the tie rod end is designed for lube service and it does not accept grease:
   A. Remove the grease fitting.
   B. Inspect the threaded grease fitting hole in the tie rod end and remove any obstructions.
   C. Install a new grease fitting.
   D. Continue the lubrication procedure.
7. Apply grease until all old grease is purged from the boot.

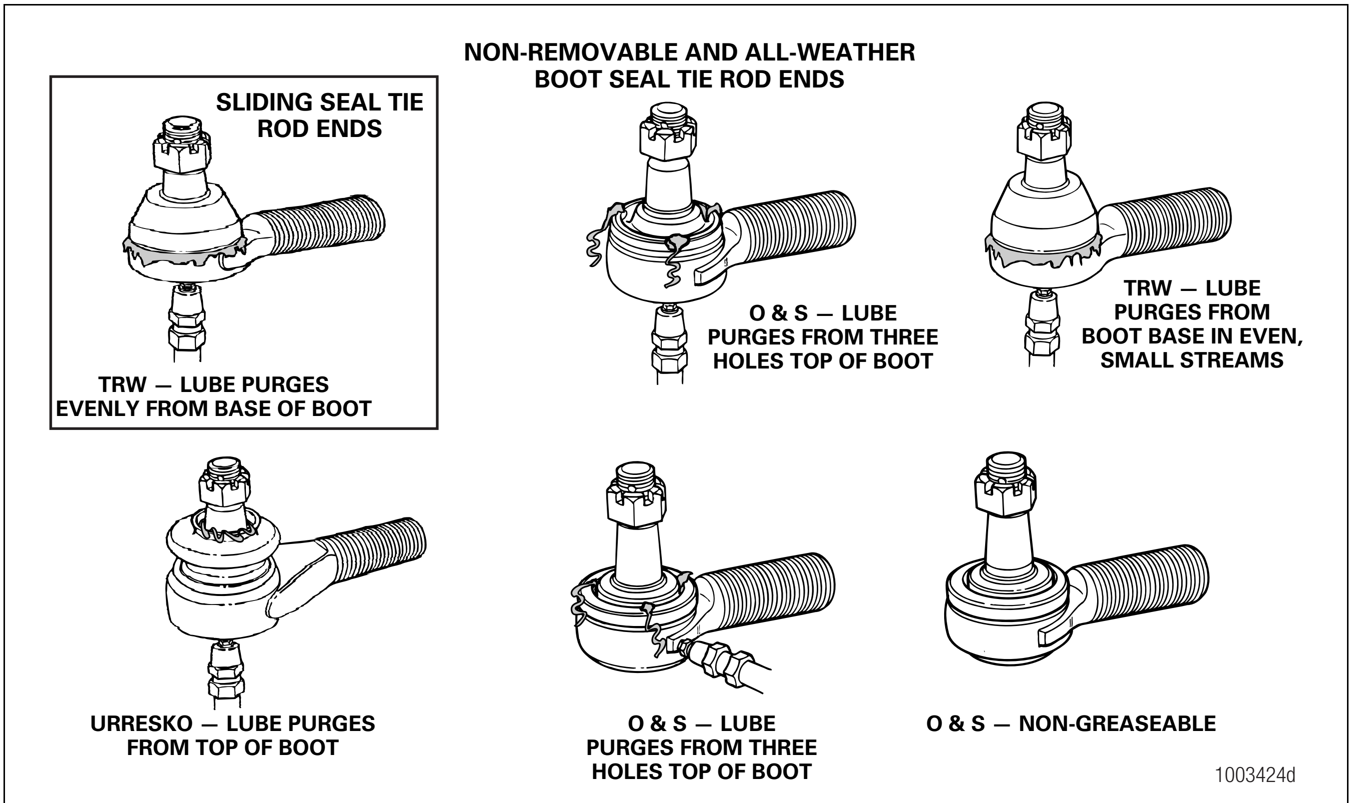


Figure 9.4

King Pins

Axles with Conventional Wheel Ends

1. Park the vehicle on a level surface. Block the wheels to keep the vehicle from moving. Set the parking brake.
2. Verify that the tires touch the ground. DO NOT RAISE THE VEHICLE.
3. Clean off all grease fittings prior to lubrication.
4. Lubricate the king pins through the top and the bottom grease fittings. Figure 9.5.

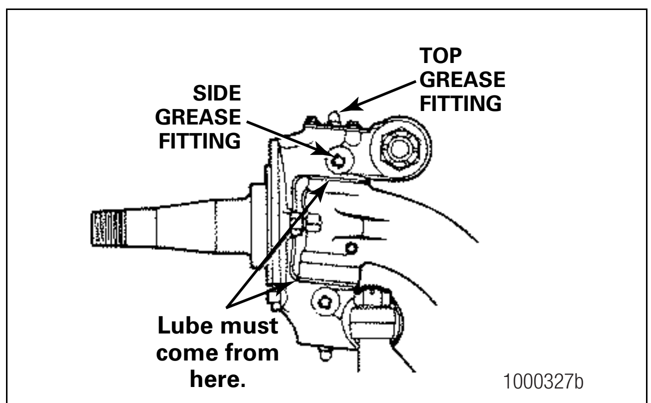


Figure 9.5

5. Apply lubricant until new lubricant comes from between the upper shim pack and thrust bearing seal.
6. Apply lubricant into the bottom fitting until new lubricant purges and fills the thrust bearing.

Axles with Unitized Wheel Ends

1. Park the vehicle on a level surface. Block the wheels to keep the vehicle from moving. Set the parking brake.
2. Verify that the tires touch the ground. DO NOT RAISE THE VEHICLE.
3. Clean off all grease fittings prior to lubrication.
4. Lubricate the king pins through the grease fittings on the top and bottom king pin caps. Figure 9.6.
5. Force lubricant into the upper and lower king pin grease fitting caps until new lubricant flows from between the upper axle beam end and the knuckle, and the lower axle beam end and the knuckle. Figure 9.6.

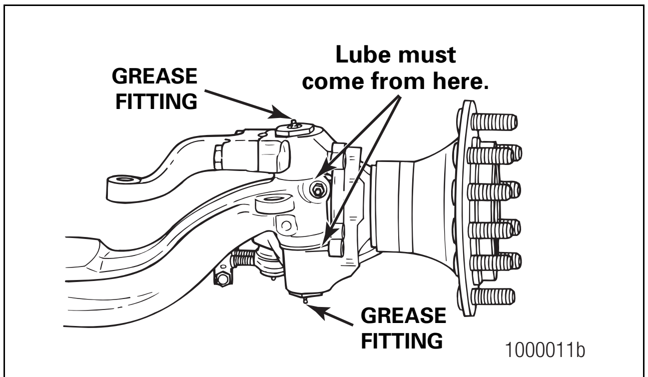


Figure 9.6

Ball Studs on the Steering Arm and the Tie Rod Arm Ends

Axles with Conventional and Unitized Wheel Ends

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Set the parking brake.
2. Verify that the tires touch the ground. DO NOT RAISE THE VEHICLE.
3. Clean off all grease fittings prior to lubrication.
4. Apply lubricant until new lubricant comes from the boot. Figure 9.7 and Figure 9.8.

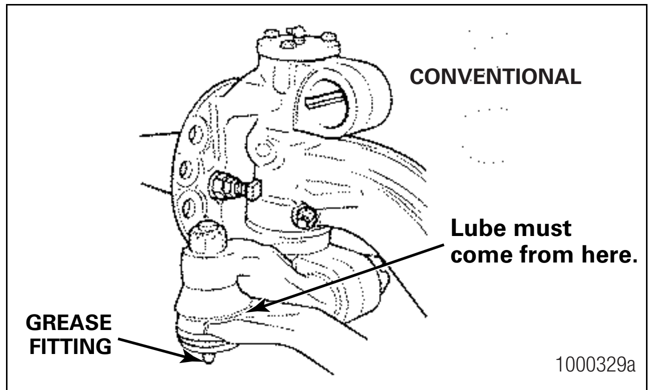


Figure 9.7

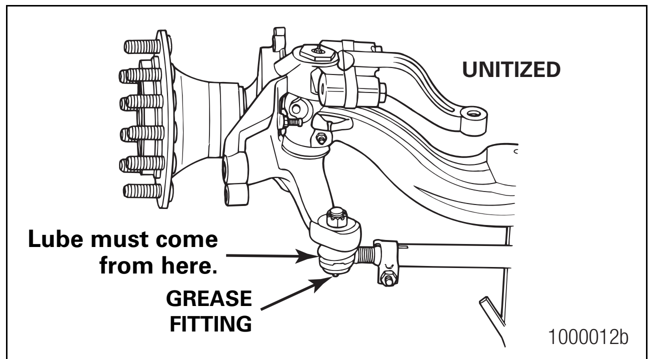


Figure 9.8

Grease-Lubricated Wheel Bearings

Axles with Conventional Wheel Ends

NOTE: This procedure applies to hubs with grease-lubricated wheel bearings.

1. Park the vehicle on a level surface. Block the wheels to keep the vehicle from moving. Set the parking brake.
2. Remove the tire and wheel assembly. Remove and disassemble the hub. Refer to Section 4.
3. Remove the old lubricant from all parts. Discard the seals. Inspect the wheel bearings for wear or damage. Replace worn or damaged bearings. Refer to Section 5.
4. Force the specified lubricant from the large end of the cones into the cavities between the rollers and cage. Pack the hub between the bearing cups with lubricant to the level of the smallest diameter of the cups. Figure 9.9.

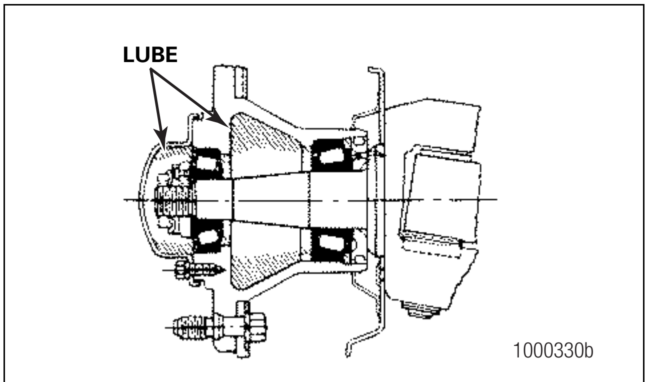


Figure 9.9

5. Install the inner and outer bearing cones into the cups in the hubs. The bearing cups must be pressed tight against the shoulder in the hubs.
6. Install new wheel seals into the hubs.
7. Install the hub and the wheel and tire assembly. Install the outer wheel bearing cone into the hub. Install the adjusting nut.
8. Adjust the wheel bearings. Refer to Section 7.

Oil-Lubricated Wheel Bearings

Axles with Conventional Wheel Ends

NOTE: This procedure applies to hubs with oil-lubricated wheel bearings.

1. Check the level on the cap. If the oil level is not at the specified level on the cap, remove the fill plug.
2. Add the specified oil until the oil is at the specified level. Figure 9.10.

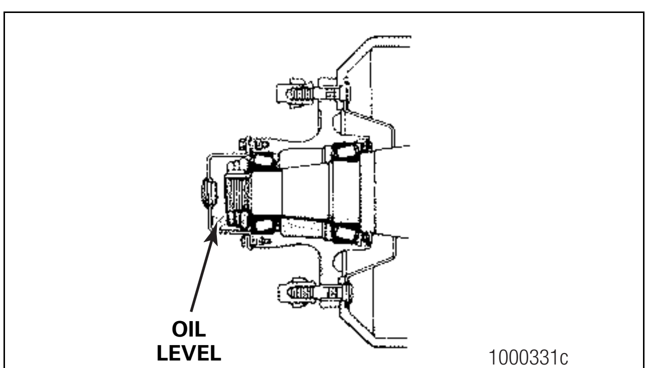


Figure 9.10

Maintenance

Tighten Draw Key Nuts

Axles with Conventional and Unitized Wheel Ends

NOTE: This procedure applies to all except 901, 903 and 970 Series axles. These axles do not use a draw key. Refer to the identification tag on the front of the axle beam.

Tighten the nuts on the side of the knuckle that hold the draw keys to 30-45 lb-ft (41-61 N•m) at the following times. Figure 9.11 and Figure 9.12.

- After the first 6,000 miles (10 000 km) of new vehicle operation
- Every 36,000 miles (58 000 km) of operation

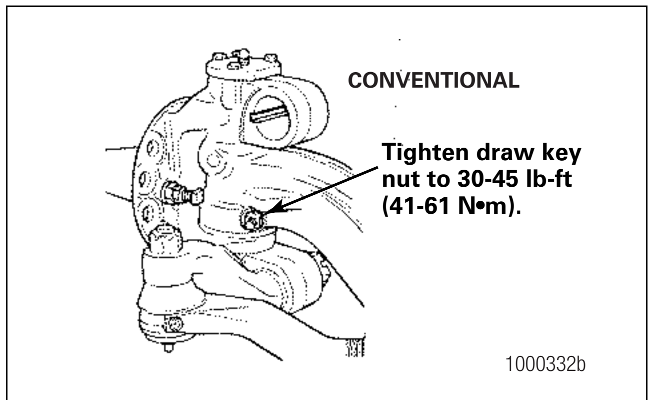


Figure 9.11

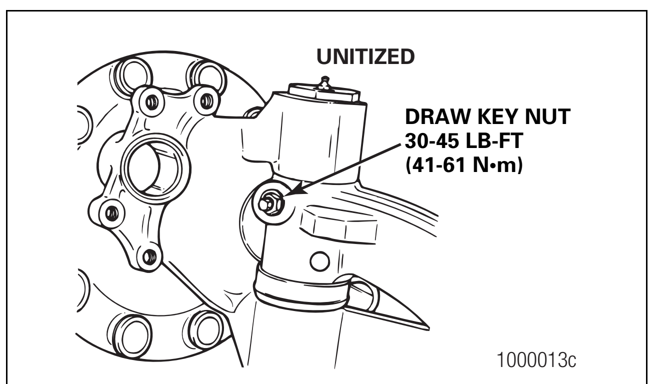


Figure 9.12

Check the Steering Arm Bolts

WARNING

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin. If Loctite® adhesive material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

1. Check the steering arm bolts for minimum torque. Refer to Table O.

Table O: Steering Arm Bolts Torque Specifications

Axle	Torque lb-ft (N•m)
MFS-6	215-265 (290-360)
MFS-7 or MFS-8	360-470 (490-638)
All other axles	300-450 (406-610)

- **If steering arm bolt torque has fallen below minimum torque:**

  A. Remove the bolts. Clean all the threads. Install new Loctite® 680 adhesive, Meritor part number 2297-K-5523.

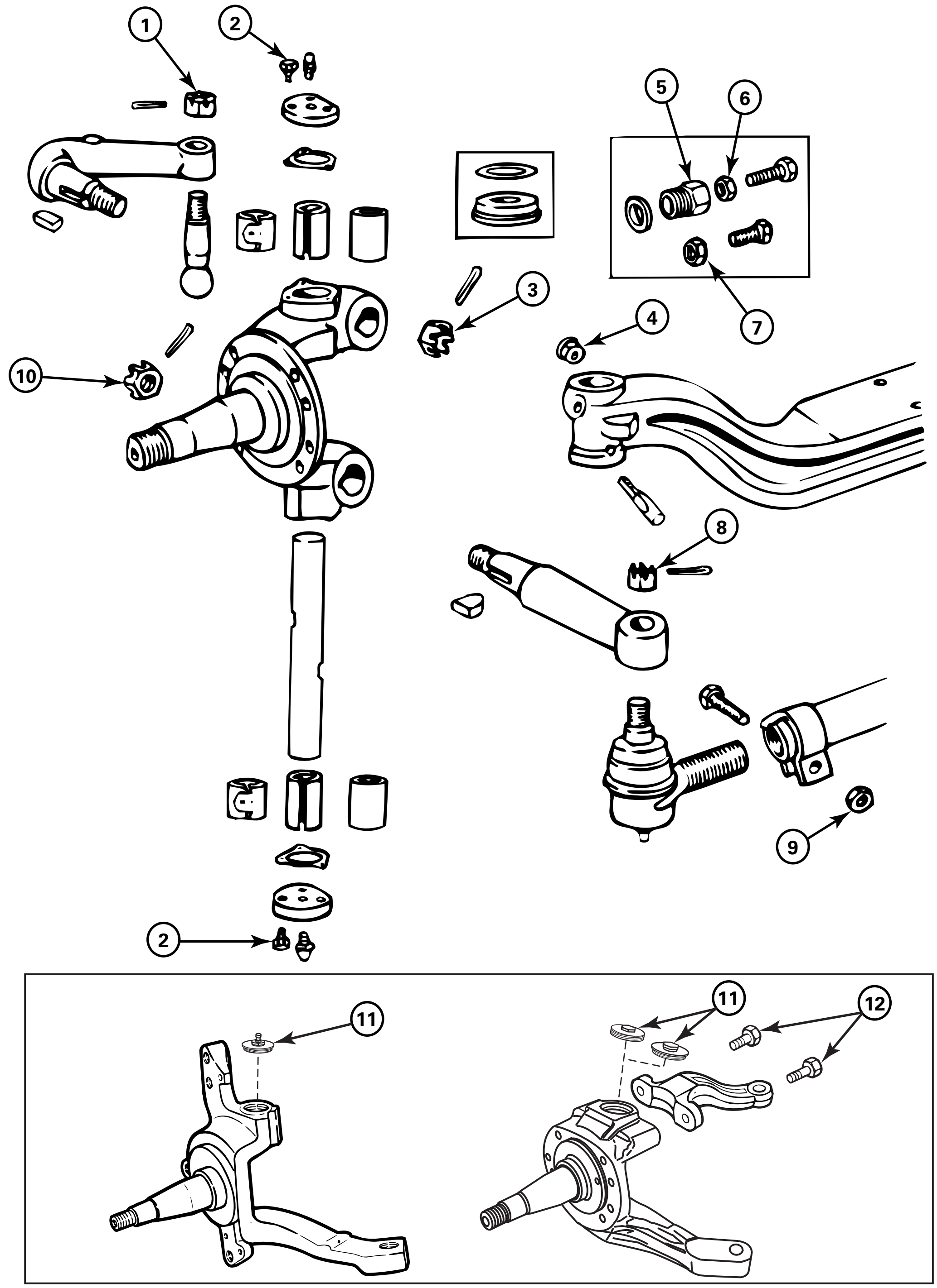
  B. Tighten the bolts to specification. Refer to Table O.

2. Check the steering arm bolt torque every 200,000 miles (320 000 km) or 24 months.

3. Refer to Section 5 for Dri-Loc® fastener installation procedures.

Torque Specifications

Front Non-Drive Axles with Conventional Wheel Ends



1000403d

Table P: Front Axle with Conventional Wheel-End Torque Specifications

Item	Description	Size	Torque Range lb-ft	Torque Range N•m
1	Steering Arm-to-Drag Link Nut	Refer to the vehicle manufacturer's specifications.		
2	Knuckle Cap Capscrew	5/16"-18	20-30	28-40
3	Steering Arm-to-Knuckle Nut	7/8"-14	250-450	339-610
		1"-14	390-725	529-982
		1-1/8"-12	550-1025	746-1389
		1-1/4"-12	775-1450	1051-1965
		1-1/2"-12	1350-2525	1831-3423
4	Draw Key Nut	7/16"-20	30-45	41-61
5	3/4" Stop Screw Adapter		65-115	88-155
6	1/2" Stop Screw Lock/Jam Nut		50-75	68-101
7	3/4" Stop Screw Lock/Jam Nut		65-85	88-115
8	Tie Rod Arm-to-Tie Rod End Nut	7/8"-14	160-300	217-406
		1"-14	250-450	339-610
		1-1/8"-12	350-650	475-881
		1-1/4"-12	500-675	678-915
9	Cross Tube Clamp Nut	5/8"-11	40-60	55-81
		3/4"-10	155-175	211-237
10	Tie Rod Arm-to-Knuckle Nut	7/8"-14	250-450	339-610
		1"-14	390-725	529-982
		1-1/8"-12	550-1025	746-1389
		1-1/4"-12	775-1450	1051-1965
		1-1/2"-12	1350-2525	1831-3423
11	Threaded Knuckle Cap	2.00"-20	70-90	95-122
		1-5/8"-20		
12	Steering Arm Knuckle Bolt	3/4"-16	360-470	490-638
		M16 x 2.0	215-265	290-360

Front Non-Drive Axles with Unitized Wheel Ends

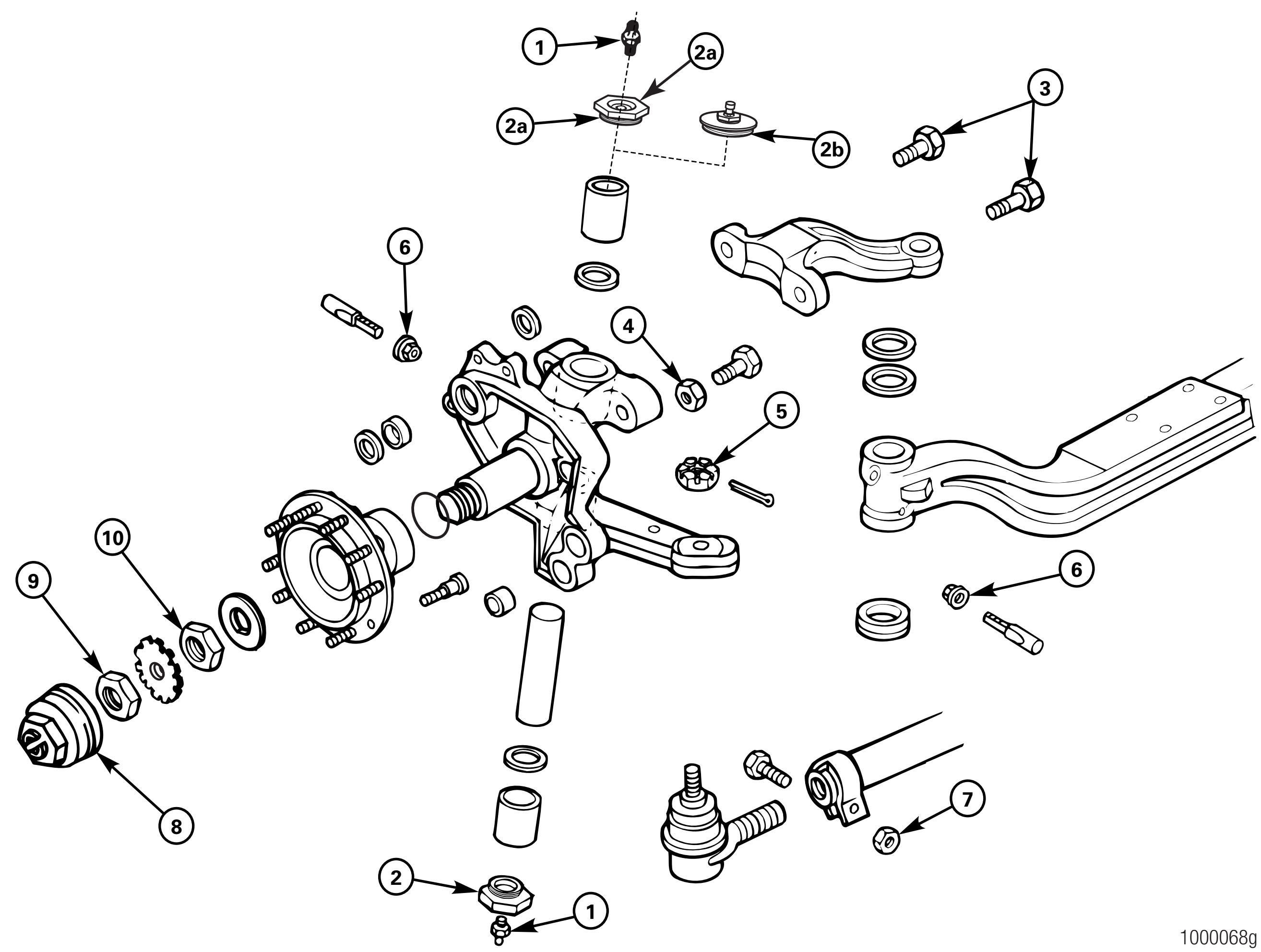


Table Q: Front Axle with Unitized Wheel End Torque Specifications

			Torque Range	
Item	**Description**	**Size**	**lb-ft**	**N•m**
1	Grease Fitting	1/8"-27 P.T.F.	10 minimum	13.558 minimum
2a	Old Hexagon Threaded King Pin Cap	2-1/4"-20	60-80	81-108
2b	New Round Threaded King Pin Cap	2-1/4"-20	70-90	95-120
3	Steering Arm Knuckle Bolt	7/8"-14	300-450	406-610
4	Stop Screw Nut	1/2"-13	50-75	68-101
5	Tie Rod Arm-to-Tie Rod End Nut	7/8"-14	160-300	217-406
		1"-14	250-450	339-610
		1-1/8"-12	350-650	475-881
		1-1/4"-12	500-675	678-915
6	Draw Key Nut	7/16"-20	30-45	41-61
7	Cross Tube Clamp Nut	5/8"-11	40-60	55-81
		3/4"-10	155-175	211-237
8	Hubcap	3-1/2" Plastic	50-100	67-135
		3-1/2" Aluminum	325-375	440-508
9	Outer Wheel Bearing Nut	—	200-300	271-406
10	Inner Wheel Bearing Nut	—	500-700	677-949

NOTE: All torque values apply to parts lightly coated with rust preventive grease. For dry parts, increase torque values by 10%. For parts heavily coated with grease, decrease torque values by 10%.

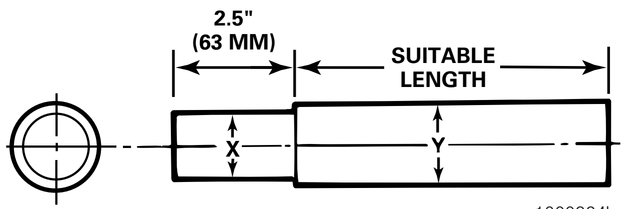
Special Tools

To obtain these tools, refer to the Service Notes page on the front inside cover of this manual.

Table R: Special Tools

Description	SPX Kent-Moore Tool Number	Owatonna Tool Number	Snap-On® Tool Number	Great Lakes Tool	References
King Pin Remover	4240	4240	20 Ton: CG430HYB 35 Ton: CG730HY	—	Section 4
King Pin Bushing Service Kit	[1]				Section 4 Section 6
Basic Service Kit	PT 4375-A	—	—	—	
FF- and FG-Series Kits	PT 4370-10	—	—	—	
FL-Series Kit	PT 4370-20	—	—	—	
MFS-6	PT-4370-110	—	—	—	
FC and MFS-7 and -8	PT-4370-120	—	—	—	
Seal Installer	—	—	—	Meritor Front Axle Seal Installer Kit	Section 6

[1] Use the Basic Service Kit along with the correct axle series kit.



1000364b

Table S: Dimensions for Bushing Removal and Installation Tool

Axle Model Number	Dimension X (± 0.001-inch)	Dimension X (± 0.025 mm)	Dimension Y (± 0.001-inch)	Dimension Y (± 0.025 mm)
FC-901				
FC-903	1.22	31.191	1.350	34.290
FC-921				
FC-941	1.493	37.922	1.618	41.097
FD-901	1.427	36.245	1.552	39.420
FD-931	1.600	40.640	1.725	43.815
FD-933				
FD-961	1.786	45.364	1.911	48.539
FE-970	1.600	40.640	1.725	43.815
FF-921				
FF-931				
FF-932	1.787	45.389	1.911	
FF-933				
FF-934				48.539
FF-941				
FF-942				
FF-943				
FF-944	1.786	45.364	1.911	
FF-961				
FF-966				
FF-967				
FF-971	1.600	40.640	1.725	43.815
FF-981				
FF-982				
FF-983				
FF-984	1.786	45.364	1.911	48.539
FF-986				
FF-987				

Table S: Dimensions for Bushing Removal and Installation Tool (cont'd.)

Axle Model Number	Dimension X (± 0.001-inch)	Dimension X (± 0.025 mm)	Dimension Y (± 0.001-inch)	Dimension Y (± 0.025 mm)
FG-931	1.787	45.389	1.911	48.539
FG-933				
FG-941	1.786	45.364		
FG-943				
FL-931	1.922	50.596	2.116	53.746
FL-933				
FL-941	1.990	50.546		
FL-943				
FL-951	1.992	50.596		
FU-910	2.054	52.171	2.179	55.346
FU-935				
MFS 6	1.228	31.191	1.350	34.290
MFS 7	1.493	37.922	1.618	41.097
MFS 8				
MFS 10	1.786	45.364	1.911	48.539
MFS 12	1.786			
MFS 13				
MFS 14				
MFS 16	1.990	50.546	2.116	53.746
MFS 18				
MFS 20				

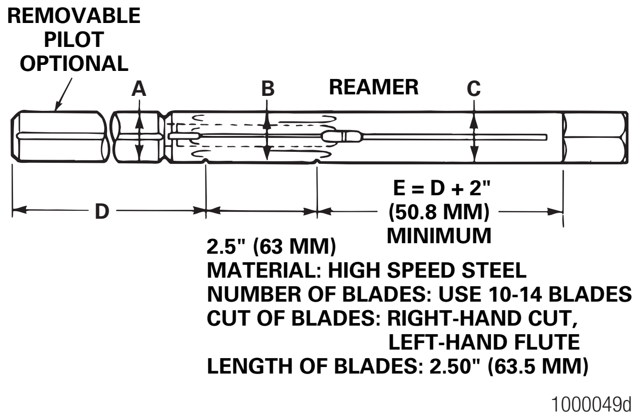


Table T: Bushing Reamer Dimensions

	Lower Pilot Diameter Dimension A (± 0.001-inch or ± 0.0245 mm)		Blade Diameter Dimension B (± 0.0005-inch or ± 0.0127 mm)		Upper Pilot Diameter C (± 0.001-inch or ± 0.0245 mm)		Lower Pilot Length Dimension D		Upper Pilot Length Minimum Dimension E	
Axle Model	inch	mm	inch	mm	inch	mm	inch	mm	inch	mm
FC-901										
FC-901[1]	1.2225	31.0515	1.2375	31.4325	1.2320	31.2928+	6.75	171.45	8.75	222.25
FC-903										
FC-921			1.2360							
FC-941	1.4875	37.7825	1.5015	38.1381	1.4960	37.9984	8.90	226.06	10.90	276.86
FD-901	1.4220	36.1188	1.4370	36.4998	1.4315	36.3601				
FD-901[1]				36.4498						
FD-931							8.50	215.90	10.50	266.70
FD-933	1.5950	40.5130	1.6100	40.8940	1.6405	41.6687				
FD-961	1.7800	45.2120	1.7955	45.6057	1.7900	45.4660	10.25	260.35	12.25	311.15
FE-970	1.5950	40.5130	1.6100	40.8940	1.6405	41.6687	8.50	215.90	10.50	266.70
FF-921									11.20	
FF-931										
FF-932	1.7820	45.2628	1.7970	45.6438	1.7915	45.5041	9.30	236.22		287.02
FF-933									11.30	
FF-934										
FF-941										
FF-942										
FF-943										
FF-944	1.7800	45.2120	1.7955	45.6057	1.7900	45.4660	10.25	260.35	12.25	311.15
FF-961										
FF-966										
FF-967										
FF-971	1.5950	40.5130	1.6100	40.8940	1.6405	41.6687	8.50	215.90	10.50	266.70

[1] Use these specifications when replacing the existing bushing with an Easy Steer™ bushing.

Table T: Bushing Reamer Dimensions (cont'd.)

	Lower Pilot Diameter Dimension A (± 0.001-inch or ± 0.0245 mm)		Blade Diameter Dimension B (± 0.0005-inch or ± 0.0127 mm)		Upper Pilot Diameter C (± 0.001-inch or ± 0.0245 mm)		Lower Pilot Length Dimension D		Upper Pilot Length Minimum Dimension E	
Axle Model	**inch**	**mm**	**inch**	**mm**	**inch**	**mm**	**inch**	**mm**	**inch**	**mm**
FF-981	1.7800	45.2120	1.7955	45.6057	1.7900	45.4660	10.25	260.35	12.25	311.15
FF-982										
FF-983										
FF-984										
FF-986										
FF-987										
FG-931	1.7820	45.2628	1.7970	45.6438	1.7915	45.5041	9.30	236.22	11.30	287.02
FG-933										
FG-941	1.7800	45.2120	1.7955	45.6057	1.7900	45.4660	10.25	260.35	12.25	311.15
FG-943						45.4787				
FL-931	1.9870	50.4698	2.0025	50.8635	1.9970	50.7238	10.10	256.54	12.10	307.34
FL-933										
FL-941	1.9850	50.4190	2.0005	50.8127	1.9950	50.6730				
FL-943										
FL-951										
FU-910	2.0490	52.0446	2.0640	52.4256	2.0585	52.2859	11.32	287.52	13.32	338.32
FU-935										
MFS 6	1.2225	31.0515	1.2360	31.4325	1.2320	31.2928	6.75	171.45	8.75	222.25
MFS 7	1.4875	37.7825	1.5015	38.1381	1.4960	37.9984	8.90	226.06	10.90	276.86
MFS 8										
MFS 10	1.7800	45.2120	1.7955	45.6057	1.7900	45.4660	10.25	260.35	12.25	311.15
MFS 12										
MFS 13	1.7800	45.2120	1.7955	45.6057	1.7900	45.4660	10.25	260.35	12.25	311.15
MFS 14										
MFS 16	1.9850	50.4190	2.0005	50.8127	1.9950	50.6730	10.10	256.54	12.10	307.34
MFS 18										
MFS 20										

[1] Use these specifications when replacing the existing bushing with an Easy Steer™ bushing.

Meritor Heavy Vehicle Systems, LLC
2135 West Maple Road
Troy, MI 48084 USA
800-535-5560
arvinmeritor.com

Printed in USA

Revised 10-06
Maintenance Manual 2 (16579/22882)

ArvinMeritor™

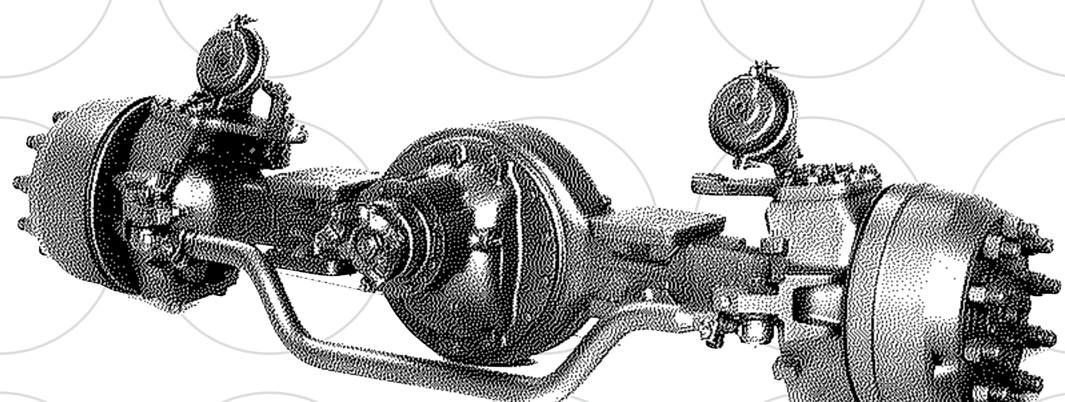
MERITOR®
an ArvinMeritor brand

Maintenance Manual 12

Heavy-Duty Front Drive Steer Axles

RF-16, RF-21, RF-22, RF-23 and FDS Series

Revised 10-07



About This Manual

This manual provides maintenance and service information for the Meritor heavy-duty front drive steer axles equipped with either wedge brakes or Q Series or Q Plus™ cam brakes.

Before You Begin

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Hazard Alert Messages and Torque Symbols

WARNING
A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.

CAUTION
A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components.

This symbol alerts you to tighten fasteners to a specified torque value.

How to Obtain Additional Maintenance and Service Information

On the Web

Visit Literature on Demand at arvinmeritor.com to access and order product, service, aftermarket, and warranty literature for ArvinMeritor's truck, trailer and specialty vehicle components.

Literature on Demand DVD (LODonDVD)

The LODonDVD contains product, service and warranty information for ArvinMeritor components. To order the DVD, visit Literature on Demand at arvinmeritor.com and specify TP-0742.

How to Obtain Tools and Supplies Specified in This Manual

Call ArvinMeritor's Commercial Vehicle Aftermarket at 888-725-9355 to obtain Meritor tools and supplies.

Contents

Contents

ASBESTOS FIBERS WARNING

The following procedures for servicing brakes are recommended to reduce exposure to asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from ArvinMeritor.

Hazard Summary

Because some brake linings contain asbestos, workers who service brakes must understand the potential hazards of asbestos and precautions for reducing risks. Exposure to airborne asbestos dust can cause serious and possibly fatal diseases, including asbestosis (a chronic lung disease) and cancer, principally lung cancer and mesothelioma (a cancer of the lining of the chest or abdominal cavities). Some studies show that the risk of lung cancer among persons who smoke and who are exposed to asbestos is much greater than the risk for non-smokers. Symptoms of these diseases may not become apparent for 15, 20 or more years after the first exposure to asbestos.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. Separate Work Areas. Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons. OSHA has set a maximum allowable level of exposure for asbestos of 0.1 f/cc as an 8-hour time-weighted average and 1.0 f/cc averaged over a 30-minute period. Scientists disagree, however, to what extent adherence to the maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling asbestos dust. OSHA requires that the following sign be posted at the entrance to areas where exposures exceed either of the maximum allowable levels:

DANGER: ASBESTOS
CANCER AND LUNG DISEASE HAZARD
AUTHORIZED PERSONNEL ONLY
RESPIRATORS AND PROTECTIVE CLOTHING
ARE REQUIRED IN THIS AREA.

2. Respiratory Protection. Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA for use with asbestos at all times when servicing brakes, beginning with the removal of the wheels.

3. Procedures for Servicing Brakes.

a. Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.
b. As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.
c. If an enclosed vacuum system or brake washing equipment is not available, employers may adopt their own written procedures for servicing brakes, provided that the exposure levels associated with the employer's procedures do not exceed the levels associated with the enclosed vacuum system or brake washing equipment. Consult OSHA regulations for more details.
d. Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.
e. **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components as wetting agents.

4. Cleaning Work Areas. Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA for use with asbestos. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

5. Worker Clean-Up**.** After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. Waste Disposal. Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.

NON-ASBESTOS FIBERS WARNING

The following procedures for servicing brakes are recommended to reduce exposure to non-asbestos fiber dust, a cancer and lung disease hazard. Material Safety Data Sheets are available from ArvinMeritor.

Hazard Summary

Most recently manufactured brake linings do not contain asbestos fibers. These brake linings may contain one or more of a variety of ingredients, including glass fibers, mineral wool, aramid fibers, ceramic fibers and silica that can present health risks if inhaled. Scientists disagree on the extent of the risks from exposure to these substances. Nonetheless, exposure to silica dust can cause silicosis, a non-cancerous lung disease. Silicosis gradually reduces lung capacity and efficiency and can result in serious breathing difficulty. Some scientists believe other types of non-asbestos fibers, when inhaled, can cause similar diseases of the lung. In addition, silica dust and ceramic fiber dust are known to the State of California to cause lung cancer. U.S. and international agencies have also determined that dust from mineral wool, ceramic fibers and silica are potential causes of cancer.

Accordingly, workers must use caution to avoid creating and breathing dust when servicing brakes. Specific recommended work practices for reducing exposure to non-asbestos dust follow. Consult your employer for more details.

Recommended Work Practices

1. Separate Work Areas. Whenever feasible, service brakes in a separate area away from other operations to reduce risks to unprotected persons.

2. Respiratory Protection. OSHA has set a maximum allowable level of exposure for silica of 0.1 mg/m^3 as an 8-hour time-weighted average. Some manufacturers of non-asbestos brake linings recommend that exposures to other ingredients found in non-asbestos brake linings be kept below 1.0 f/cc as an 8-hour time-weighted average. Scientists disagree, however, to what extent adherence to these maximum allowable exposure levels will eliminate the risk of disease that can result from inhaling non-asbestos dust.

Therefore, wear respiratory protection at all times during brake servicing, beginning with the removal of the wheels. Wear a respirator equipped with a high-efficiency (HEPA) filter approved by NIOSH or MSHA, if the exposure levels may exceed OSHA or manufacturers' recommended maximum levels. Even when exposures are expected to be within the maximum allowable levels, wearing such a respirator at all times during brake servicing will help minimize exposure.

3. Procedures for Servicing Brakes.

a. Enclose the brake assembly within a negative pressure enclosure. The enclosure should be equipped with a HEPA vacuum and worker arm sleeves. With the enclosure in place, use the HEPA vacuum to loosen and vacuum residue from the brake parts.
b. As an alternative procedure, use a catch basin with water and a biodegradable, non-phosphate, water-based detergent to wash the brake drum or rotor and other brake parts. The solution should be applied with low pressure to prevent dust from becoming airborne. Allow the solution to flow between the brake drum and the brake support or the brake rotor and caliper. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.
c. If an enclosed vacuum system or brake washing equipment is not available, carefully clean the brake parts in the open air. Wet the parts with a solution applied with a pump-spray bottle that creates a fine mist. Use a solution containing water, and, if available, a biodegradable, non-phosphate, water-based detergent. The wheel hub and brake assembly components should be thoroughly wetted to suppress dust before the brake shoes or brake pads are removed. Wipe the brake parts clean with a cloth.
d. Wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA when grinding or machining brake linings. In addition, do such work in an area with a local exhaust ventilation system equipped with a HEPA filter.
e. **NEVER** use compressed air by itself, dry brushing, or a vacuum not equipped with a HEPA filter when cleaning brake parts or assemblies. **NEVER** use carcinogenic solvents, flammable solvents, or solvents that can damage brake components as wetting agents.

4. Cleaning Work Areas. Clean work areas with a vacuum equipped with a HEPA filter or by wet wiping. **NEVER** use compressed air or dry sweeping to clean work areas. When you empty vacuum cleaners and handle used rags, wear a respirator equipped with a HEPA filter approved by NIOSH or MSHA, to minimize exposure. When you replace a HEPA filter, wet the filter with a fine mist of water and dispose of the used filter with care.

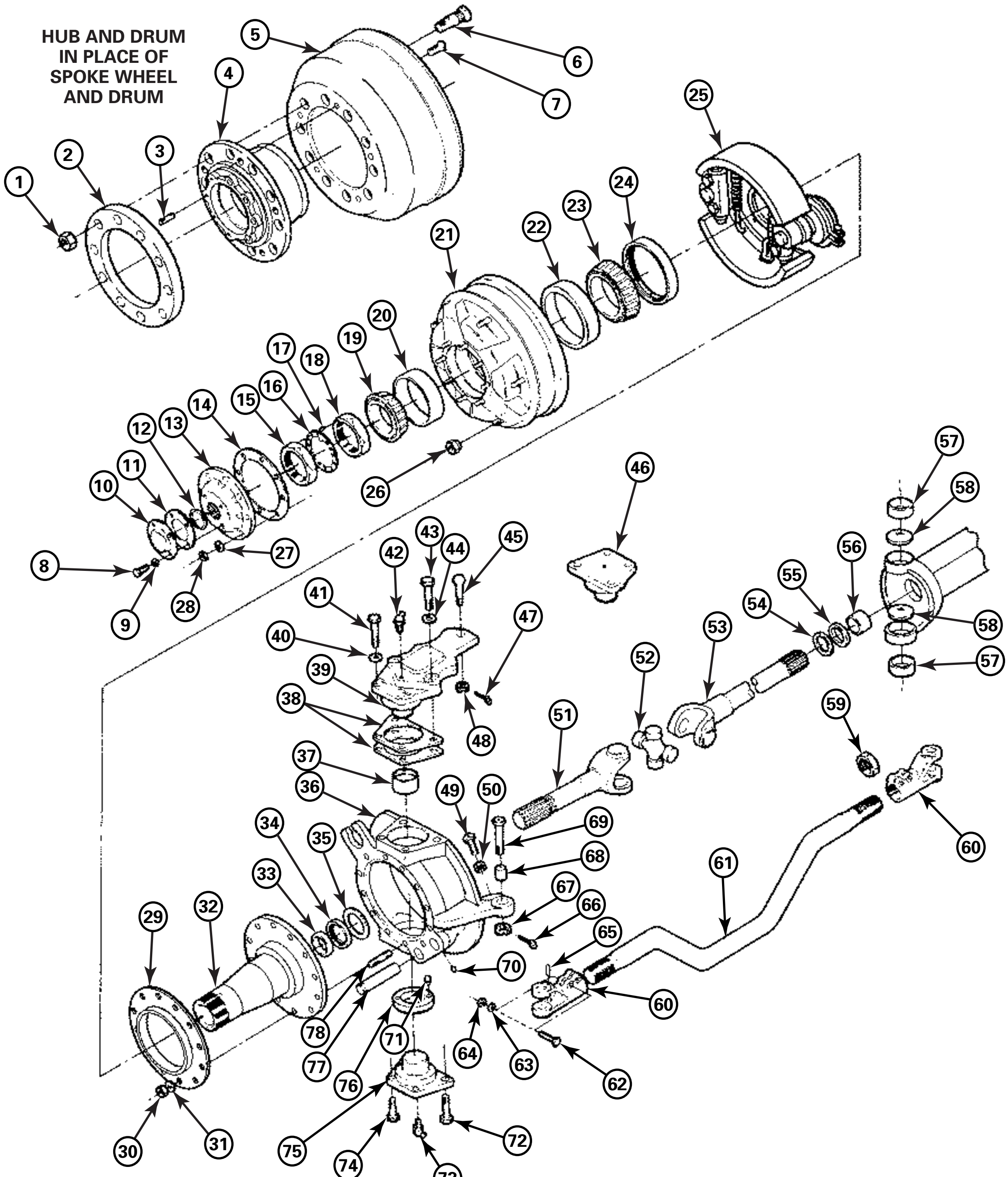
5. Worker Clean-Up. After servicing brakes, wash your hands before you eat, drink or smoke. Shower after work. Do not wear work clothes home. Use a vacuum equipped with a HEPA filter to vacuum work clothes after they are worn. Launder them separately. Do not shake or use compressed air to remove dust from work clothes.

6. Waste Disposal**.** Dispose of discarded linings, used rags, cloths and HEPA filters with care, such as in sealed plastic bags. Consult applicable EPA, state and local regulations on waste disposal.

Regulatory Guidance

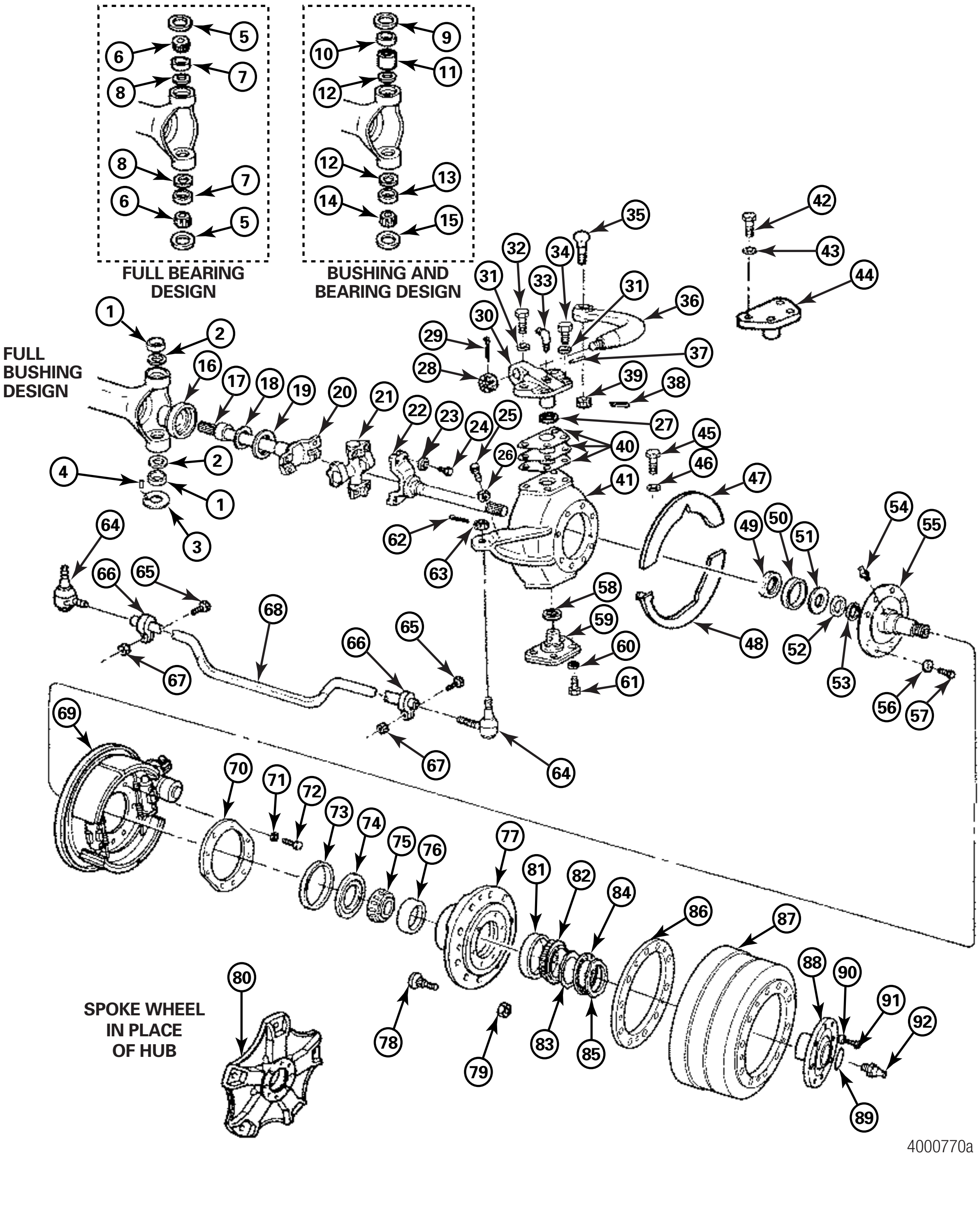
References to OSHA, NIOSH, MSHA, and EPA, which are regulatory agencies in the United States, are made to provide further guidance to employers and workers employed within the United States. Employers and workers employed outside of the United States should consult the regulations that apply to them for further guidance.

FDS-1600 Series with Wedge Brakes



Item	Description	Item	Description
1	Nut	40	Washer
2	Wheel Spacer	41	Outer Capscrew
3	Stud	42	Grease Fitting
4	Hub	43	Inner Capscrew
5	Brake Drum	44	Washer
6	Wheel Stud	45	Steering Arm Ball
7	Screw	46	Upper Cap
8	Capscrew	47	Cotter Pin
9	Washer	48	Nut
10	Hubcap	49	Stop Screw
11	Shim	50	Stop Screw Jam Nut
12	Snap Ring	51	Shaft or Yoke — Wheel Side
13	Flange	52	Cross/U-Joint
14	Gasket	53	Shaft or Yoke — Carrier Side
15	Nut	54	Washer
16	Washer	55	Oil Seal
17	Dowel	56	Bushing
18	Nut	57	Bushing
19	Outer Bearing Cone	58	Expansion Ring
20	Outer Bearing Cup	59	Nut
21	Wheel and Drum Assembly	60	Cross Tube End
22	Inner Bearing Cup	61	Cross Tube
23	Inner Bearing Cone	62	Capscrew
24	Oil Seal	63	Lock Washer
25	Brake Assembly	64	Nut
26	Nut	65	Pin
27	Lock Washer	66	Cotter Pin
28	Nut	67	Nut
29	Adapter	68	Bushing
30	Nut	69	Bolt
31	Washer	70	Set Screw
32	Spindle Assembly	71	Pin
33	Felt	72	Capscrew
34	Oil Seal	73	Grease Fitting
35	Washer	74	Capscrew
36	Knuckle	75	Lower Cap
37	Bushing	76	Thrust Washer
38	Shim	77	Anchor Pin
39	Steering Arm	78	Stud

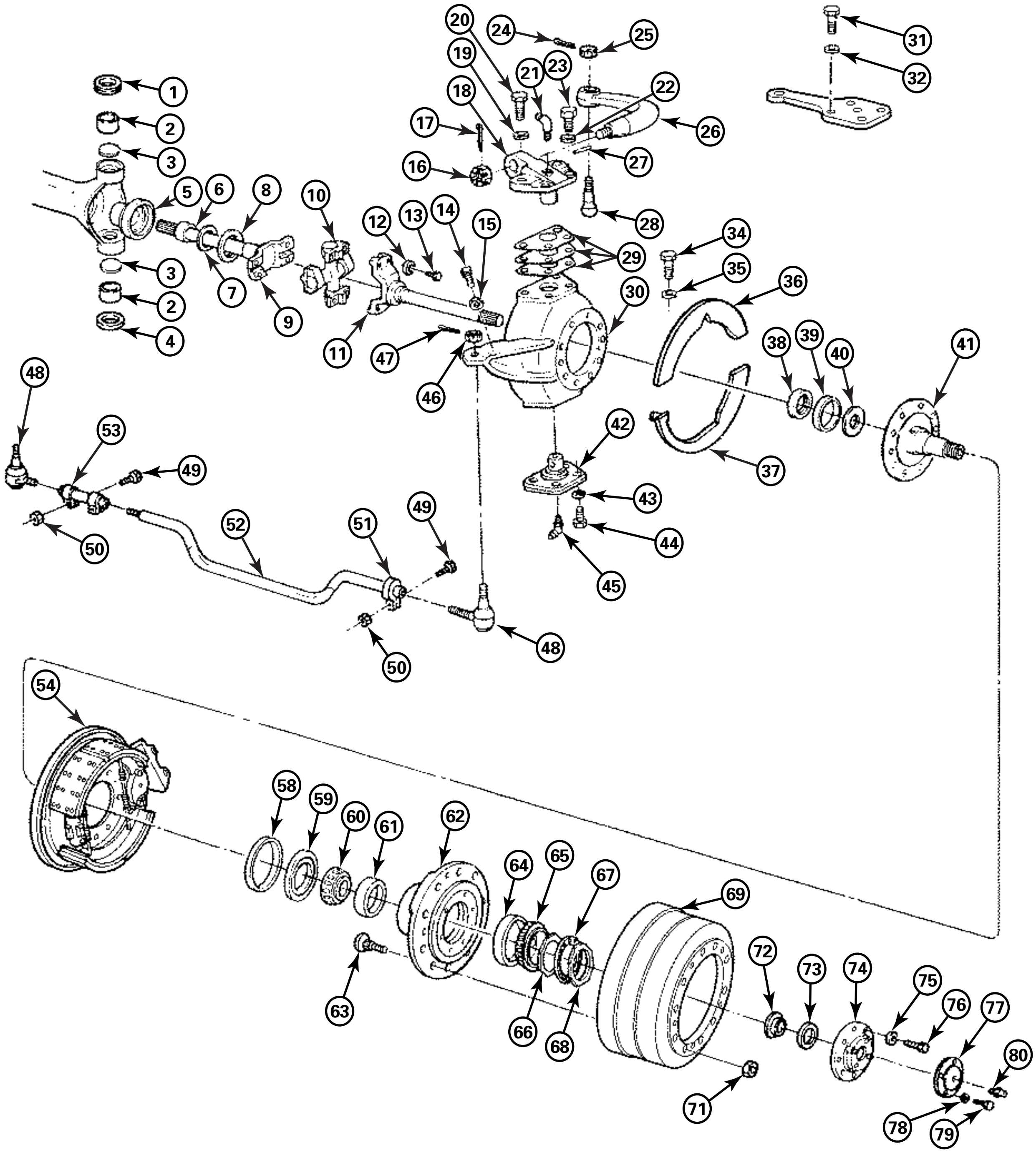
FDS-1800 and FDS-2100 Series with Wedge Brakes



Item	Description	Item	Description
1	Bushing	36	Steering Arm
2	Expansion Plug	37	Key
3	Thrust Washer	38	Cotter Pin
4	Pin	39	Nut
5	Grease Seal	40	Shims
6	Bearing Cone	41	Knuckle
7	Bearing Cup	42	Capscrew
8	Expansion Plug or Socket Plug	43	Washer
9	Grease Seal	44	Upper Cap
10	Adapter	45	Capscrew
11	Bushing	46	Washer
12	Expansion Plug	47	Upper Dust Shield
13	Bearing Cup	48	Lower Dust Shield
14	Bearing Cone	49	Oil Seal
15	Grease Seal	50	Sleeve
16	Adapter	51	Washer
17	Bushing	52	Retainer
18	Thrust Washer	53	Felt Seal
19	Oil Seal	54	Grease Fitting
20	Shaft or Yoke — Carrier Side	55	Spindle Assembly
21	Cross or U-Joint	56	Washer
22	Shaft or Yoke — Wheel Side	57	Capscrew
23	Washer	58	Grease Seal
24	Capscrew	59	Lower Cap
25	Stop Screw	60	Washer
26	Stop Screw Jam Nut	61	Capscrew
27	Grease Seal	62	Nut (Included with Item 64)
28	Nut	63	Cotter Pin (Included with Item 64)
29	Cotter Pin	64	Tie Rod End
30	Upper Adapter	65	Capscrew
31	Washer	66	Clamp
32	Capscrew — Long	67	Nut
33	Grease Fitting	68	Cross Tube
34	Capscrew — Short	69	Brake Assembly
35	Steering Arm Ball	70	Oil Deflector

Item	Description
71	Washer
72	Capscrew
73	Sleeve
74	Oil Seal
75	Inner Bearing Cone
76	Inner Bearing Cup
77	Hub
78	Wheel Stud
79	Nut
80	Wheel Assembly
81	Outer Bearing Cup
82	Outer Bearing Cone
83	Nut
84	Lock Washer
85	Nut
86	Wheel Spacer
87	Brake Drum
88	Flange
89	Expansion Plug
90	Washer
91	Capscrew
92	Grease Fitting

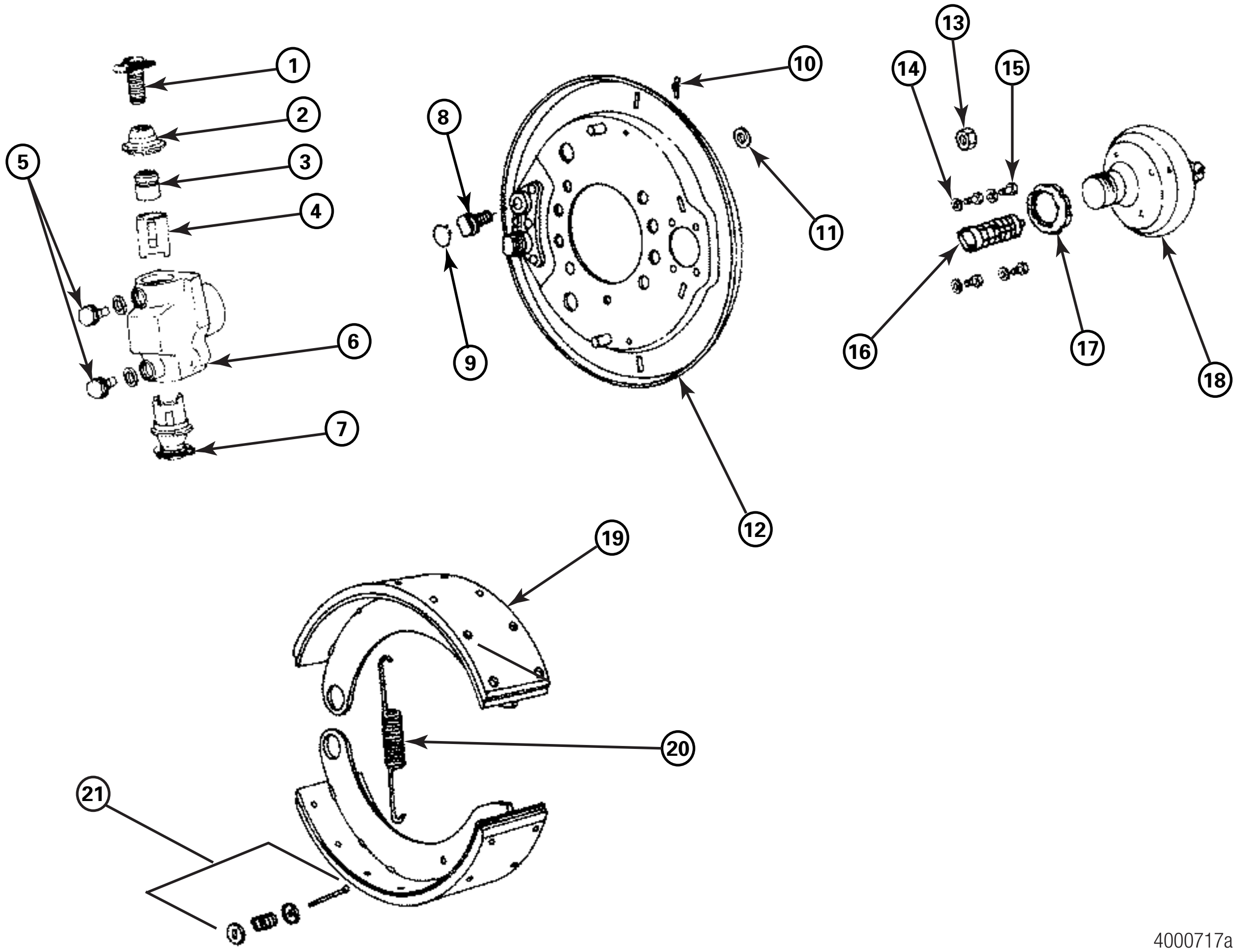
RF-16, RF-21 and RF-23 Series with Q Series Cam Brakes



Item	Description
1	Grease Seal
2	Bushing
3	Expansion Plug
4	Thrust Bearing
5	Adapter
6	Bushing
7	Thrust Washer
8	Oil Seal
9	Shaft or Yoke — Carrier Side
10	Cross or U-Joint
11	Shaft or Yoke — Wheel Side
12	Washer
13	Capscrew
14	Stop Screw
15	Stop Screw Jam Nut
16	Nut
17	Cotter Pin
18	Upper Adapter
19	Washer
20	Capscrew — Long
21	Grease Fitting
22	Washer
23	Capscrew — Short
24	Cotter Pin
25	Nut
26	Steering Arm
27	Key
28	Steering Arm Ball
29	Shims
30	Knuckle
31	Capscrew
32	Washer
33	Upper Cap
34	Capscrew
35	Washer
36	Dust Shield Assembly
37	Dust Shield Assembly
38	Oil Seal
39	Sleeve
40	Washer

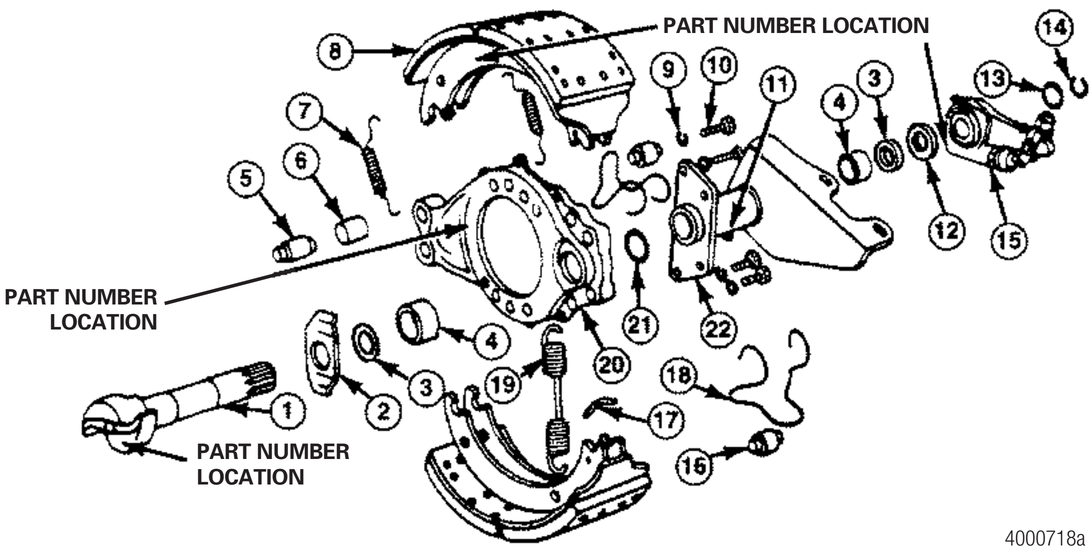
Item	Description
41	Spindle Assembly
42	Lower Cap
43	Washer
44	Capscrew
45	Grease Fitting
46	Nut
47	Cotter Pin
48	Tie Rod End
49	Capscrew
50	Nut
51	Clamp
52	Cross Tube
53	Turnbuckle Clamp
54	Brake Assembly
55	Mounting Bracket
56	Washer
57	Capscrew
58	Sleeve
59	Oil Seal
60	Inner Bearing Cone
61	Inner Bearing Cup
62	Hub
63	Wheel Stud
64	Outer Bearing Cup
65	Outer Bearing Cone
66	Nut
67	Lock Washer
68	Nut
69	Brake Drum
70	Not Shown
71	Nut
72	Retainer
73	Felt
74	Flange
75	Washer
76	Capscrew
77	Flange Cap
78	Washer
79	Capscrew
80	Grease Fitting

Wedge Brake



Item	Description	Item	Description
1	Adjusting Bolt	12	Backing Plate
2	Adjusting Plunger Assembly Seal	13	Anchor Pin Nut
3	Actuator	14	Plunger Housing Mounting Washer
4	Adjusting Plunger	15	Plunger Housing Mounting Capscrew
5	Pawl Assembly	16	Wedge Assembly
6	Plunger Housing	17	Collet Nut
7	Anchor Plunger	18	Air Chamber
8	Anchor Pin	19	Brake Shoe and Lining Assembly
9	Anchor Pin Snap Ring	20	Shoe Return Spring
10	Adjusting and Inspection Hole Plug	21	Shoe Anti-Rattle Rod Assembly
11	Anchor Pin Washer		

Q Series Brake



Item	Description
1	Camshaft
2	Cam Head Washer
3	Camshaft Seal
4	Camshaft Bushing
5	Brake Shoe Anchor Pin
6	Anchor Pin Bushing
7	Brake Shoe Retaining Spring
8	Brake Shoe and Lining Assembly
9	Flat Washer
10	Capscrew
11	Grease Fitting
12	Spacing Outer Washer
13	Spacing Inner Washer

Item	Description
14	Camshaft Lock Ring
15	Automatic Slack Adjuster
16	Brake Shoe Roller
17	Brake Shoe Return Spring Pin
18	Shoe Roller Retainer
19	Brake Shoe Return Spring
20	Brake Spider
21	Chamber Bracket Seal
22	Camshaft and Chamber Bracket

Description

Meritor produces a complete line of heavy-duty front drive steer axles with single axle capacities of 7,500-23,000 lbs (3400-10 432 kg). Figure 2.1.

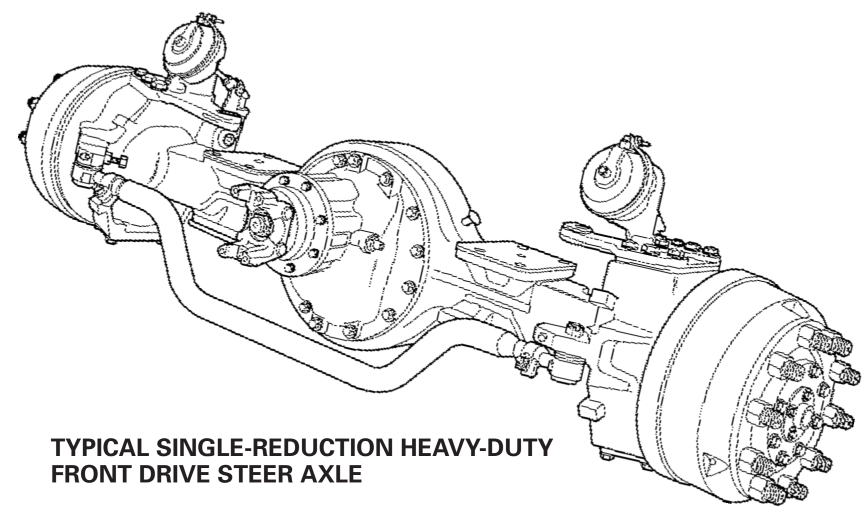


Figure 2.1

Some axle models are available with the following features.

- Single- or double-reduction carriers
- Right-hand or left-hand gearing
- Wedge or cam brakes
- Standard or wide tracks
- Driver-controlled main differential lock for increased traction

NOTE: Since 1994, the Q Series and Q Plus™ brakes have replaced the wedge brake on the RF-21 and RF-23 Series.

Basic Axle Models Covered in This Manual

Current Models	Prior Models	
RF-16-145	FDS-1600	FDS-2102
RF-21-155	FDS-1805	FDS-2107
RF-21-156	FDS-1807	FDS-2110
RF-21-160	FDS-1808	FDS-2111
RF-21-355	FDS-2100	FDS-2117
RF-22-166	FDS-2101	
RF-23-180		

Identification

Prior Axle Models

Meritor heavy-duty front drive steer axle models manufactured before 1989 were identified as shown in the following example. An 18,000 lb (8165 kg) front drive steer axle with a double-reduction 255 carrier model was identified as:

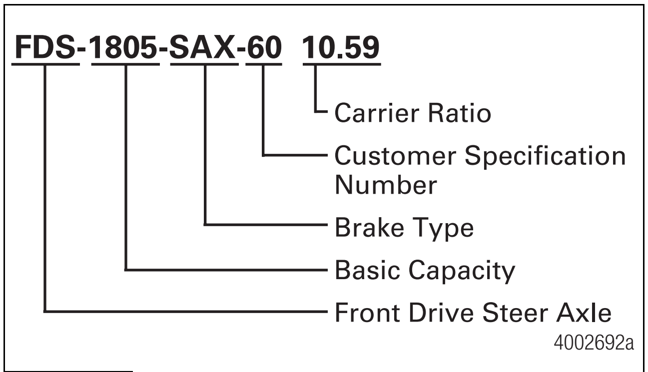


Figure 2.2

Prior Axle Model Designations

Meritor makes a complete line of FDS Series front drive axles with single axle capacities of 7,500-23,000 lbs (3400-10 500 kg).

FDS Series front drive axle model designations show the capacity, carrier model and design modifications of each model. The letters and numbers of the model designation correspond with information listed in Table A.

Table A: Model Information

Axle Model	Capacity[1] lbs (kg)	Carrier Model	Design Modification
FDS-75	7,500 (3400)	F-106	Standard
FDS-78	7,500 (3400)	F-106	Heavy-duty wheel ends
FDS-85	9,000 (4082)	H-140	Special carrier
FDS-90	9,000 (4082)	F-106	Standard
FDS-93	9,000 (4082)	F-106	Special track and offset bowl
FDS-1600	16,000 (7257)	H-140	Right-hand or left-hand gearing
FDS-1805	18,000-21,000 (8165-9525)	R-255	Double-reduction
FDS-1807	18,000-21,000 (8165-9525)	R-155	Single-reduction
FDS-1808	18,000-21,000 (8165-9525)	R-155	Right-hand gearing
FDS-2100	21,000 (9525)	R-155	Right-hand gearing
FDS-2101	21,000 (9525)	R-155	Left-hand gearing
FDS-2102	21,000-23,000 (9525-10 433)	R-255	Double-reduction
FDS-2107	23,000 (10 433)	R-170	Single-reduction
FDS-2110	21,000 (9525)	R-155	Wide track, right-hand gearing
FDS-2111	21,000 (9525)	R-155	Wide track, left-hand gearing
FDS-2112	21,000 (9525)	R-255	Wide track, double-reduction
FDS-2117	23,000 (10 433)	R-170	Wide track, single-reduction

1 Capacities vary with application and service. All applications must be approved by the Meritor Engineering Department.

Current Axle Models

Current heavy-duty front drive steer axle models are identified by a letter and number system. The letters and numbers give important information about the specific axle model.

The first seven positions of the designations identify a basic axle model. The second group of letters and numbers identify particular specifications.

As an example, a 16,000 lb (7258 kg) front drive steer axle with a single-reduction 145 model carrier is identified in Figure 2.3.

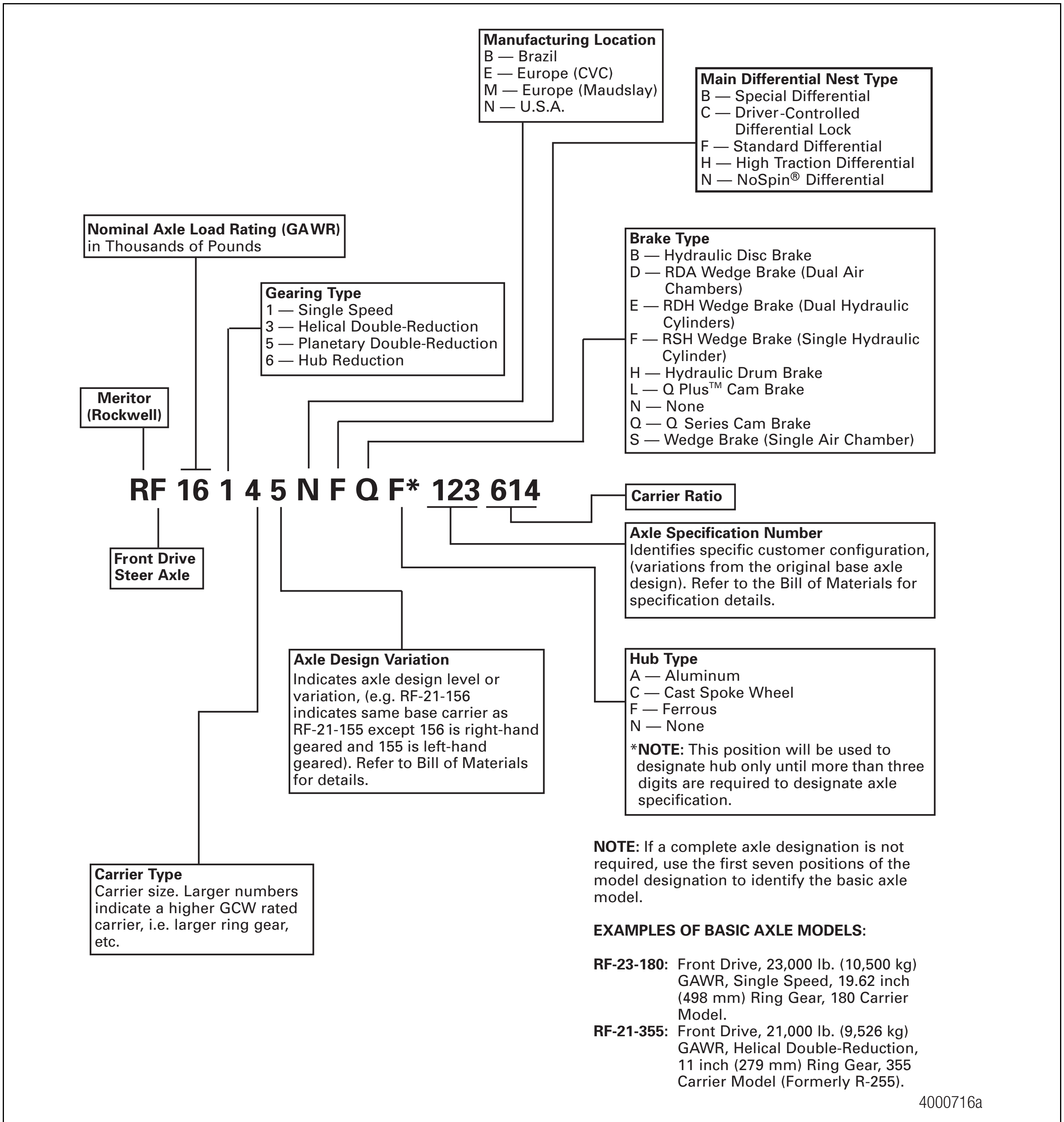

Manufacturing Location
B — Brazil
E — Europe (CVC)
M — Europe (Maudslay)
N — U.S.A.
Main Differential Nest Type
B — Special Differential
C — Driver-Controlled Differential Lock
F — Standard Differential
H — High Traction Differential
N — NoSpin® Differential
Nominal Axle Load Rating (GAWR) in Thousands of Pounds
Gearing Type
1 — Single Speed
3 — Helical Double-Reduction
5 — Planetary Double-Reduction
6 — Hub Reduction
Brake Type
B — Hydraulic Disc Brake
D — RDA Wedge Brake (Dual Air Chambers)
E — RDH Wedge Brake (Dual Hydraulic Cylinders)
F — RSH Wedge Brake (Single Hydraulic Cylinder)
H — Hydraulic Drum Brake
L — Q Plus™ Cam Brake
N — None
Q — Q Series Cam Brake
S — Wedge Brake (Single Air Chamber)
Meritor (Rockwell)
RF 16 1 4 5 N F Q F* 123 614
Carrier Ratio
Front Drive Steer Axle
Axle Specification Number
Identifies specific customer configuration, (variations from the original base axle design). Refer to the Bill of Materials for specification details.
Axle Design Variation
Indicates axle design level or variation, (e.g. RF-21-156 indicates same base carrier as RF-21-155 except 156 is right-hand geared and 155 is left-hand geared). Refer to Bill of Materials for details.
Hub Type
A — Aluminum
C — Cast Spoke Wheel
F — Ferrous
N — None
*NOTE: This position will be used to designate hub only until more than three digits are required to designate axle specification.
Carrier Type
Carrier size. Larger numbers indicate a higher GCW rated carrier, i.e. larger ring gear, etc.
NOTE: If a complete axle designation is not required, use the first seven positions of the model designation to identify the basic axle model.
EXAMPLES OF BASIC AXLE MODELS:
RF-23-180: Front Drive, 23,000 lb. (10,500 kg) GAWR, Single Speed, 19.62 inch (498 mm) Ring Gear, 180 Carrier Model.
RF-21-355: Front Drive, 21,000 lb. (9,526 kg) GAWR, Helical Double-Reduction, 11 inch (279 mm) Ring Gear, 355 Carrier Model (Formerly R-255).
4000716a

Figure 2.3

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Inspection

Tie Rod End Wear

You may not be able to detect loose or worn tie rod ends during operation. Under normal operating conditions, wear occurs over time. The preload bearings inside each tie rod end provide less resistance, which can affect steering control, front tire wear and other axle components.

Regularly-scheduled inspection and maintenance helps to minimize the effects of tie rod end wear on the vehicle. Refer to Table B for inspection intervals. Figure 3.1.

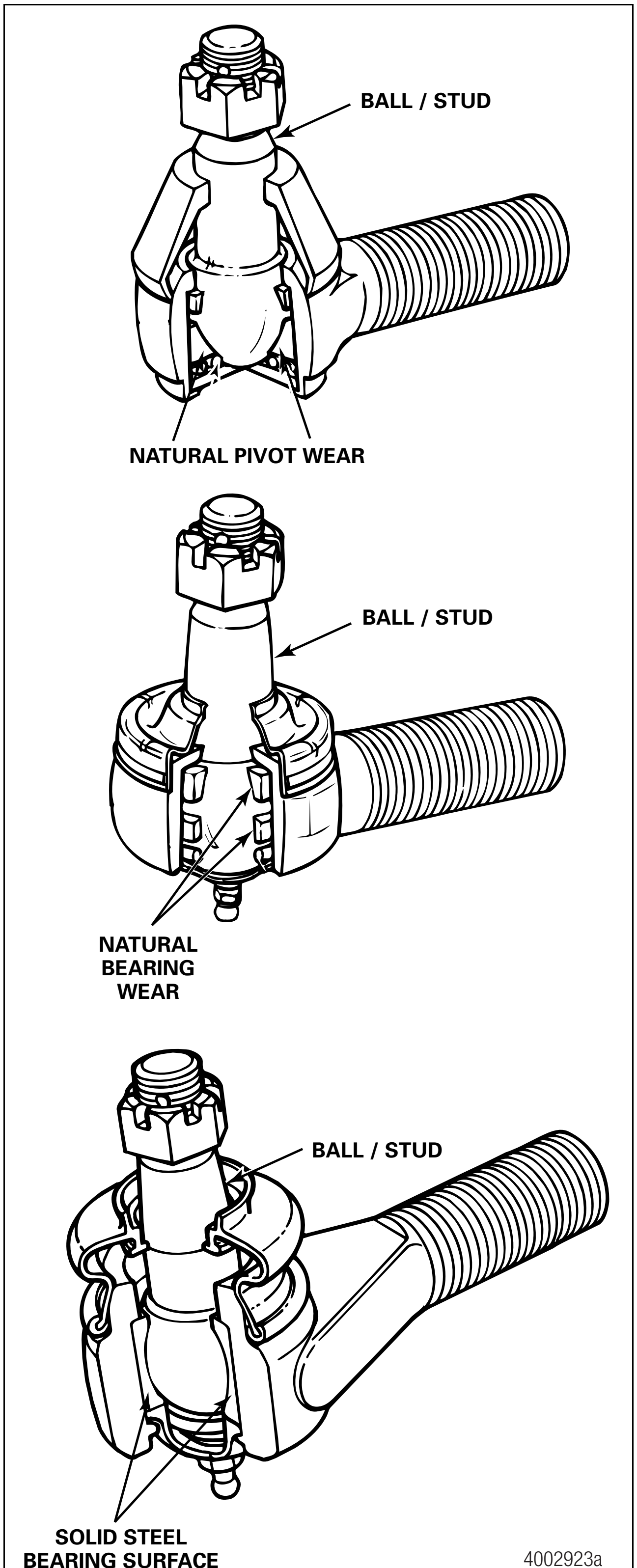


Figure 3.1

Does Tie Rod End Wear Affect the Steering Linkage?

Unless tie rod end wear becomes excessive, a safe steering linkage is maintained. However, tie rod end wear can affect uniform steering control and, ultimately, wear to the front tires.

Can the Driver Detect Tie Rod End Wear During Vehicle Operation?

A driver may not always detect a loose tie rod end condition during vehicle travel conditions. This is why it is important to inspect tie rod ends for wear and allowable movement at regular intervals. Refer to Table B for inspection intervals.

Table B: Tie Rod End Service Intervals

Group Number	Typical Vocations	Vehicle Build	Inspection Interval	Lube Interval [1, 2]	Typical Operation Conditions
1 Light	On highway or turnpike, linehaul only	After July 1, 1996 Before July 1, 1996, see category 3	Each oil change or maximum 50,000 miles (80 500 km)	100,000 miles (161 000 km)	High mileage operation, more than 50,000 miles per year (80 500 km per year) 95% on-highway or turnpike surface
2 Medium	Fire and rescue, city delivery, inner city coach, heavy haul, school bus, motor home, transit coach	After July 1, 1996 Before July 1, 1996, use category 3	20,000 miles (32 200 km)	40,000 miles (64 400 km)	Lower mileage operation, less than 50,000 miles per year (80 500 km per year)
3 Harsh	Logging, oil field, construction, heavy haul, highway-licensed yard tractor, residential refuse	ALL	10,000 miles (16 100 km)	10,000 miles (16 100 km)	Low mileage operation, less than 25,000 miles per year (40 250 km per year) Heavy-duty service with substantial off-road operation
4 Severe	Mining, on-highway-licensed yard tractor, land fill refuse		5,000 miles 100 hours	5,000 miles 100 hours	Heavy-duty service
5 Very Severe	Mining, logging, construction		48 hours	48 hours	Severe duty 80-100% off-highway

[1] If power washers are used during vehicle cleaning operations, lubrication intervals need to be adjusted. Frequent power-washed vehicles will require more frequent lubrication.

[2] Tie rod ends with an anti-tilt style seal require lubrication intervals every 10,000 miles (16 100 km).

Tie Rod Assembly for Movement

For roadside inspection, refer to the procedure in this section.

Vehicle Raised and Supported with Safety Stands

To perform this inspection, the entire system must be unloaded. The front end of the vehicle must be raised and supported with stands.

NOTE: Do not grease the tie rod assembly before you perform the inspection.

⚠ WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface with the wheels STRAIGHT. Block the wheels to prevent the vehicle from moving. Set the parking brake. Figure 3.2.

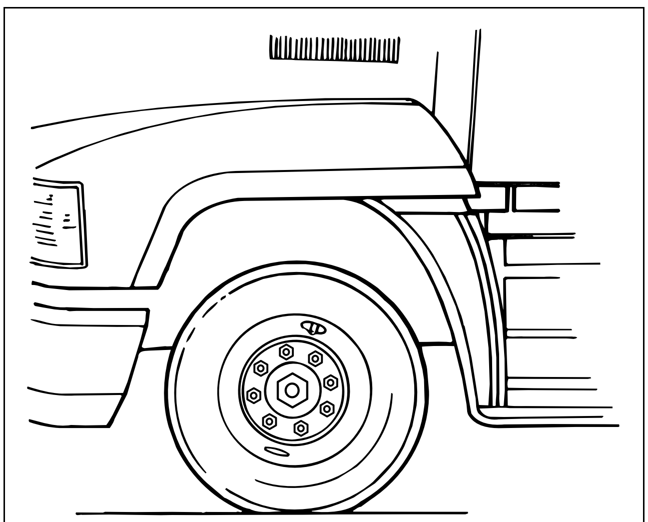


Figure 3.2

2. Raise the vehicle so that the front wheels are off the ground. Support the vehicle with safety stands. Do not use a jack to support the vehicle.
3. With the engine off, turn the wheels from full left to full right. Return to the straight-ahead position. This step will require more force for vehicles with the power steering off.
4. Check the tie rod boot for cracks, tears or other damage. Also check the boot seals for damage. Replace the entire tie rod end if the boot is damaged or missing. Figure 3.3.

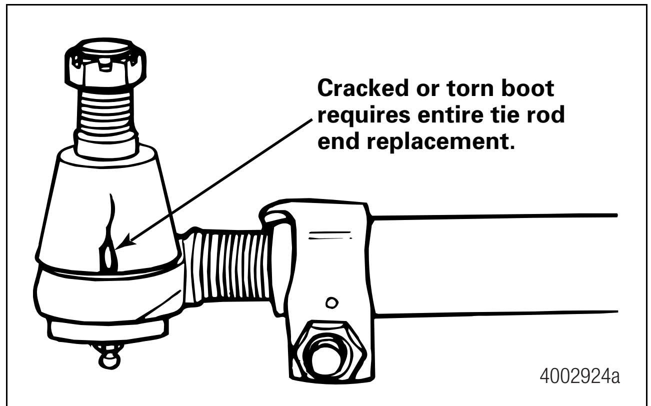


Figure 3.3

⚠ WARNING

Verify that a cotter pin is installed through the tie rod end, and the tie rod end nut is tightened to the correct torque specification. Replace a missing cotter pin and tighten a loose tie rod end nut. A missing cotter pin or loose tie rod end nut can cause loss of steering control. Serious personal injury and damage to components can result.

5. Check that the tie rod end nut is installed and secured with a cotter pin.
   - **If the cotter pin is missing:** Tighten the tie rod end nut to the correct specification. Install a new cotter pin. Always tighten the tie rod end nut to the specified torque when setting the cotter pin. Refer to Section 10. Do not back-off the nut to insert the cotter pin. Figure 3.4.

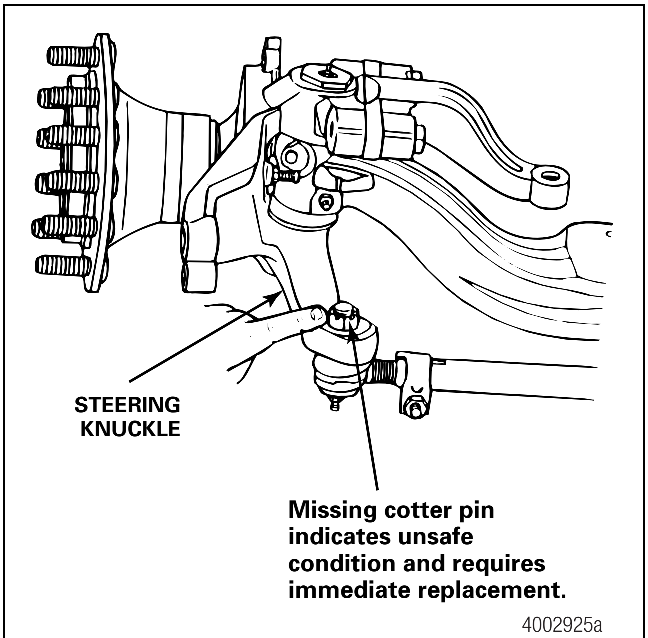


Figure 3.4

6. Check that the tie rod end is threaded correctly into the cross tube and installed deeper than the end of the cross tube slot. The tie rod end must be visible the entire length of the cross tube slot. Figure 3.5.

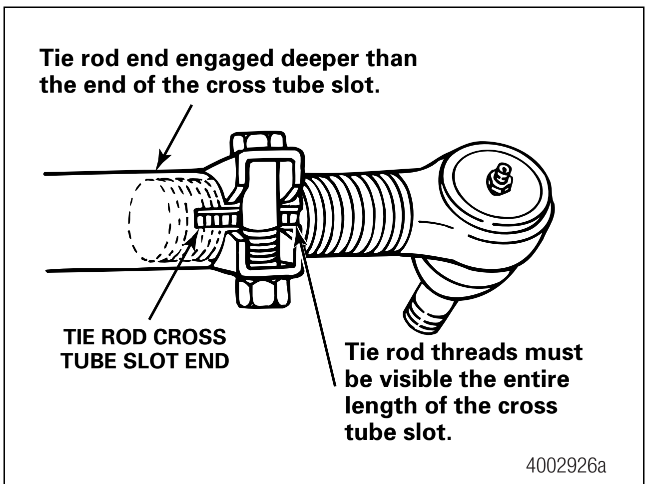


Figure 3.5

7. Check that the grease fittings are installed. Replace a damaged grease fitting.
   - **If the tie rod ends are non-greaseable:** Do not install a grease fitting. Figure 3.6.

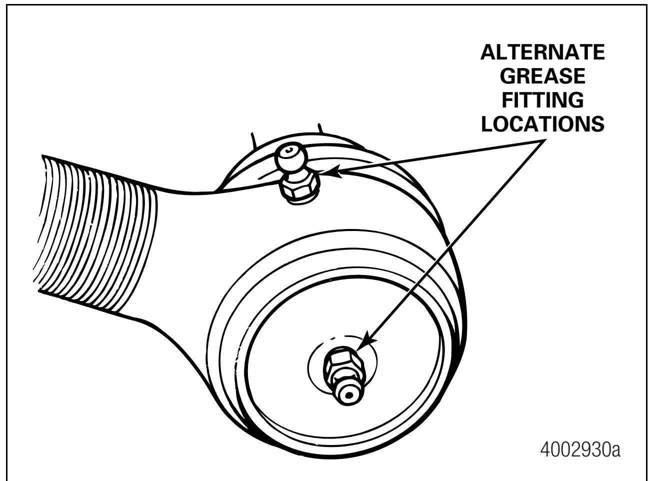


Figure 3.6

8. By hand or using a pipe wrench with jaw protectors to avoid gouging the cross tube, rotate the cross tube toward the FRONT of the vehicle and then toward the REAR. After rotating, center the cross tube between the stop positions.
   - **If the cross tube will not rotate in either direction:** Replace both tie rod ends.
9. Position yourself directly below the ball stud socket. Using both hands, grasp the assembly end as close to the socket as possible, no more than 6-inches (152.4 mm) from the end.

CAUTION

Only use your hands to check for movement or looseness of the tie rod assembly. Do not use a crow bar, pickle fork or two-by-four. Do not apply pressure or force to the tie rod assembly ends or joints. Do not rock the tires with the vehicle on the ground or with the wheels raised. Damage to components can result.

10. Apply hand pressure of approximately 100 pounds (45 kg) in a vertical PUSH-and-PULL motion several times. Check for any movement or looseness at both tie rod ends. Figure 3.7.
    - **If there is any movement in the tie rod assembly:** Replace both tie rod ends.

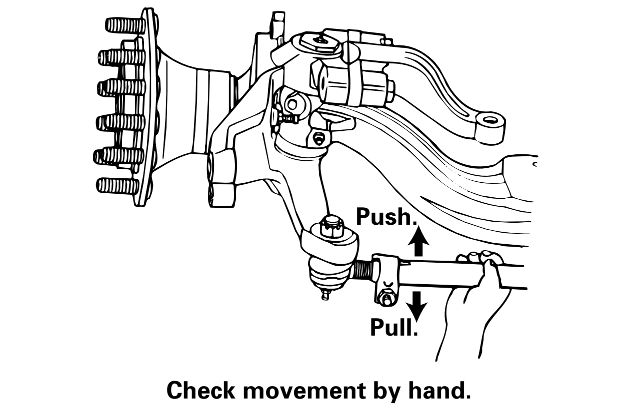


Figure 3.7

⚠ CAUTION

Replace bent or damaged cross tubes with original equipment parts of the same length, diameter and threads. Do not attempt to straighten a bent cross tube. Damage to components can result.

11. Inspect the cross tube and clamps for damage. Figure 3.8.
    - **If the cross tube is bent or cracked:** Replace it. Use original equipment parts of the same length, diameter and threads.
    - **If the clamps are damaged:** Replace them.
    - **If either clamp has become welded to the cross tube:** Replace the entire cross tube assembly. Use original equipment parts of the same length, diameter and threads.

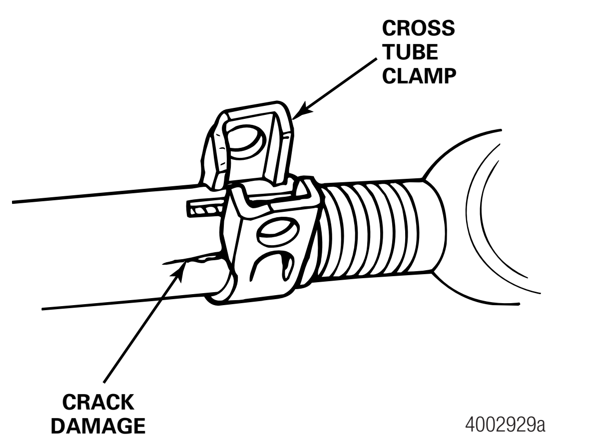


Figure 3.8

Federal Out of Service Roadside Inspection Criteria (Department of Transportation)

The following cross tube and tie rod end components may be checked during roadside inspections. Deficiencies may result in the vehicle being placed out-of-service by authorized personnel.

1. Loose clamps or clamp bolts on the tie rods.
2. Any looseness in the threaded tie rod end and cross tube joint.
3. Loose or missing nuts on the tie rods or cross tube.
4. Any movement under the steering load of a tie rod arm ball stud nut.
5. Any motion, other than rotational, between any linkage member and its attachment point of more than 0.125-inch (3 mm), when measured with hand pressure.
6. Any obvious welded repairs.

Replacement Criteria

Any detectable movement of 0.125-inch (3 mm) or more requires that the vehicle is immediately taken out of service for replacement of the tie rod ends.

When the roadside check indicates tie rod end movement of less than 0.125-inch (3 mm), the vehicle does not need to be immediately removed from a service run. It is advisable to schedule a major out-of-service inspection and maintenance as soon as possible.

Commercial Vehicle Safety Alliance (CVSA) Criteria

The following are reprinted with permission from the CVSA operations manual.

When any of these values are met or exceeded, vehicle shall be placed out-of-service.

g. Ball and Socket Joints:

(1) Any movement under steering load of a stud nut. [396.3(a)(1)]

(2) Any motion, other than rotational, between any linkage member and its attachment point of more than 1/8 inch (3mm) measured with hand pressure only. [396.3(a)(1)]

(3) Any obvious welded repair(s). [396.3(a)(1)]

h. Tie Rods and Drag Links:

(1) Loose clamp(s) or clamp bolt(s) on tie rods or drag links. [396.3(a)(1)]

(2) Any looseness in any threaded joint. [396.3(a)(1)]

i. Nuts:

Loose or missing on tie rods, pitman arm, drag link, steering arm, or tie rod arm. [393.209(d)]

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

Disassembly

Front Drive Steer Axle Wheel Ends Equipped with Wedge Brakes

NOTE: When servicing drive shafts only, you may remove the steering knuckle as an assembly. To remove the steering knuckle as an assembly:

- Refer to the steering knuckle removal procedure in this section.
- After you remove the steering knuckle, proceed to the procedure in this section to service the drive shafts.

Removal

Wheels, Drums and Hubs from the Axle

WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

You must manually adjust the brake after you perform maintenance or service. Do not depend on the automatic adjusters to remove the excessive clearance created when you back off the brake during service. The automatic adjusters are designed to compensate for normal lining wear. Damage to components and serious personal injury can occur.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Use a jack to raise the vehicle so that the wheels to be serviced are off the ground. Support the vehicle with safety stands.
3. Remove the dust shield.
4. Retract the brake linings so that the drums will clear the linings. Refer to Maintenance Manual 4R, Wedge Brakes. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.
   A. Remove the plugs from the adjustment and inspection slots on the dust shield.
   B. Rotate the drum to verify that the brake is completely released.

      NOTE: Meritor KIT 1184 includes an adjusting spoon plus a seal driver and a brake spring tool. To obtain the kit and individual tools, refer to the Service Notes page on the front inside cover of this manual.

   C. While you rotate the drum, use an adjusting spoon to turn the adjusting bolt until the linings drag heavily on the drum.
   D. Repeat the previous step for the other adjuster on the brake.

5. Pull the hub, drum and wheel assembly straight off the spindle. If necessary, hit the inside of the wheel with a mallet to loosen it. Be careful that the outer bearing cone does not fall when the hub is removed. It is not necessary to remove the rim and tire at this time.
   - **If the steering axle universal joint is to be removed from the housing:** Remove the oil drain plug and drain the lubricant from the axle.

CAUTION

To loosen the drive flange from the hub, hit the flange with a soft mallet. Do not pry off the parts with a sharp tool. Damage to the mounting surfaces can occur.

6. Remove the drive flange from the wheel hub. The hubcap does not need to be removed from the drive flange unless it is damaged. Figure 4.1.

   NOTE: The felt seal and retainer are only included with the greaseable drive flange design.

7. If necessary, remove the felt seal and retainer from the drive flange. Figure 4.1.

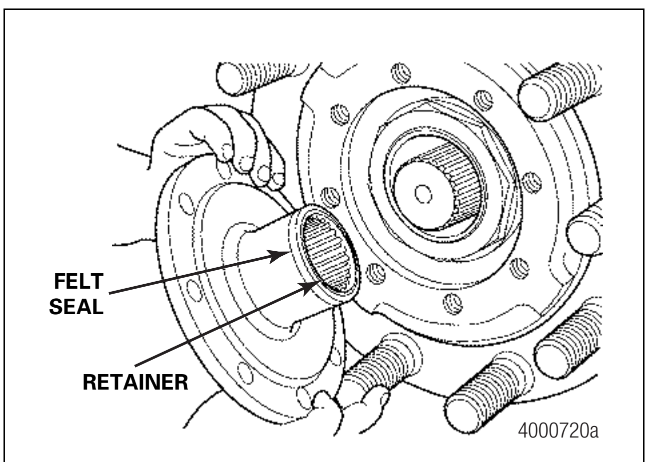


Figure 4.1

8. If necessary, remove the hubcap. Use a puller to remove the drive flange. Figure 4.2.

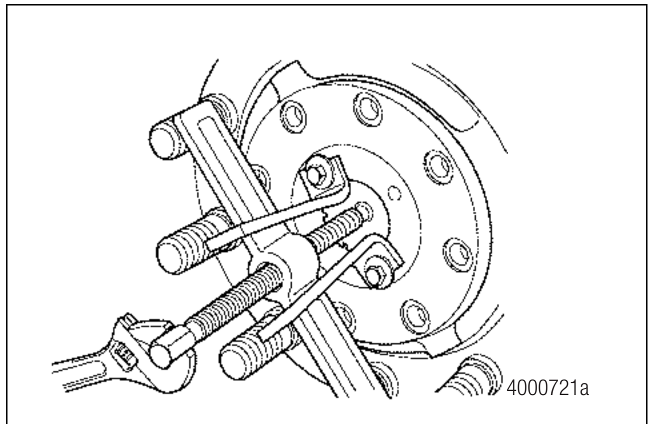


Figure 4.2

9. Remove the outer adjusting nut, lock ring and the inner adjusting nut from the spindle. Use the correct size wrench socket to remove the adjusting nut. Figure 4.3.

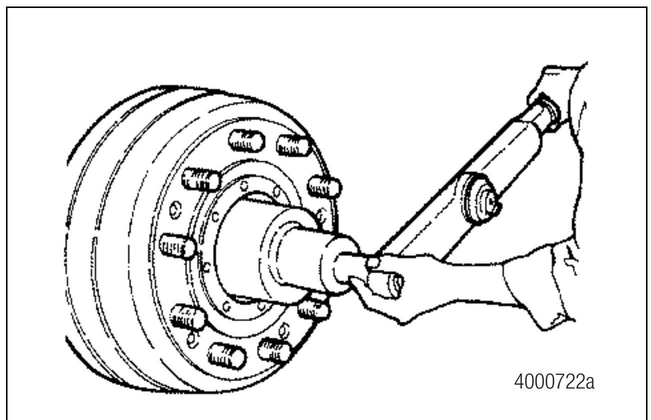


Figure 4.3

Disassembly

Bearing Cups and Oil Seal from the Hub

1. Remove the wheel, rim and tire, from the hub if not previously removed.
2. To remove the drum from the hub, remove the flat head capscrews, if used, from the drum.
3. If necessary, place the hub in a press to remove the wheel studs from the hub. Support the hub flange and press the studs through the hub.
   - **If a press is not available:** Use a brass hammer or drift.
4. If necessary, use a long screwdriver to remove the oil seal from the hub. Discard the oil seal. Figure 4.4.

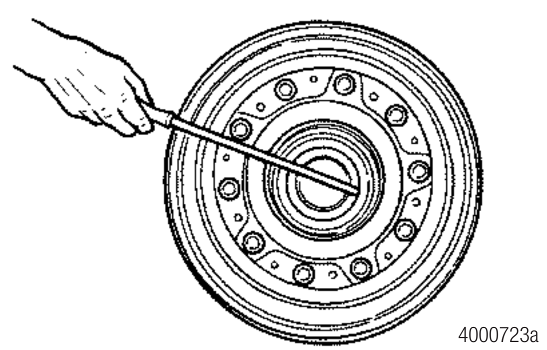


Figure 4.4

5. Remove the inner bearing cone from the hub.
6. Use a press and sleeve or a bearing puller to remove the inner and outer bearing cups from the hub.
7. Remove the oil seal sleeve from the spindle.

Removal

Steering Knuckle from the Housing

Meritor front drive steer axles have four different knuckle designs. Figure 4.5.

- Full Bearing King Pin
- Upper Bushing, Lower Bearing King Pin
- Full Bushing King Pin
- Full Bushing and Thrust Bearing King Pin

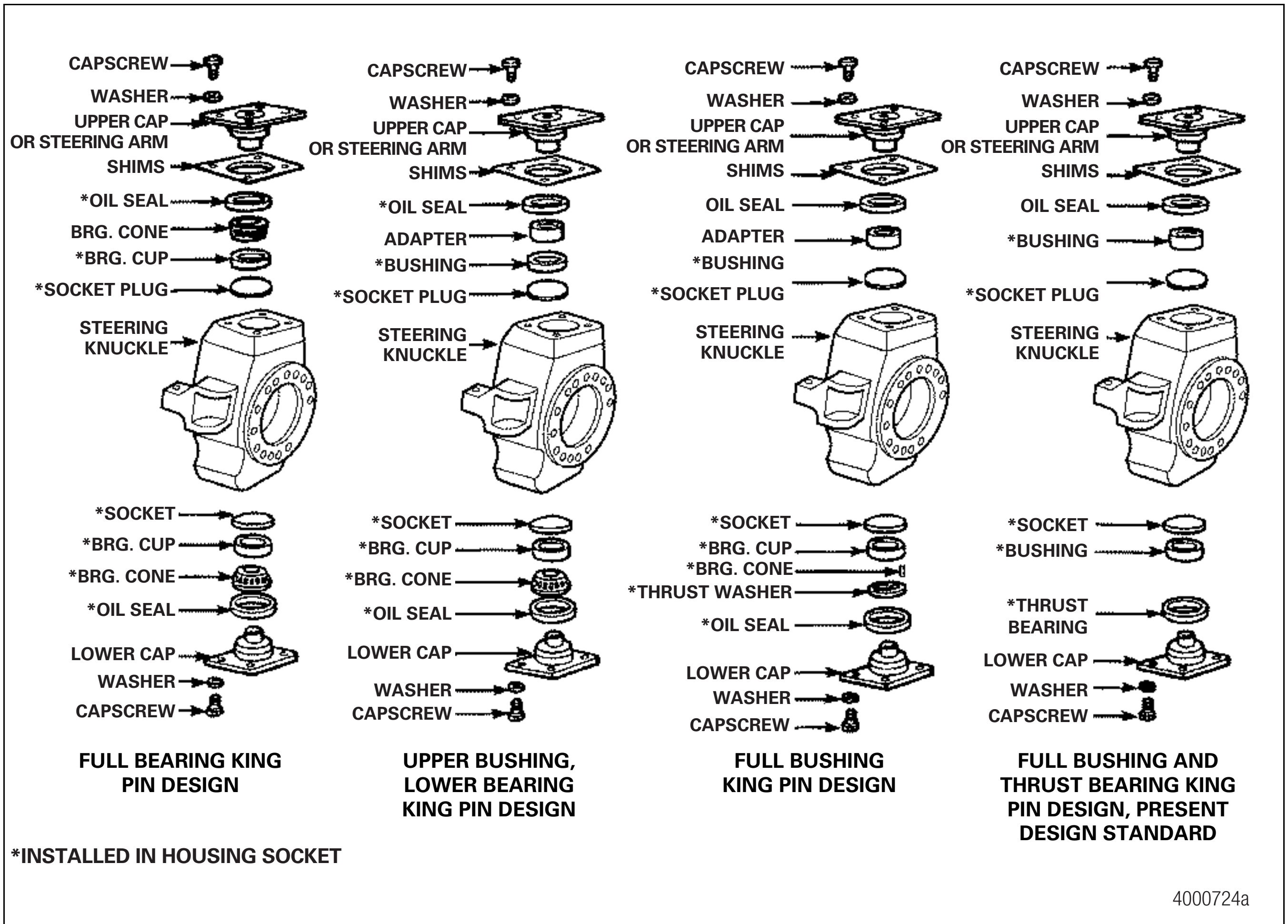


Figure 4.5

On axles above 16,000 lb (7258 kg) GAWR, the steering knuckle must be disassembled before the steering universal joint can be removed. On 16,000 lb (7258 kg) axles with the 850 joint, FDS-1600, the knuckle does not have to be disassembled.

On all models, the steering arm and cross tube assemblies can be serviced without removing the steering knuckle from the housing.

1. Remove the steering arm ball cotter pin and nut to disconnect the steering linkage from the steering arm. It is not necessary to remove the steering arm from the adapter cap and knuckle at this time.
2. Remove the tie rod cotter pin and nut to disassemble the tie rod from the knuckle arm. Figure 4.6.

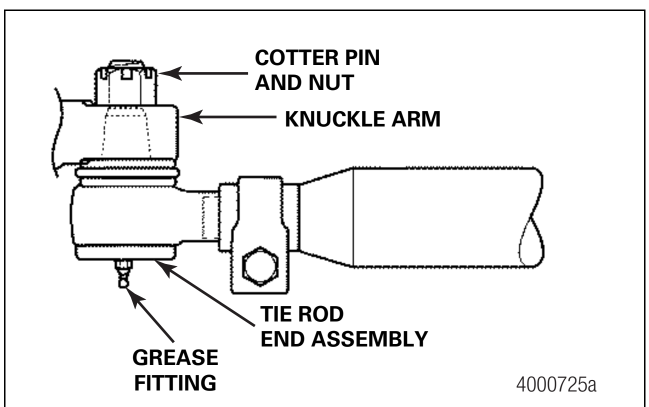


Figure 4.6

3. Push the ball stud for the cross tube end through the knuckle arm. If necessary, use a hard mallet to hit the arm to loosen the taper lock.

   NOTE: It is not necessary to disassemble both cross tube ends unless both knuckle assemblies are being serviced at the same time.

4. Remove the four capscrews from the upper knuckle cap.
5. Lift the upper knuckle cap assembly from the bore. Keep the shims together for use at reassembly. Figure 4.7.

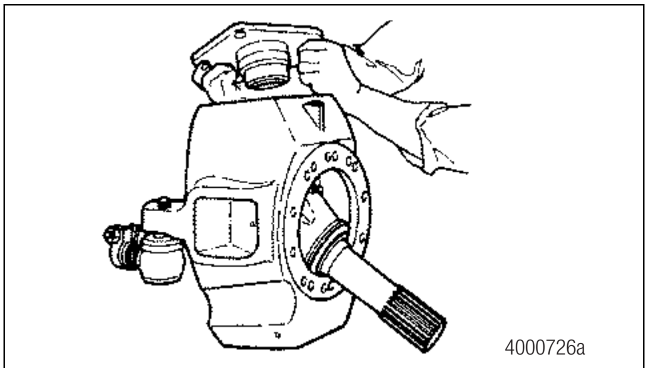


Figure 4.7

6. Follow the appropriate procedure below to disassemble the upper and lower knuckle caps.

   A. **Full Bearing King Pin Design:** Inspect the oil seal and bearing cone on the upper knuckle cap for wear and damage. Replace all parts that are worn or damaged.

   B. Disassemble the lower knuckle cap. Keep the shims together for use at reassembly. Inspect the oil seal and bearing cone for wear and damage. Replace all parts that are worn or damaged.

   C. Proceed to Step 7.

   A. **Upper Bushing, Lower Bearing King Pin Design:** Inspect the adapter and oil seal on the upper knuckle cap for wear and damage. Replace all parts that are worn or damaged.

   B. Disassemble the lower knuckle cap. Inspect the oil seal and bearing cone for wear and damage. Replace all parts that are worn or damaged.

   C. Proceed to Step 7.

   A. **Full Bushing King Pin Design:** Inspect the bushing journal and oil seal on the upper knuckle cap for wear and damage. Replace all parts that are worn or damaged at reassembly.

   B. Disassemble the lower knuckle cap. Inspect the bushing journal and oil seal for wear and damage. Replace all parts that are worn or damaged at reassembly.

   C. Remove the thrust washer and retaining pin, if necessary, from the lower socket. Inspect the thrust washer and pin for wear and damage and replace it, if necessary, at reassembly.

   D. Proceed to Step 7.

   A. **Full Bushing/Thrust Bearing King Pin Design:** Inspect the bushing journal and oil seal on the upper knuckle cap for wear and damage. Replace all parts that are worn or damaged at reassembly.

   B. Disassemble the lower knuckle cap. Inspect the thrust bearing and the bushing journal on the lower knuckle cap for wear and damage. Replace all parts that are worn or damaged at reassembly.

   C. Proceed to Step 7.

7. After both the upper and lower knuckle cap assemblies are removed, pull the steering knuckle from the housing. Leave the universal joint in the housing.
8. Depending on which design of knuckle you are working on, the bushings or bearing cups will remain in the sockets of the housing. Inspect the upper and lower bushings or bearing cups while they are still in the sockets for wear or damage. Figure 4.8.

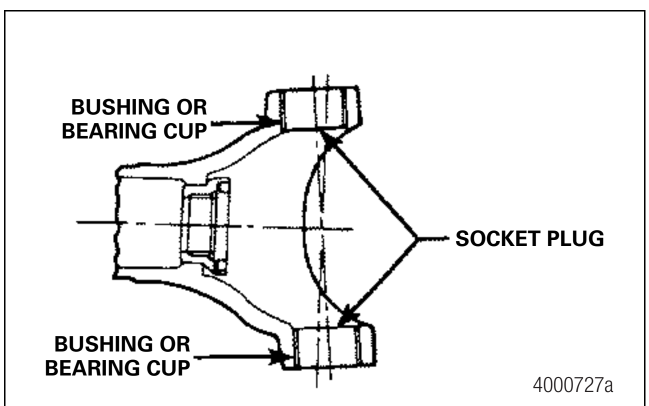


Figure 4.8

9. If necessary, remove the bushings or bearing cups and the socket plugs from the upper and lower sockets in the housing.

Disassembly

Wedge Brake and Spindle from the Steering Knuckle

ASBESTOS AND NON-ASBESTOS FIBERS WARNING

Some brake linings contain asbestos fibers, a cancer and lung disease hazard. Some brake linings contain non-asbestos fibers, whose long-term effects to health are unknown. You must use caution when you handle both asbestos and non-asbestos materials.

WARNING

Before you service a spring chamber, carefully follow the manufacturer's instructions to compress and lock the spring to completely release the brake. Verify that no air pressure remains in the service chamber before you proceed. Sudden release of compressed air can cause serious personal injury and damage to components.

1. Drain the air tank.
2. Disconnect the air lines at the brake assembly.
3. Remove the air brake chambers. Refer to Maintenance Manual 4R, Wedge Brakes. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

   NOTE: Oil deflector not included with greaseable drive flange design.

4. To disassemble the oil deflector and wedge brake assembly from the spindle and steering knuckle, remove the attaching capscrews. Some wedge brake models require that the shoe return springs and brake shoes be removed before the capscrews can be reached. Refer to Maintenance Manual 4R, Wedge Brakes. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.
5. Pull the spindle straight from the knuckle and drive shaft. Figure 4.9.

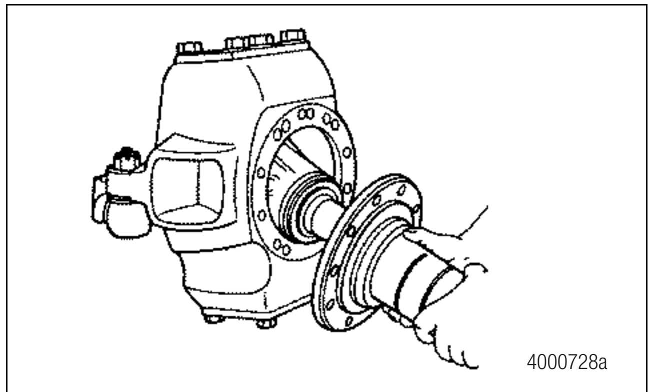


Figure 4.9

NOTE: The felt seal and retainer are not included with the greaseable drive flange design.

6. The felt seal and retainer, if used, and the sleeve and thrust washer will remain inside the spindle. If necessary, disassemble these pieces with a screwdriver.

Removal

Bearings and Bushings from the Housing Socket

Full Bushing, Thrust Bearing and Full Bushing King Pin Designs

1. Grind off the four tack welds that hold the socket plugs to the housing. Grind the tack welds carefully so that the bore is not damaged.
2. Use a drift that fits inside the bushing to remove the plug. Drive it toward the center of the socket. Figure 4.10.

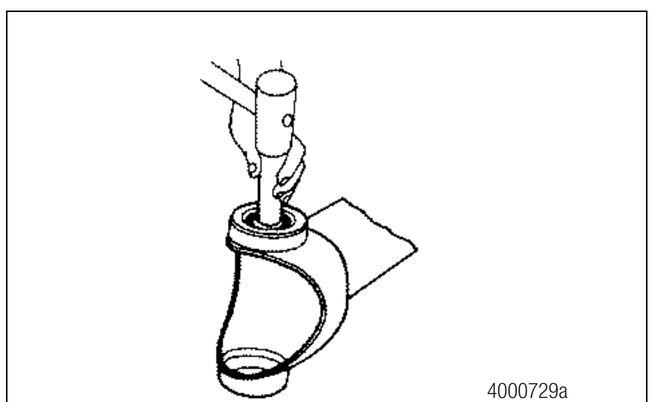


Figure 4.10

3. Use a sleeve that is slightly smaller than the socket bore to drive the bushing toward the outside of the socket. Figure 4.11.

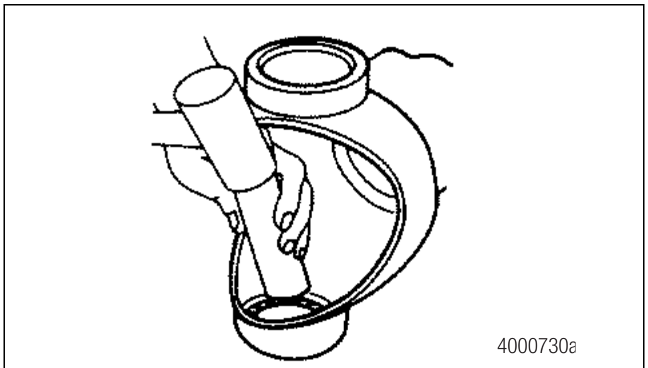


Figure 4.11

4. Clean all grease and dirt from the bores before reassembly.

Upper Bushing, Lower Bearing and Full Bearing King Pin Designs

1. Place a sleeve with approximately the same diameter as the inside bore of the socket against the plugs. There are no tack welds to remove.
2. Use a bottle jack to drive the plugs and bushings or bearing cups toward the outside of the socket. Figure 4.11.

Steering Universal Joint from the Housing

1. Pull the universal joint and drive shaft assembly straight from the carrier housing. Figure 4.12.

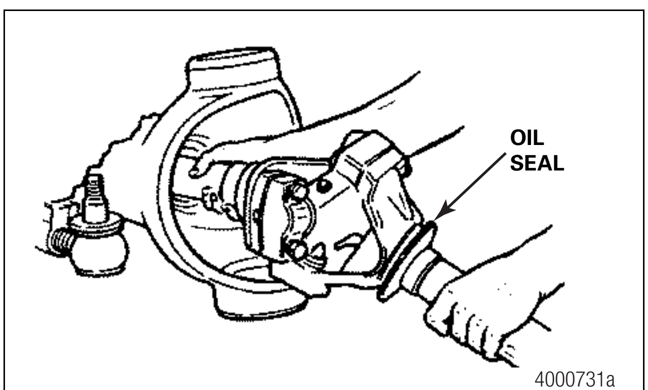


Figure 4.12

2. Remove the oil seal from the outer drive shaft. Discard the seal. Figure 4.12.

3. If necessary, the thrust washer can be removed by tack welding a bar to its outer surface.

   NOTE: Some axles have the inner drive shaft bushing installed in the bushing adapter. Do not remove the adapter from the housing. Figure 4.13.

4. If required, remove the inner drive shaft oil seal, thrust washer and bushing from the axle housing. Figure 4.13.

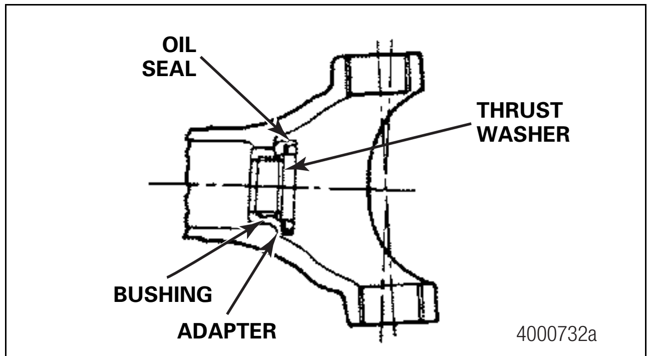


Figure 4.13

Disassembly

Steering Universal Joint

NOTE: Do not disassemble Permalube™ joints. Disassembly will void the Meritor warranty.

Meritor front drive steer axles with wedge brakes have two different universal joint designs:

- Wing Bearing Yokes. Figure 4.14.
- Round Bearing Yokes. Figure 4.15.

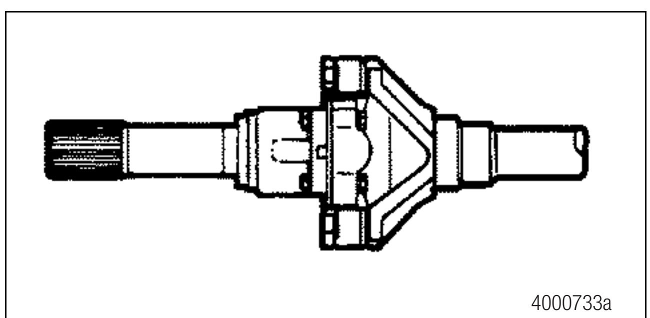


Figure 4.14

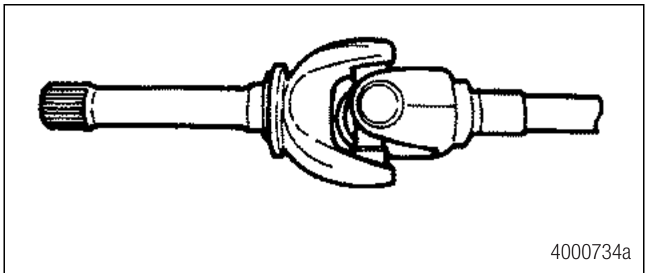


Figure 4.15

Wing Bearing Yokes

1. Remove the four cross assembly capscrews from each yoke.
2. Do not disassemble the cross assembly. If the cross assembly needs service, replace it with a new assembly.

Round Bearing Yokes

1. Use snap ring pliers to remove the snap rings. Figure 4.16.

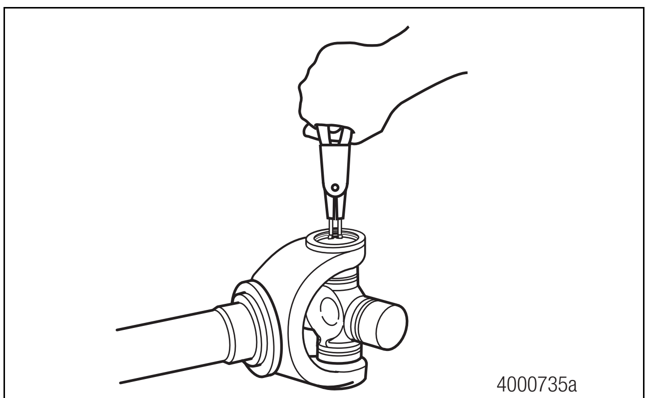


Figure 4.16

2. If necessary, use a brass drift and lightly tap the center of the bushing to assist in snap ring removal. Figure 4.17.

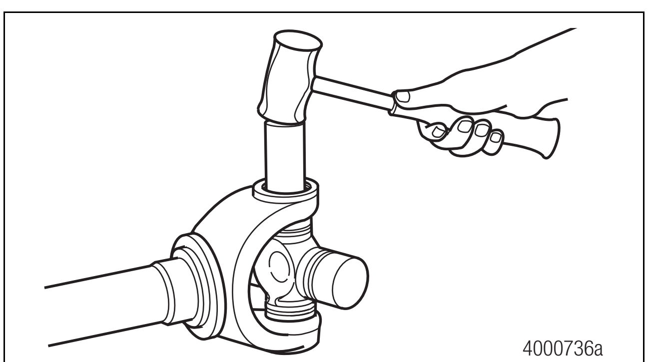


Figure 4.17

3. Repeat the previous step on the other sides of the yoke.
4. Use a press, bridge and bearing cup bushing receiver as shown in Figure 4.18. The bridge and bearing cup bushing receiver are detailed in Figure 4.19.

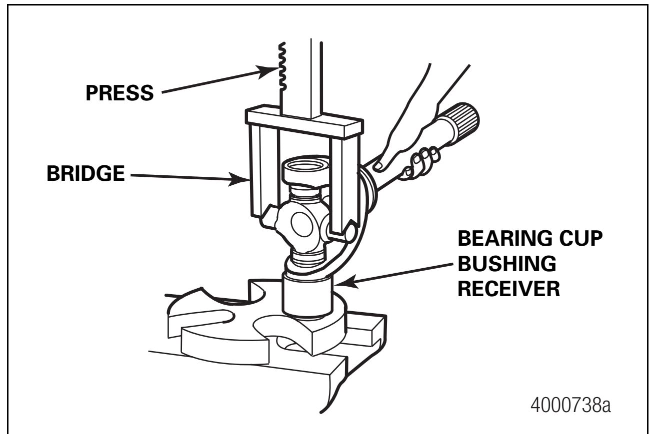


Figure 4.18

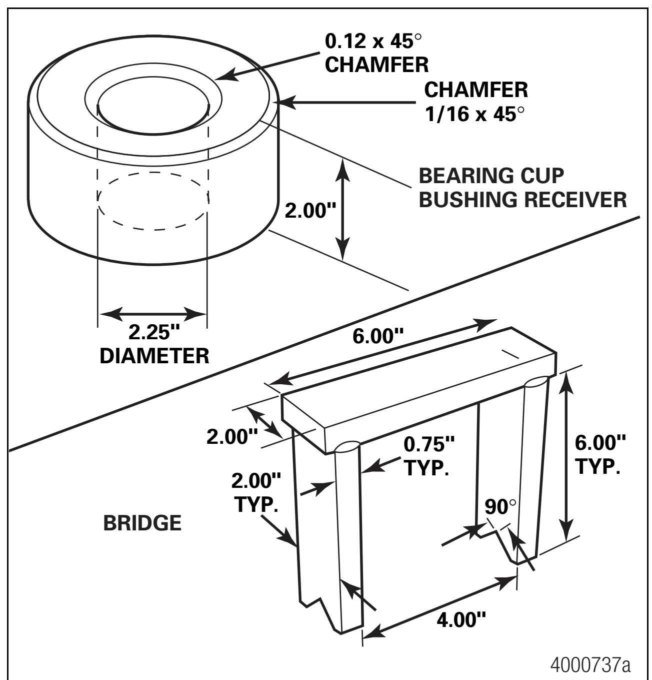


Figure 4.19

5. Press DOWN until the first round bushing is loose. Figure 4.18.

6. Remove the round bushing. Figure 4.20.

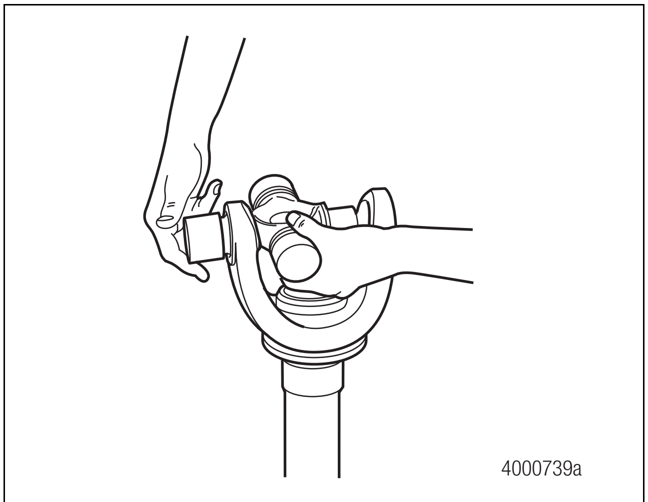


Figure 4.20

7. Turn over the universal joint. Repeat the procedure for the opposite side of the universal joint. Figure 4.21.

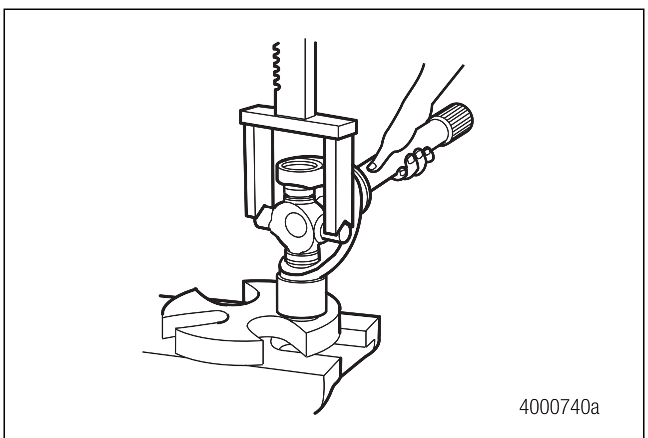


Figure 4.21

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

Disassembly

Front Drive Steer Axle Wheel Ends Equipped with Cam Brakes

NOTE: When servicing drive shafts only, you may remove the steering knuckle as an assembly. To remove the steering knuckle as an assembly:

- Refer to the steering knuckle removal procedure in this section.
- After you remove the steering knuckle, refer to the procedure in this section to service the drive shafts.

Removal

Wheels, Drums and Hubs from the Axle

WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface. Block the wheels to keep the vehicle from moving.
2. Use a jack to raise the vehicle so that the wheels to be serviced are off the ground. Support the vehicle with safety stands.
3. Retract the brake linings so that the drums will clear the linings.
4. Remove the automatic slack adjuster. Refer to Maintenance Manual 4B, Automatic Slack Adjusters. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.
5. If the steering universal joint is to be removed from the housing, remove the oil drain plug and drain the lubricant from the axle.

   NOTE: It is not necessary to remove the rim and tire at this time.

6. Remove the capscrews and washers that connect the drive flange to the wheel hub. The hubcap does not need to be removed from the drive flange unless it is damaged. Figure 5.1.

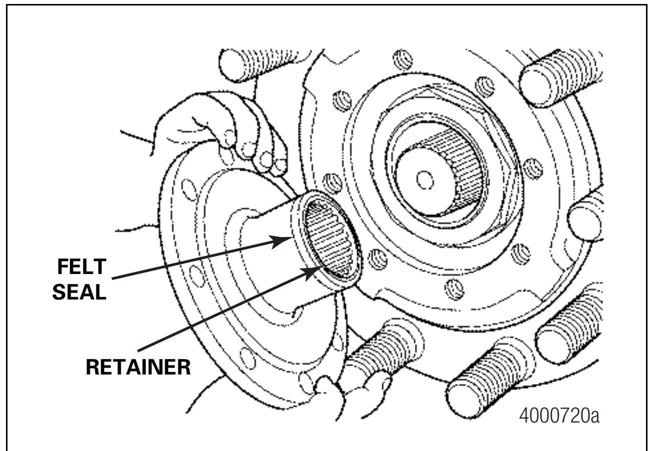


Figure 5.1

CAUTION

To loosen the drive flange from the hub, hit the flange with a soft mallet. Do not pry off the parts with a sharp tool. Damage to the mounting surfaces can occur.

7. If necessary, remove the hubcap. Use a puller to remove the drive flange. Figure 5.2.

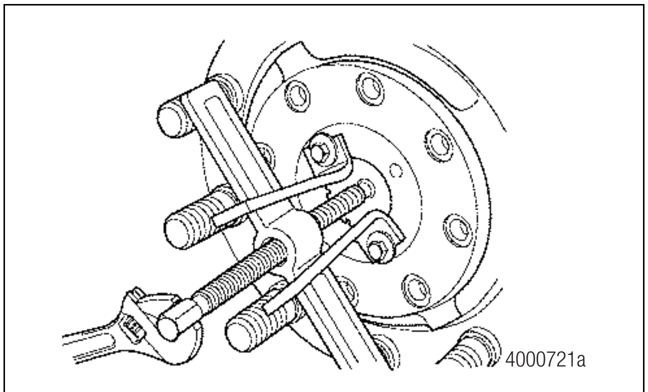


Figure 5.2

8. If necessary, remove the felt seal and retainer from the drive flange.
9. Remove the outer adjusting nut, lock washer and inner adjusting nut from the spindle. Use the correct size wrench socket to remove the adjusting nut. Refer to Table G. Figure 5.3.

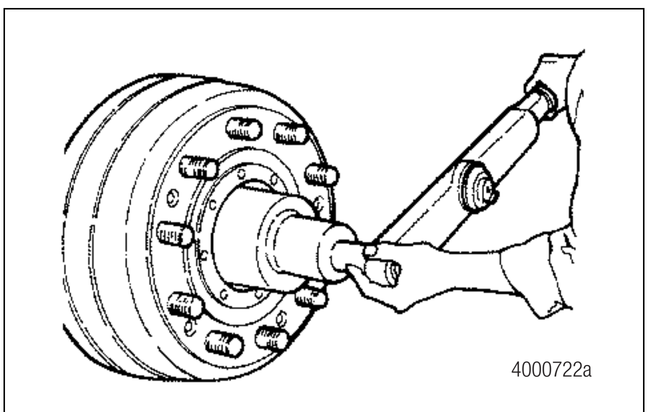


Figure 5.3

10. Remove the hub, drum and wheel assembly, if still mounted, straight off the spindle. If necessary, hit the inside of the wheel with a mallet to loosen it. Prevent the outer bearing cone from falling when you remove the hub.

Disassembly

Bearing Cups and Oil Seal from the Hub

1. Remove the wheel, rim and tire, from the hub if not previously removed.
2. If it is necessary to remove the wheel studs from the hub, place the hub in a press. Support the hub flange and press the studs through the hub.
   - **If a press is not available:** Use a brass hammer or drift.
3. If necessary, use a long screwdriver to remove the oil seal from the hub. Discard the oil seal. Figure 5.4.

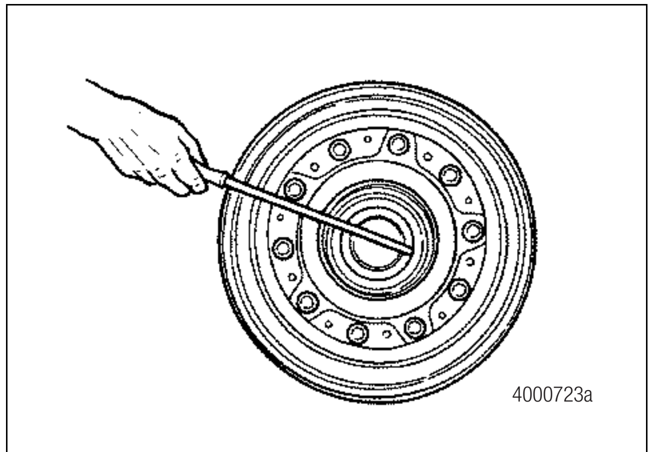


Figure 5.4

4. If necessary, on units equipped for ABS, use a suitable puller to remove the ABS tooth wheel from the hub.
5. Remove the inner bearing cone from the hub.
6. Use a press and sleeve or a bearing puller to remove the inner and outer bearing cups from the hub.
7. Tap and stretch the oil sleeve to remove it from the spindle. Do not reuse the sleeve.

Removal

Steering Knuckle from the Housing

The steering knuckle must be disassembled before the steering universal joint can be removed.

The steering arm and cross tube assemblies can be serviced without removing the steering knuckle from the housing.

1. Remove the steering arm ball cotter pin and nut to disconnect the steering linkage from the steering arm.
2. Remove the cross tube, tie rod, cotter pin and nut to disassemble the cross tube from the knuckle arm. Figure 5.5.

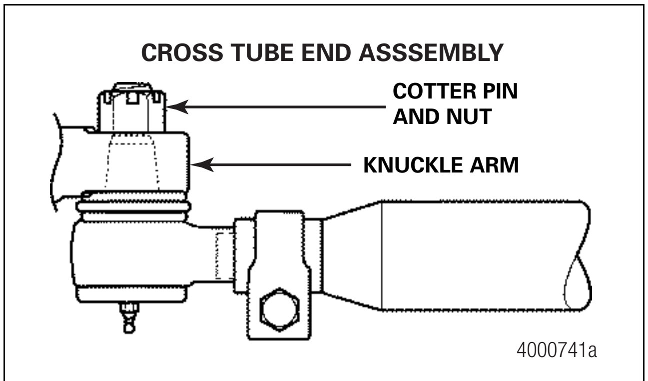


Figure 5.5

3. Push the stud for the cross tube end through the knuckle arm. If necessary, use a soft mallet to drive the stud through the knuckle arm.
4. On units equipped for ABS, remove the grommet for the ABS cable and the ABS sensor from the knuckle.

   NOTE: It is not necessary to disassemble both cross tube ends unless both knuckle assemblies are being serviced at the same time.

5. Remove the six capscrews from the upper knuckle cap or steering arm.
6. Lift the upper knuckle cap or steering arm from the bore. Keep the shims together for use at reassembly. Figure 5.6.

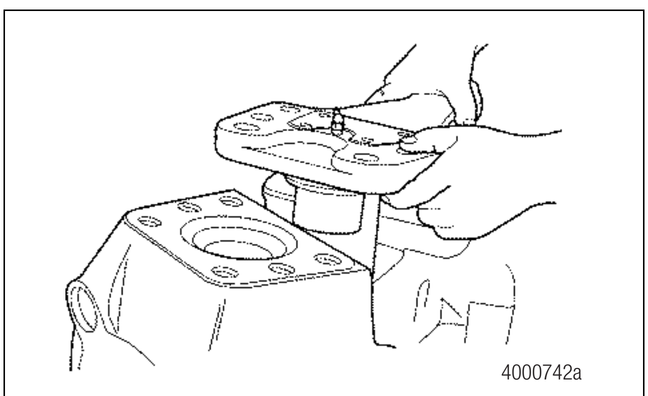


Figure 5.6

7. Inspect the steering arm oil seal on the upper knuckle cap for wear and damage. Replace a worn or damaged oil seal at reassembly. Figure 5.7.

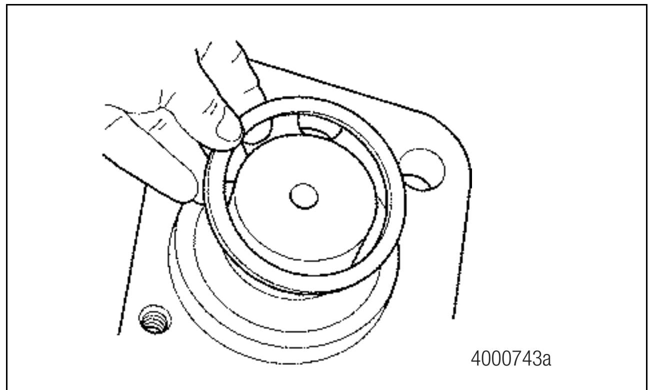


Figure 5.7

8. Disassemble the lower knuckle cap. Inspect the thrust bearing for wear and damage. Replace a worn or damaged thrust bearing at reassembly. Figure 5.8.

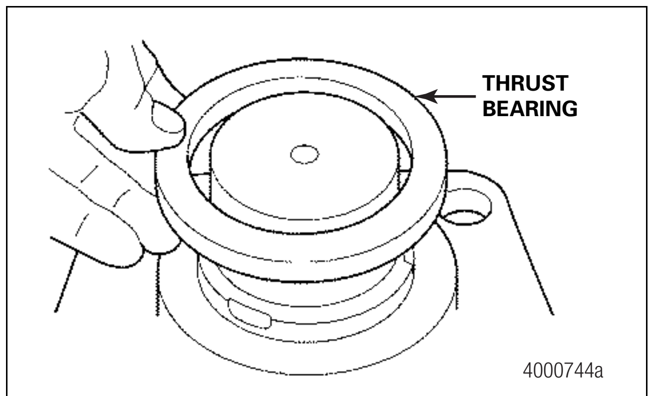


Figure 5.8

9. After both the upper and lower knuckle cap and steering arm assemblies are removed, pull the steering knuckle from the housing.
10. The bushings will remain in the sockets of the housing. Inspect the upper and lower bushings while they are still in the sockets for wear and damage.
11. Pull the universal joint and drive shaft assembly straight from the carrier housing. Figure 5.9.

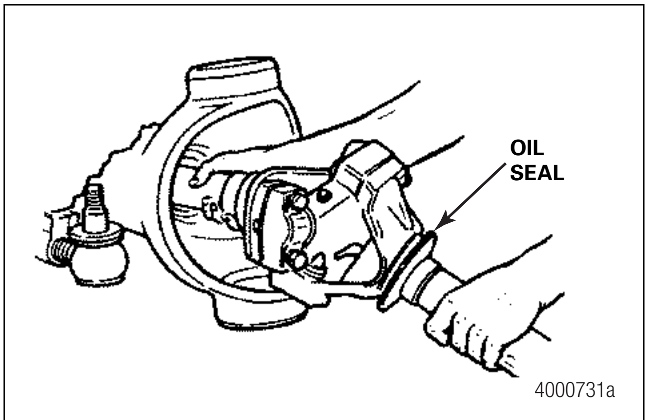


Figure 5.9

12. Remove the oil seal from the outer drive shaft. Discard the seal. Figure 5.9.
13. If required, remove the inner drive shaft oil seal, thrust washer and bushing from the axle housing.
14. If necessary, remove the bushings and the socket plugs from the upper and lower sockets in the housing.
15. Grind off the four tack welds, if used, that hold the socket plugs to the housing. Grind the tack welds carefully so that the bore is not damaged. Some housings use a pressed-in socket plug.
16. Use a sleeve that is slightly smaller than the socket bore to drive the socket plug and bushing toward the outside of the socket using. Figure 5.10.

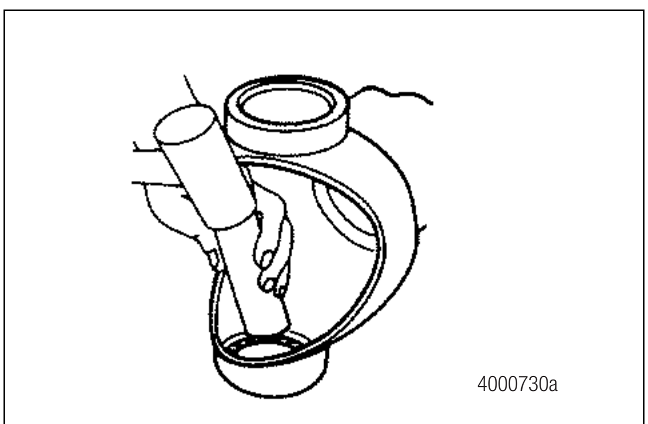


Figure 5.10

17. Clean all grease and dirt from the bores before reassembly.

Disassembly

Steering Universal Joint

NOTE: Do not disassemble Permalube™ joints. Disassembly will void the Meritor warranty.

Meritor front drive steer axles with cam brakes have two different universal joint designs:

- Wing Bearing Yokes. Figure 5.11.
- Round Bearing Yokes. Figure 5.12.

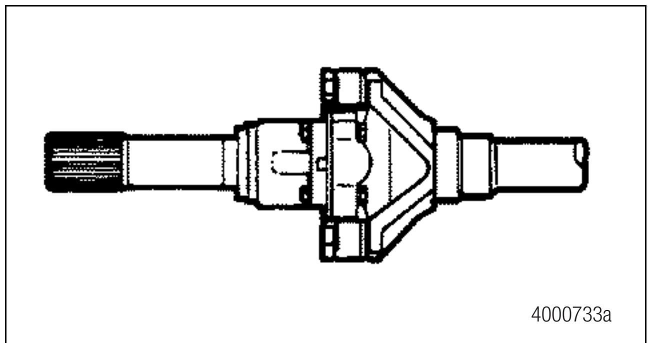


Figure 5.11

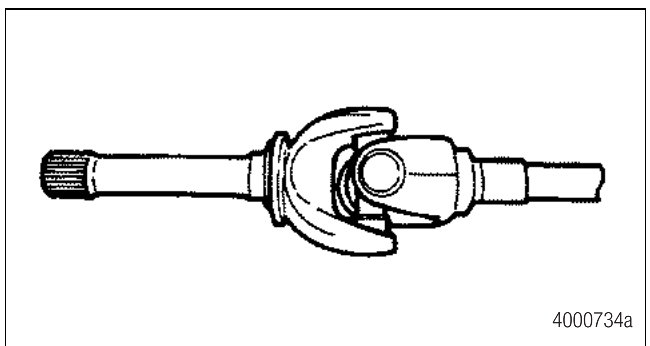


Figure 5.12

Wing Bearing Yokes

1. Remove the four cross assembly capscrews from each yoke.
2. Do not disassemble the cross assembly. If the cross assembly needs service, replace it with a new assembly.

Round Bearing Yokes

1. Use snap ring pliers to remove the snap rings. Figure 5.13.

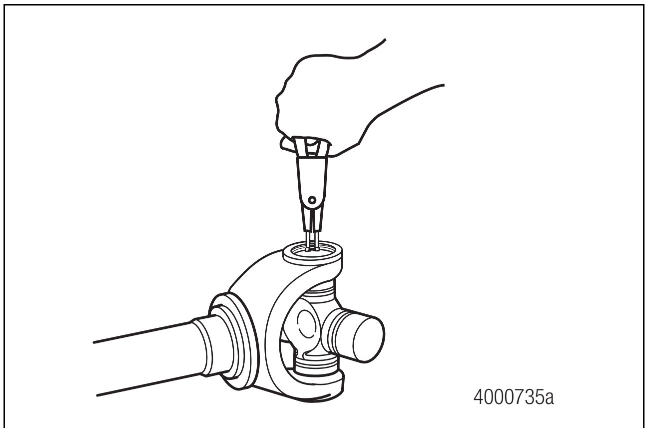


Figure 5.13

2. If necessary, use a brass drift and lightly tap the center of the bushing to assist in snap ring removal. Figure 5.14.

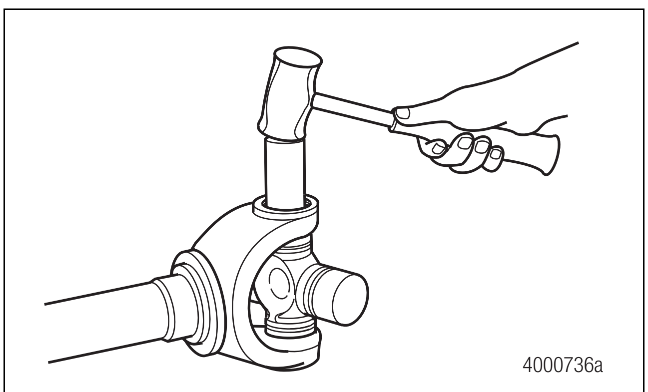


Figure 5.14

3. Repeat the previous step on the other sides of the yoke.
4. Use a press, bridge and bearing cup bushing receiver as shown in Figure 5.15. The bridge and bearing cup bushing receiver are detailed in Figure 5.16.

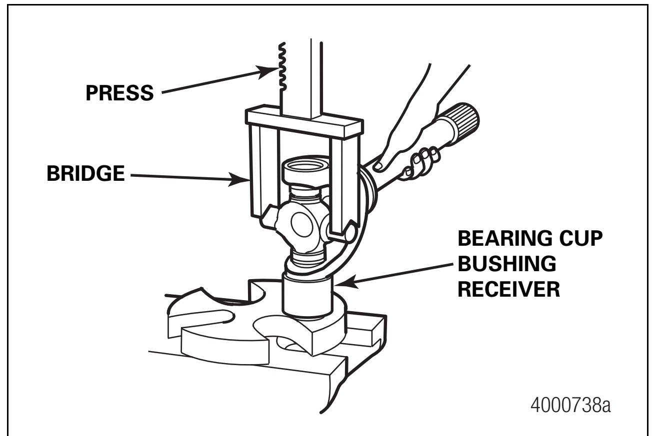


Figure 5.15

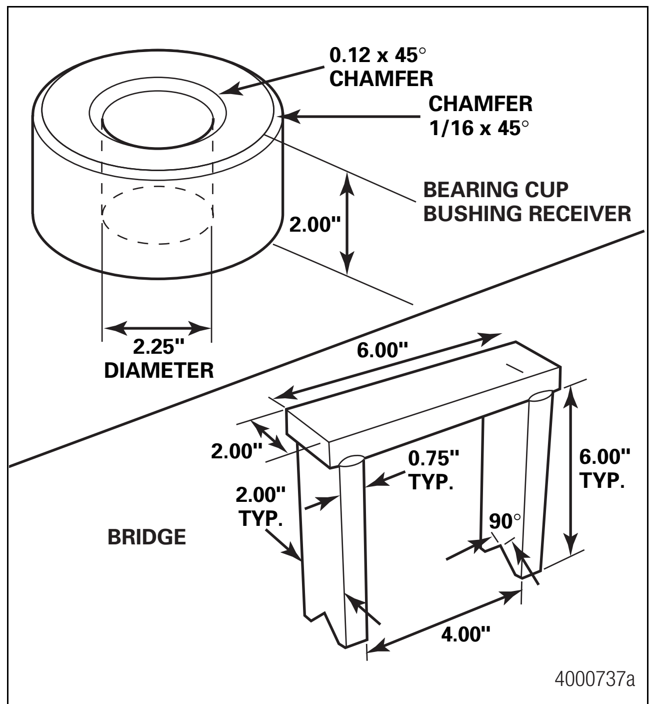


Figure 5.16

5. Press DOWN until the first round bushing is loose. Figure 5.15.

6. Remove the round bushing. Figure 5.17.

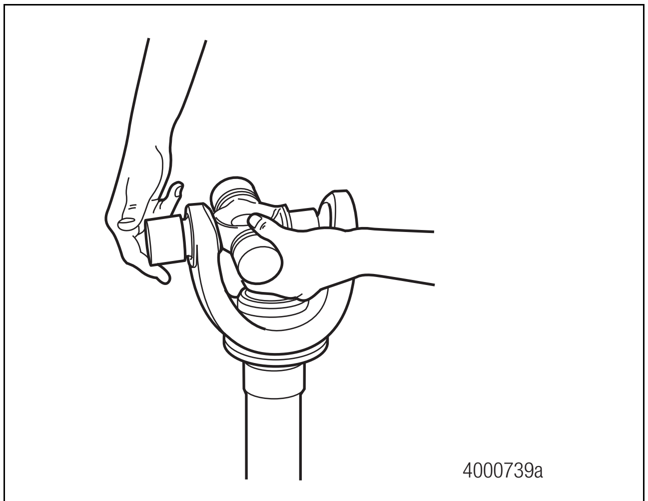


Figure 5.17

7. Turn over the universal joint. Repeat the procedure for the opposite side of the universal joint. Figure 5.18.

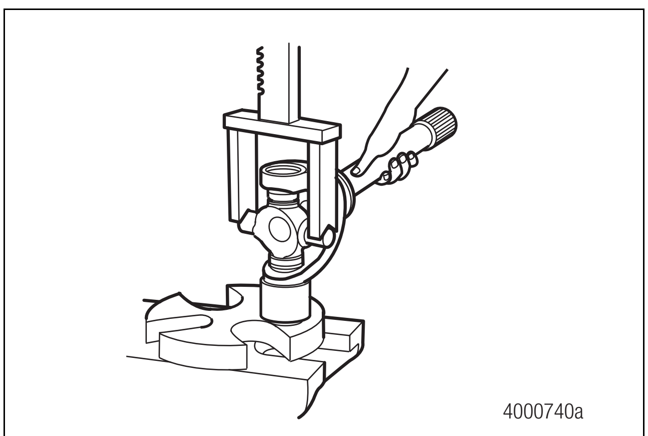


Figure 5.18

Cam Brake and Spindle from the Steering Knuckle

⚠ ASBESTOS AND NON-ASBESTOS FIBERS WARNING

Some brake linings contain asbestos fibers, a cancer and lung disease hazard. Some brake linings contain non-asbestos fibers, whose long-term effects to health are unknown. You must use caution when you handle both asbestos and non-asbestos materials.

NOTE: It is possible to remove the brake as an assembly after removing the slack adjuster and the brake spider-to-knuckle attachment screws.

1. Remove the cam brake return springs and brake shoes from the brake spiders. Figure 5.19.

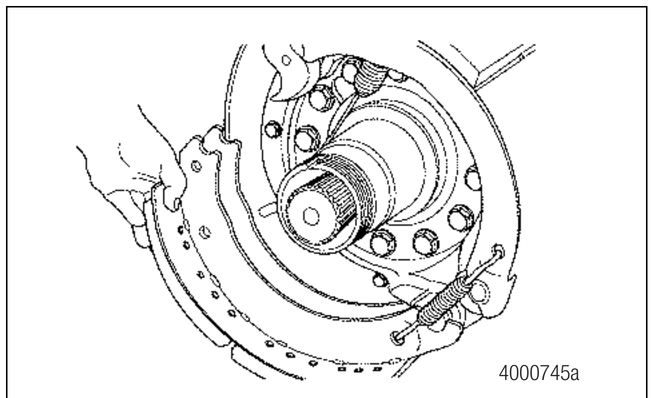


Figure 5.19

2. Remove the dust shield from the brake spider. Figure 5.20.

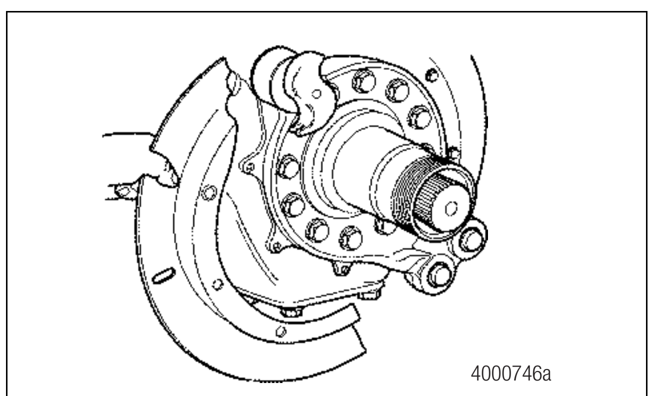


Figure 5.20

3. Remove the slack adjuster retaining ring at the adjuster end of the camshaft. Figure 5.21.

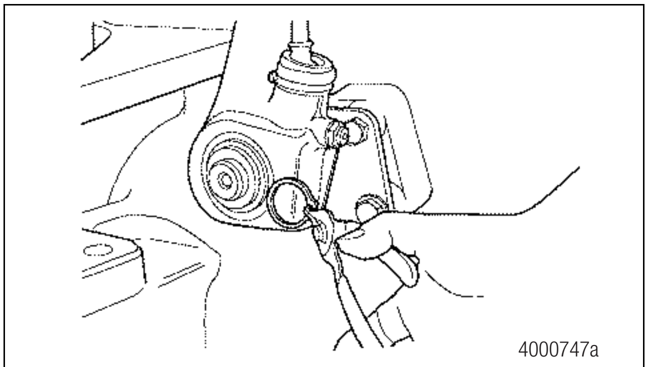


Figure 5.21

4. Remove the slack adjuster shims at the adjuster end of the camshaft. Figure 5.22.

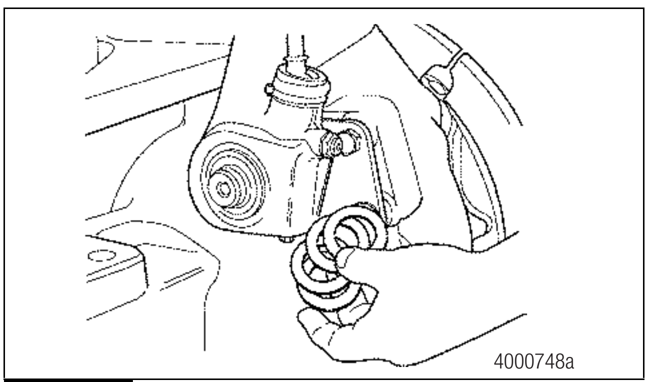


Figure 5.22

5. Remove the pins that engage the push rod yoke and the slack adjuster. Remove the slack adjuster from the camshaft. Figure 5.23.

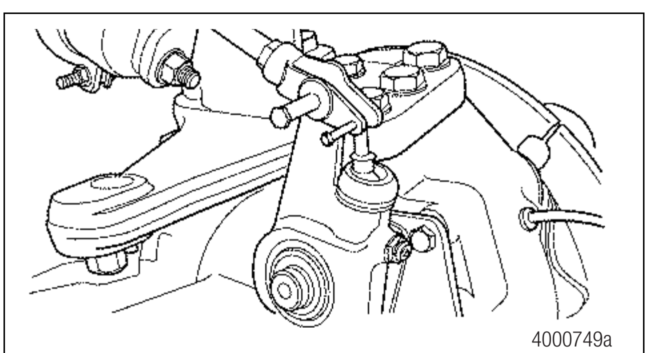


Figure 5.23

6. Remove the retaining ring from the camshaft at the back of the spider assembly. Figure 5.24.

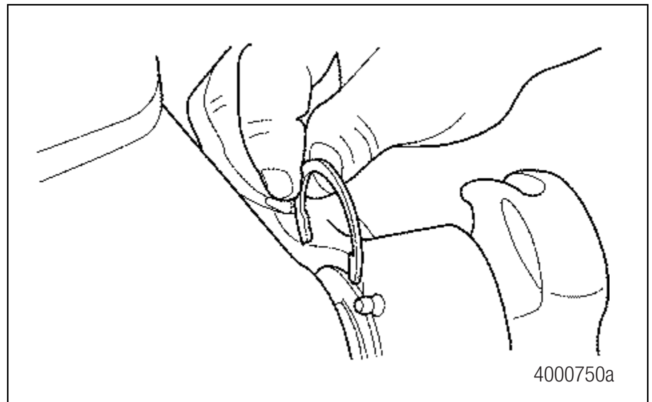


Figure 5.24

7. Remove the camshaft.

⚠ WARNING

Before you service a spring chamber, carefully follow the manufacturer's instructions to compress and lock the spring to completely release the brake. Verify that no air pressure remains in the service chamber before you proceed. Sudden release of compressed air can cause serious personal injury and damage to components.

8. Drain the air tank.
9. Disconnect the air lines at the brake chamber.
10. Remove the air brake chambers and brackets.
11. To disassemble the brake spider and spindle assembly from the steering knuckle, remove the attaching capscrews.
12. On units equipped for ABS, push the ABS sensor into the knuckle cavity.
13. Pull the spindle straight from the knuckle and drive shaft. Figure 5.25.

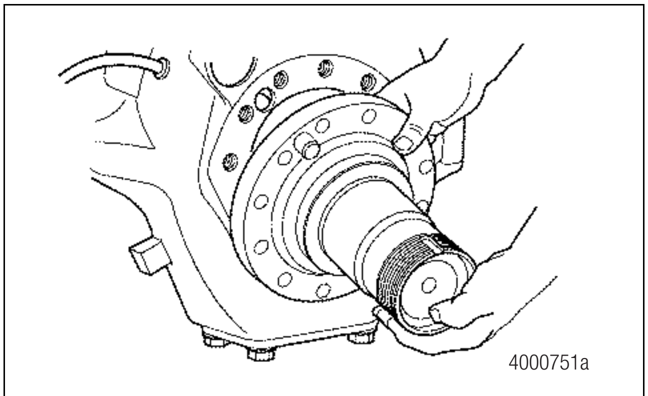


Figure 5.25

14. The seal wiper sleeve and thrust washer will remain inside the spindle. If necessary, use a screwdriver to disassemble these parts.
15. On units equipped for ABS, the steel sleeve and sensor clip for positioning the ABS sensor will remain on the spindle. If necessary, push out the sensor clip. Use a suitable driver to remove the sleeve.
16. Remove the screws and the bearing support bushing plate from the back side of steering knuckle. Figure 5.26.

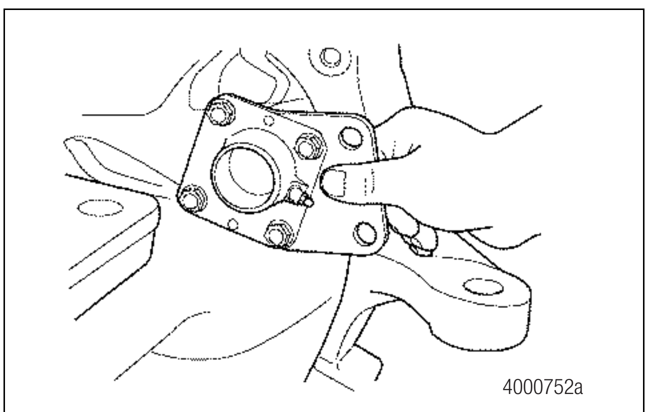


Figure 5.26

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

Prepare Parts for Assembly

Clean Ground and Polished Parts

Use a cleaning solvent to clean ground or polished parts or surfaces. Kerosene or diesel fuel oil can be used for this purpose. DO NOT USE GASOLINE.

- Do NOT clean ground or polished parts in a hot solution tank, water, steam or alkaline solutions.
- Use a knife, if required, to remove gasket material from parts. Be careful not to damage the ground or polished surfaces.

Clean Rough Parts

- Rough parts can be cleaned with cleaning solvent or in a hot solution tank with a weak alkaline solution.
- Parts must remain in hot solution tanks until completely cleaned and heated.
- When removed from the hot solution, wash the parts with water until the alkaline solution is removed.

Clean Axle Assemblies

- A completely assembled axle assembly can be steam cleaned on the outside to remove heavy amounts of dirt.
- Before the axle is steam cleaned, close or put a cover over all openings in the axle assembly. Examples of openings are breathers or vents in air chambers.

Dry Cleaned Parts

- Parts must be dried immediately after cleaning and washing.
- Dry the parts using soft clean paper or cloth rags.
- Except for bearings, parts can be dried with compressed air. Do not dry bearings by spinning with compressed air.

  NOTE: Bearings can be damaged if dried by rotating with compressed air.

Prevent Corrosion on Cleaned Parts

- Apply a light oil to cleaned and dried parts that are not damaged and are to be immediately assembled. Do not apply oil to the brake linings or the brake drums.
- If parts are to be stored, apply a good corrosion preventative to all surfaces. Do NOT apply the material to the brake linings or the brake drums. Store the parts inside special paper or other material that prevents corrosion.

Inspection

Parts

Tapered Roller Bearings

Inspect the cup, cone, rollers and cage of all tapered roller bearings in the assembly. If you find any of the following conditions, replace the bearing. Figure 6.1.

- The center of the large-diameter end of the rollers is worn level or below the outer surface.
- The radius at the large-diameter end of the rollers is worn to a sharp edge.
- You find a roller groove at the small- or large-diameter end of the cup or cone inner race surfaces.

- You can see deep cracks or breaks in the cup, cone, and inner race or roller surfaces. Figure 6.2.
- You can see bright wear marks on the outer surface of the roller cage. Figure 6.3.
- The rollers are damaged. Figure 6.4.
- The cup and cone inner race surfaces that touch the rollers are damaged. Figure 6.5.

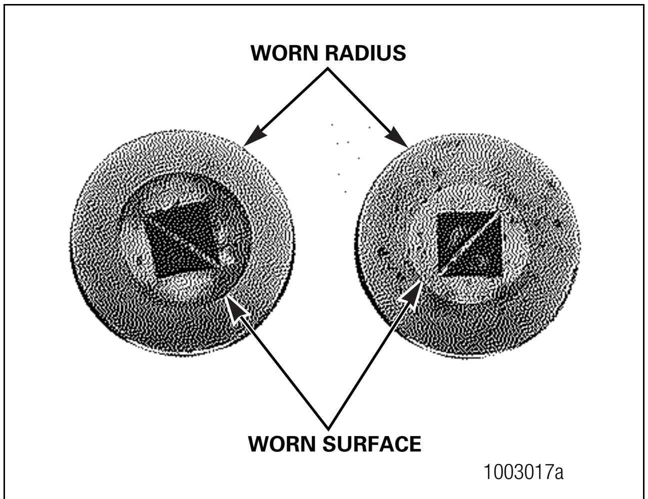


Figure 6.1

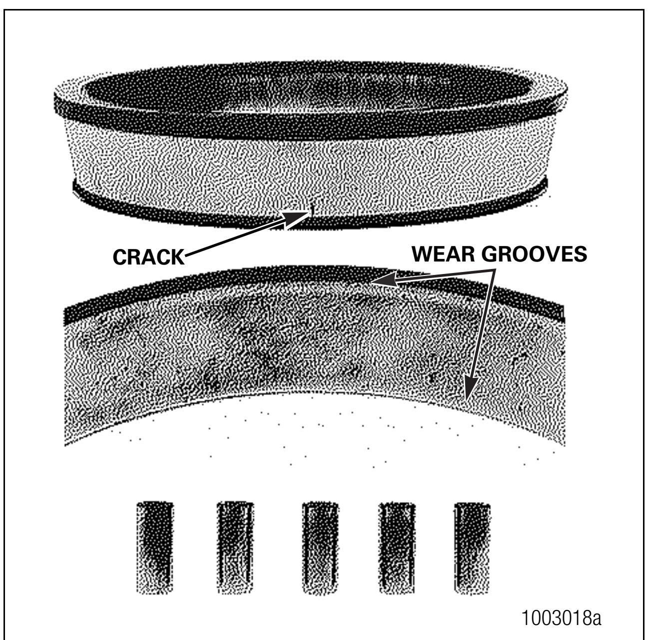


Figure 6.2

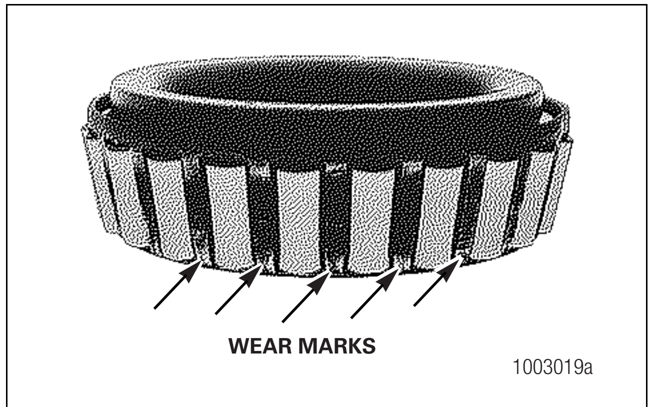


Figure 6.3

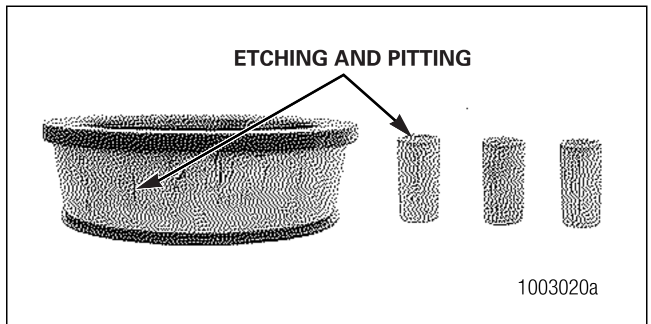


Figure 6.4

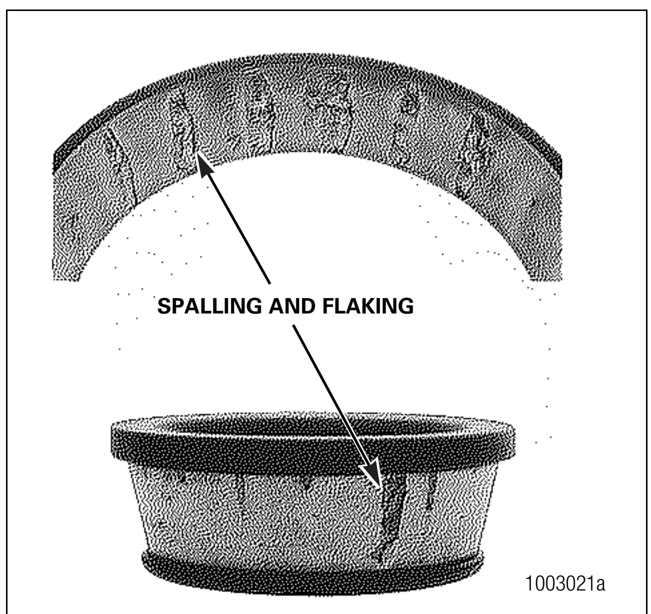


Figure 6.5

Axle Housing

1. Remove dirt from the housing sleeves. Check for cracks, loose studs and damage to machined surfaces. Repair or replace damaged parts.
2. Check the king pin bushing for wear or damage. Replace worn or damaged parts.
3. Inspect the needle roller thrust bearing for wear or damage. Replace worn or damaged parts.
4. Inspect the knuckle or steering stops for wear or damage. Replace worn or damaged parts.
5. Inspect the axle housing knuckle socket bushings for wear. Replace worn components.

Axle Shafts

1. Inspect the axle shafts for wear, stress and cracks at the splines, shaft and yoke ears. Replace damaged components.
2. Inspect the inner and outer axle shaft bushings in the housing and spindle for wear or damage. Replace worn or damaged bushings.
3. Inspect the axle shaft oil seals in the housing and spindle for damage. Replace damaged seals.

Tie Rod Ends

1. Inspect tie rod ends for wear and damage. Replace worn or damaged tie rod ends. Do not repair them.
2. Check seals for damage. Replace damaged seals. Verify that seals are fastened correctly on the socket.
3. If tie rod ends have grease fittings, check fittings for wear and damage. Replace worn or damaged fittings. If a grease fitting is missing, install a new one. Don't try to install a grease fitting onto a tie rod end that's a non-greaseable design. Figure 6.6.

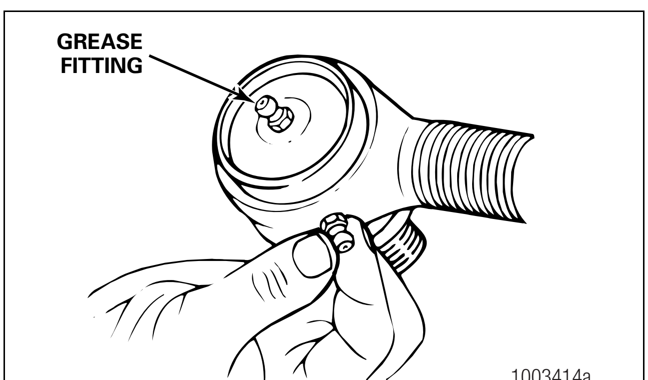


Figure 6.6

4. Tighten all grease fittings to the correct torque. Do not overtighten, which can damage the threads. Refer to Section 10.

Repair

Repair or Replace Parts

⚠ WARNING

Replace damaged or out-of-specification axle components. Do not bend, repair or recondition axle components by welding or heat-treating. A bent axle beam reduces axle strength, affects vehicle operation and voids Meritor's warranty. Serious personal injury and damage to components can result.

Replace worn or damaged parts of an axle assembly. The following are some conditions to check.

1. Replace the fasteners if the corners of the head are worn.
2. Replace damaged washers.
3. Replace the gaskets, oil seals, grease seals or felt seals at the time of axle or carrier repair.
4. Clean the parts. Apply new silicone gasket material, where required, when the axle or carrier is assembled.
5. Use a fine file, emery cloth or crocus cloth to remove rough edges from parts that have machined or ground surfaces.
6. Clean and repair fastener threads and holes. Use a die or tap of the correct size or a fine file.
7. Verify that threads are clean and not damaged, so that correct torque specifications for fasteners can be obtained.
8. Tighten all fasteners to the correct torque specifications. Refer to Section 10.

Welding on Axle Housings

For Complete Welding Instructions on Meritor Drive Axle Housings

Refer to Maintenance Manual 8, Drive Axle Housings. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

⚠ **WARNING**

Wear safe clothing and eye protection when you use welding equipment. Welding equipment can burn you and cause serious personal injury. Follow the operating instructions and safety procedures recommended by the welding equipment manufacturers.

Axle weld locations and welding procedures must adhere to Meritor's standards. Welding at locations other than those authorized by Meritor will void the warranty and can reduce axle beam fatigue life. Serious personal injury and damage to components can result.

Meritor permits drive axle housing assembly repair welding in the following locations only.

- Housing-to-cover weld joints
- Snorkel welds
- Housing seam welds between the suspension attaching brackets
- Bracket welding to the drive axle housing

Prepare the Axle

⚠ **WARNING**

The high temperature caused by the open flame from the cutting torch can ignite the oil in the axle housing and can cause serious personal injury.

1. Remove the oil drain plug from the bottom of the axle housing and drain the lubricant from the assembly.

⚠ **CAUTION**

Remove the differential carrier from the axle housing before you weld onto an axle. Do not weld onto an axle with the differential carrier installed. Electrical arcing and damage to components can result.

2. Remove the differential carrier from the axle housing. Refer to the correct Meritor carrier maintenance manual or the vehicle manufacturer's instructions.

⚠ **CAUTION**

Remove the brake air chambers before you weld onto an axle. Do not expose a brake air chamber to more than 250°F (121°C). Damage to the air chamber can result.

3. Remove the wheel-end components and brake air chambers from the axle. Refer to the correct Meritor brake maintenance manual or the vehicle manufacturer's instructions.
4. For housing-to-cover welds, clean the outside housing-to-cover weld area 2.00-3.00-inches (50.8-76.2 mm) past each end or side of the crack. Clean the inside area where the cover mates with the housing. Clean the area completely around the cover. Use a wire brush and a cleaning solvent that will remove dirt and grease from these areas. Figure 6.7.

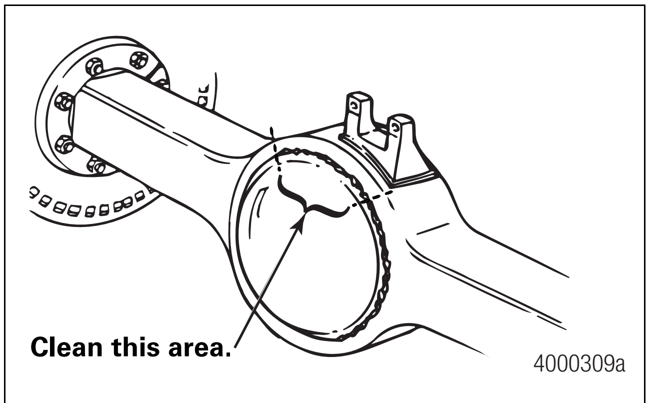


Figure 6.7

5. For suspension bracket welds, clean both lower and upper suspension brackets and the areas of the axle housing around each bracket. Use a wire brush and a cleaning solvent that will remove dirt and grease from these areas. Figure 6.8 and Figure 6.9.

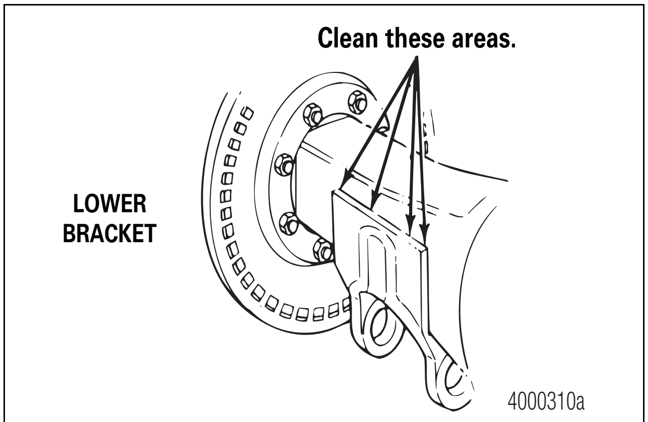


Figure 6.8

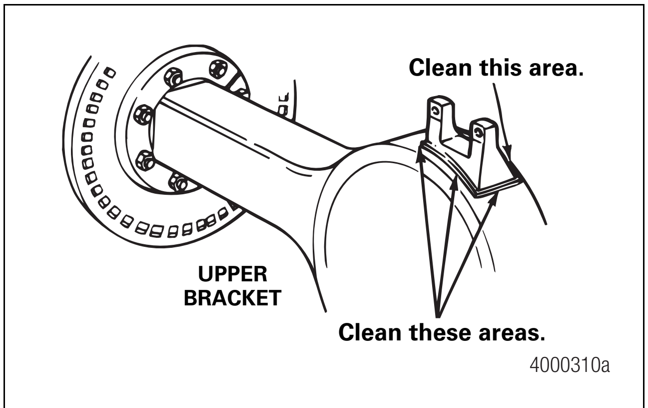


Figure 6.9

WARNING

The axle housing must be 70°F (21°C) or warmer before you weld onto the axle. Do not weld onto a cold axle or weld cold parts onto an axle. Cracks in the weld area, damage to components and serious personal injury can result.

6. Ensure that the axle housing temperature measures 70°F (21°C) or warmer.
   - **If the axle housing temperature measures less than 70°F (21°C):** Store the axle in a heated room until the housing reaches the correct temperature.
7. Heat the damaged area to approximately 300°F (149°C) before you begin welding.
8. Use suitable weld wire electrodes when you weld. Suitable weld wire electrodes include either BS EN 499 - E 42 2 B 32 H5 or BS EN 440 - G 42 2 M GSi (American Welding Society equivalents E7018 and ER70S3, respectively).
9. For complete welding instruction, refer to Maintenance Manual 8, Drive Axle Housings. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Applying Adhesive and Silicone Gasket Material

WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin.

The silicone gasket products or their equivalent listed in Table C can be used on Meritor components.

Table C

Product Name	Description
Loctite® 5699 Ultra Grey	Adhesive/Sealant
Permatex® 82194 Ultra Grey	Silicone Sealant
Three Bond 1216	Silicone Sealant
Three Bond 1216E	Silicone Sealant

Application

1. Remove all old gasket material from both surfaces.
2. Clean the surfaces where you'll apply the silicone gasket material. Remove all oil, grease, dirt and moisture. Dry both surfaces.

CAUTION

The amount of silicone gasket material applied must not exceed a 0.125-inch (3.18 mm) diameter bead. Too much gasket material can block lubrication passages. Damage to components can result.

3. Apply a 0.125-inch (3.18 mm) diameter continuous bead of Loctite® Ultra Grey 5699 flange sealant (Meritor part number 2297-Z-7098) around one surface. Also apply the gasket material around the edge of all the fastener holes on that surface. Figure 6.10.

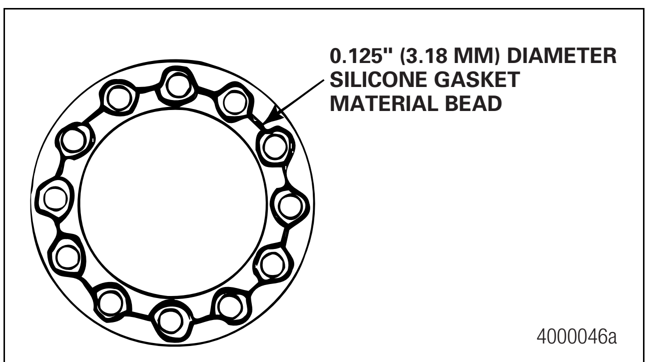


Figure 6.10

4. Assemble the components immediately to permit the gasket material to compress evenly between the parts.
5. Tighten the fasteners to the required torque specification for that size fastener. Refer to Section 10.
6. Wait 20 minutes before filling the assembly with lubricant.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

Assembly

Axle Shaft Universal Joint

Round Bearing Yokes

1. Slide the first bushing onto the trunnion. Figure 7.1.

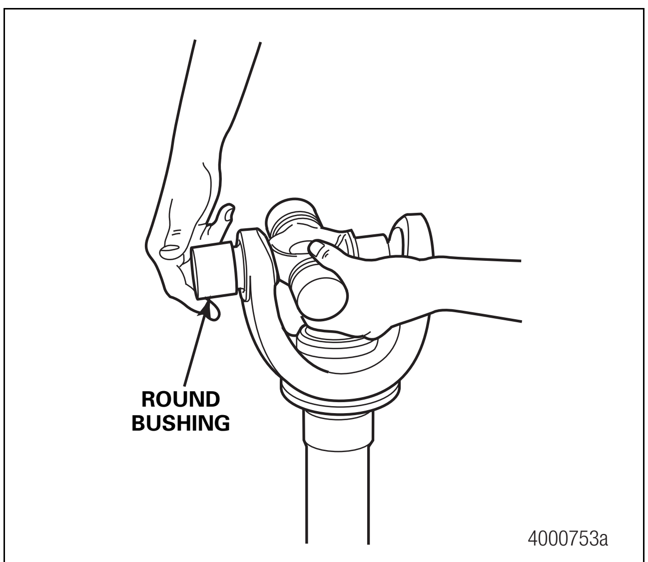


Figure 7.1

2. Press the first round bushing into the yoke slightly past the snap ring groove. Check that the bushing is aligned with the universal joint trunnion. Figure 7.2.

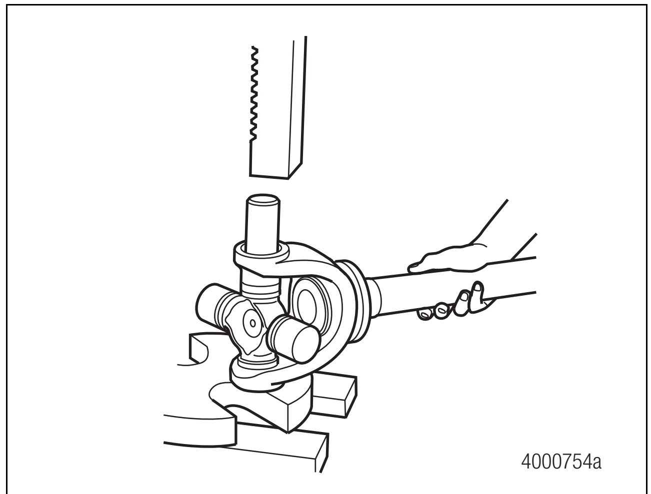


Figure 7.2

3. Use snap ring pliers to install the snap ring into the snap ring groove. You must fully seat the snap ring into the snap ring groove to avoid damage to the driveline. Figure 7.3.

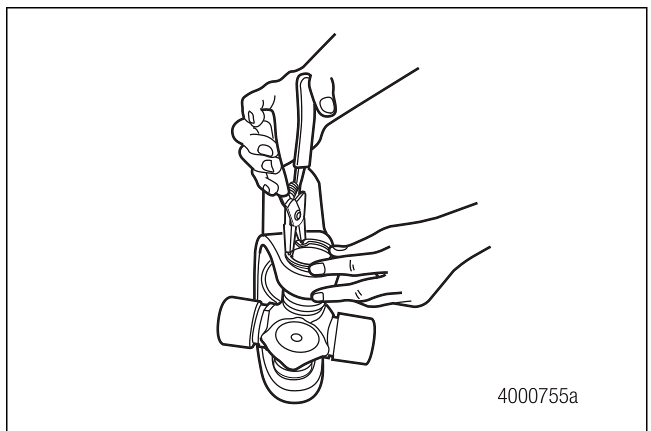


Figure 7.3

4. Use a snap ring installation gauge to check that the snap ring is fully seated in the snap ring groove. Figure 7.4.

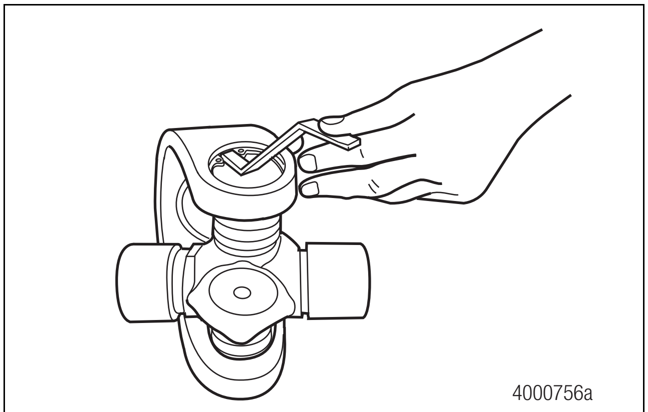


Figure 7.4

5. Repeat the previous four steps to install the remaining bushings into the yoke.
6. Lubricate the universal joint when the joint includes a grease fitting.
    - **If the universal joint does not move freely:** Strike the yoke ear with a brass or copper hammer. Figure 7.5.

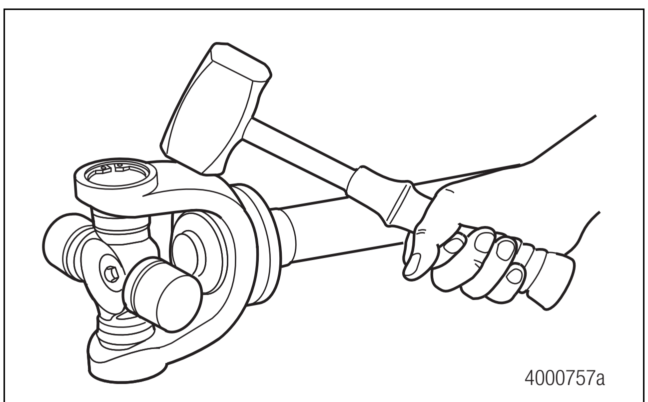


Figure 7.5

Wing Bearing Yokes

1. If the cross and cap assembly is damaged, replace all the parts with a new assembly.
2. Assemble the cross assembly to the yokes with eight capscrews and nuts. Tighten the capscrews and jam nuts to the torque listed in Table D.

Table D

Size	Capscrews lb-ft (N•m)	Jam Nuts lb-ft (N•m)
7/16"-20	70-80 (95-108)	20-30 (27-41)
1/2"-20	115-135 (155-183)	27-37 (36-50)

3. The current wing bearing yoke design utilizes a Permalube™ universal joint and does not require additional lubrication.

   Prior wing bearing yoke designs include a grease fitting and require lubrication. Refer to Section 9.

Steering Knuckle and the Axle Shaft

Prepare the Shaft and Housing Socket

1. Install a new seal onto the outer drive shaft. Figure 7.6.

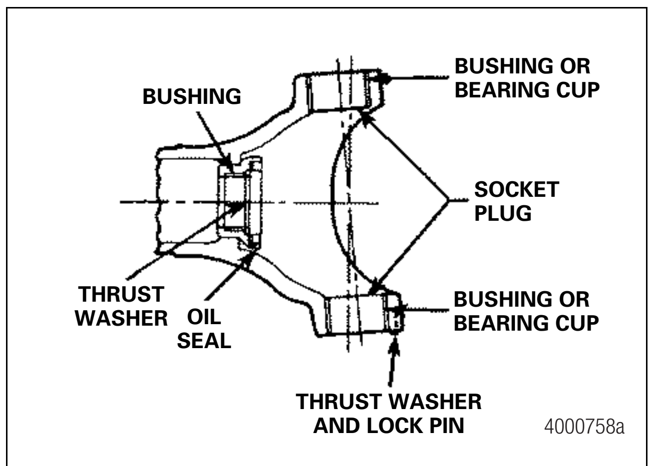


Figure 7.6

2. If required, use a correct size sleeve or driver to install a new inner drive shaft bushing, thrust washer and oil seal into the housing or housing socket adapter. Figure 7.6. Apply a layer of axle lubricant to the seal retainers before the seals are installed.

⚠ CAUTION

Do not force or hit the seal after it is correctly installed into its seat. You can damage the seal retainer.

3. If the socket plugs were removed from the housing, use one of the following procedures to reinstall them.

Upper Bushing, Lower Bearing and Full Bearing King Pin Designs

⚠ WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

1. Apply a layer of silicone gasket material to the mounting surfaces of the socket plugs only. Figure 7.6.
2. Install the plugs flat against the journals of the inside socket bores with the closed side of the plugs toward the center of the axle.
3. Apply hand pressure to the plugs before the gasket material sets to ensure the socket plugs are in solid contact with the housing.
4. Clean any gasket material from the tops of the plugs and the inside of the bores.
5. Use a correct size sleeve or driver to install the bushings or bearing cups, depending on the axle model being serviced, in the socket bores of the housing. The bushings or bearing cups must be flat against the socket plugs.
6. Install the oil seals flat into their bores in the housing socket.
7. Install shims, if used, and the bearing cone against its journal on the lower cap.
   - Axles made before March 15, 1977 require a minimum of three shims with a total thickness of 0.009-inch (0.229 mm) at the lower knuckle cap.
   - Axles made after March 15, 1977 do not require shims at the lower knuckle cap.
   - **If the old knuckles, caps and bearings are installed**: Use the same amount of shim thickness as was removed during disassembly.
8. Install the lower cap assembly through the bottom bores of the knuckle and the housing until the cap is against the knuckle.
9. Install the capscrews and tighten to the correct torque. Refer to Section 10.
10. Install the shims and the bushing adapter or bearing cone, if used, on the upper cap. Use the same thickness shim pack that was removed during disassembly. The shim pack must contain a minimum of three shims.
11. Install the cap assembly through the upper bores of the knuckle and housing until the cap is against the knuckle.
12. Install the four capscrews and tighten to the correct torque. Refer to Section 10.
13. Check knuckle bearing preload.

    NOTE: To get an accurate measurement of bearing preload, do not assemble the steering arm linkage or cross tube, tie rod, assembly to the knuckle until the preload adjustment is made.

    A. Fasten a soft wire or cord to the tie rod arm. Attach a pound scale to the opposite end of the wire or cord. Hold the outer shaft of the universal joint away from the knuckle opening and pull on the pound scale to rotate the knuckle. Read the pounds on the scale. Read the pull necessary to rotate the knuckle, not the pull necessary to start the movement. Figure 7.7.

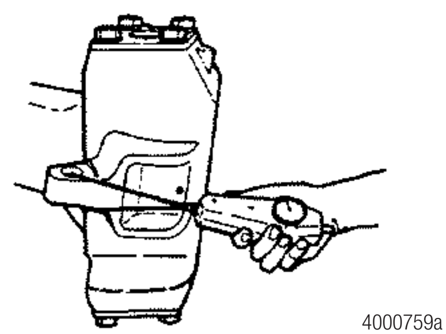


Figure 7.7

B. The pounds shown on the scale must be between 10 and 29 lbs. The correct bearing preload for FDS-1800 and 2100 Series axles is 11-20 lb-ft (14.9-27.1 N•m) rotating torque.

- **To correct the bearing preload for the upper bushing lower bearing design:** Disassemble the upper bearing cap and remove shims to increase the preload, or add shims to decrease the preload. Install the knuckle cap to the correct torque and check the bearing preload again.
- **To correct the bearing preload for the full bearing king pin design:** Disassemble both the upper and lower bearing caps. Remove shims to increase the preload, or add shims to decrease the preload. The same thickness of shims should be added or removed from each bearing cap. Install the knuckle caps to the correct torque and check the bearing preload again.

14. Inspect the housing seal and thrust washer to verify that these pieces are correctly installed. Install the universal joint into the housing. Align the inner shaft splines with the splines of the differential side gear.
15. If removed, assemble the steering arm and ball stud to the upper knuckle cap.

Full Bushing King Pin, Steel or Bronze Design

1. Drive new bushings into the socket bores so that the bushings are level with the outside of the socket. Use the correct size sleeve or driver.
2. Install new socket plugs into the inside socket bores so that the plugs are against the bushings. Tack weld the plugs in the same positions as the first tack welds. To avoid distortion to the bushing and bushing bore diameter, do not apply too much heat to the socket during tack welding of socket plugs.
3. Inspect the housing seal and thrust washer to verify that these pieces are correctly installed. Install the universal joint into the housing. Align the inner shaft splines with the splines of the differential side gear.
4. Install the thrust washer and lock pin on the lower socket bore. Turn the housing over.
5. Place the knuckle in its correct position over the end of the housing. Align the knuckle bores with the housing socket bores.
6. Assemble the lower cap assembly through the bottom bores of the knuckle and housing until the cap is against the knuckle.
7. Install the capscrews and tighten to the correct torque. Refer to Section 10.
8. Install the shims and oil seal against the base of the upper cap. Use the same thickness shim pack that was removed during disassembly. The shim pack must contain a minimum of three shims.
9. Install the cap assembly through the upper bores of the knuckle and housing until the cap is against the knuckle.
10. Install the four capscrews and tighten to the correct torque. Refer to Section 10.

NOTE: If necessary, remove the grease fitting from the lower knuckle cap to prevent damage.

11. Check steering knuckle end play.

A. Place a magnetic base dial indicator in position on the housing. Figure 7.8.

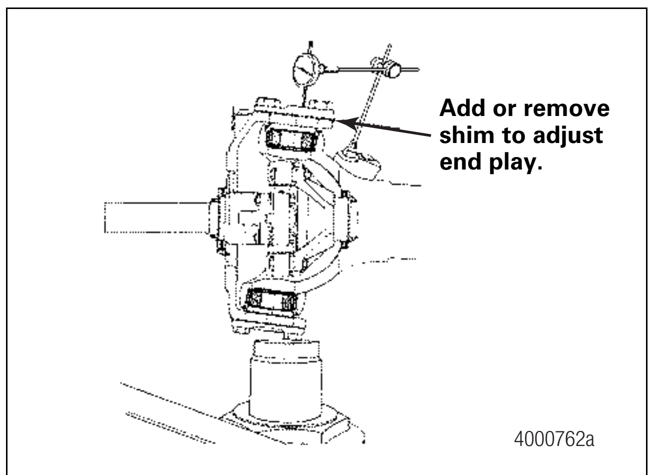


Figure 7.8

B. Use a jack to place pressure onto the lower knuckle cap. Set the dial indicator to ZERO.

C. Fully release the jack pressure and read the end play on the dial indicator. Correct end play is between 0.005-0.015-inch (0.127-0.381 mm). Remove or add shims from between the upper knuckle cap and steering knuckle to obtain the correct end play.

12. If removed, assemble the steering arm and ball stud to the upper knuckle cap.

Full Bushing and Thrust Bearing King Pin, Easy Steer™ Design

1. Use the correct size sleeve or driver to drive new bushings into the socket bores so that the bushings are level with the outside of the socket.
2. Position the socket plug 1.87-inch (47.5 mm) from top of bushing. Tack weld the plugs in the same positions as the first tack welds. To avoid distortion to the bushing and bushing bore diameter, do not apply too much heat to the socket during tack welding of the socket plugs.
3. Inspect the housing seal and thrust washer to verify that these pieces are correctly installed. Install the universal joint into the housing. Align the inner shaft splines with the splines of the differential side gear. Figure 7.9.

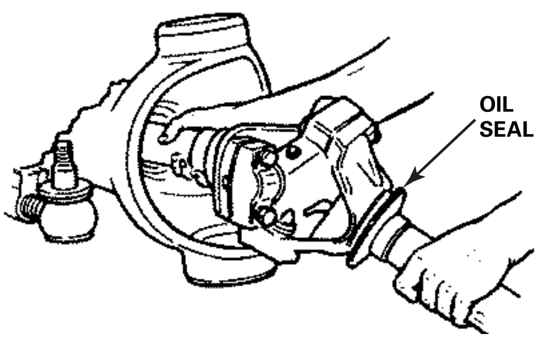


Figure 7.9

4. Install the thrust bearing against the journal on the lower cap.
5. Place the knuckle into its correct position over the end of the housing. Align the knuckle bores with the housing socket bores. Figure 7.10.

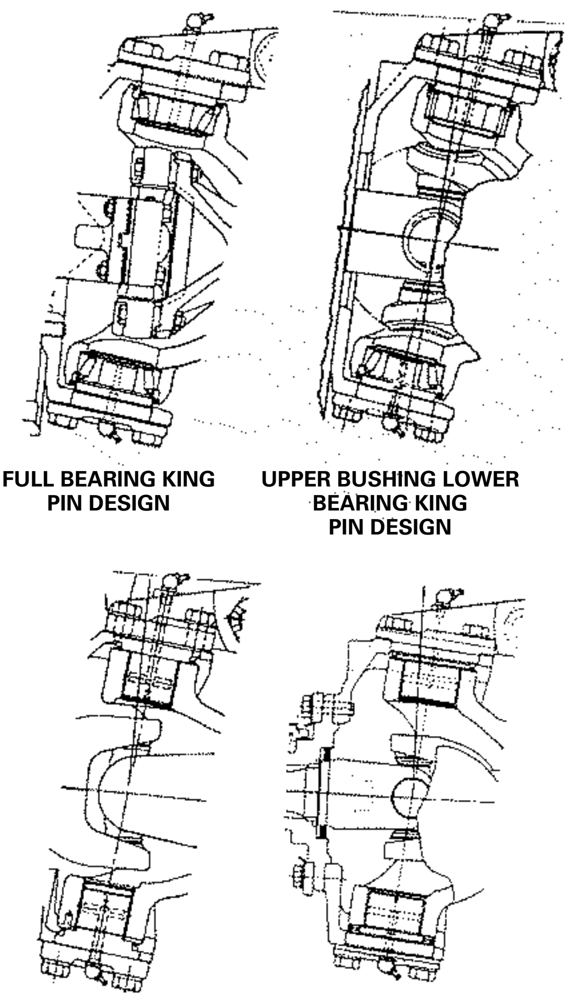


Figure 7.10

6. Install the lower cap assembly through the bottom bores of the knuckle and housing until the cap is against the knuckle.
7. Install the four capscrews and tighten to the correct torque. Refer to Section 10.
8. Install the shims and grease seal against the base of the upper cap. Use the same thickness shim pack that was removed during disassembly. The shim pack must contain a minimum of three shims.
9. Install the cap assembly through the upper bores of the knuckle and housing until the cap is against the knuckle. Figure 7.11.

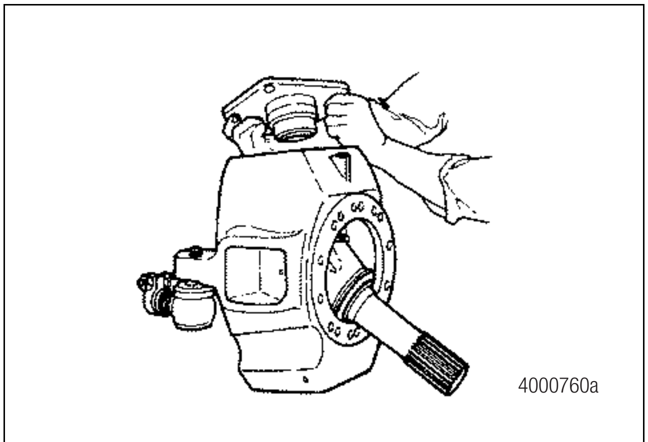


Figure 7.11

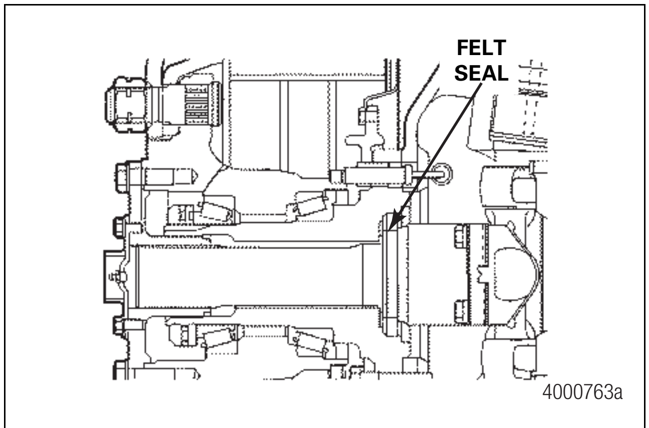


Figure 7.12

10. Install the four capscrews and tighten to the correct torque. Refer to Section 10.
11. If removed, attach the steering arm and ball stud to the upper knuckle cap.
12. Check steering knuckle end play.
    A. Place a magnetic base dial indicator into position on the housing. Figure 7.8.

       NOTE: If necessary, remove the grease fitting from the lower knuckle cap to prevent damage.

    B. Use a jack to place pressure onto the lower knuckle cap. Set the dial indicator to ZERO.
    C. Fully release the jack pressure and read the end play on the dial indicator. Correct end play is between 0.005-0.015-inch (0.127-0.381 mm). Remove or add shims from between the upper knuckle cap and steering knuckle to obtain the correct end play. Figure 7.8.

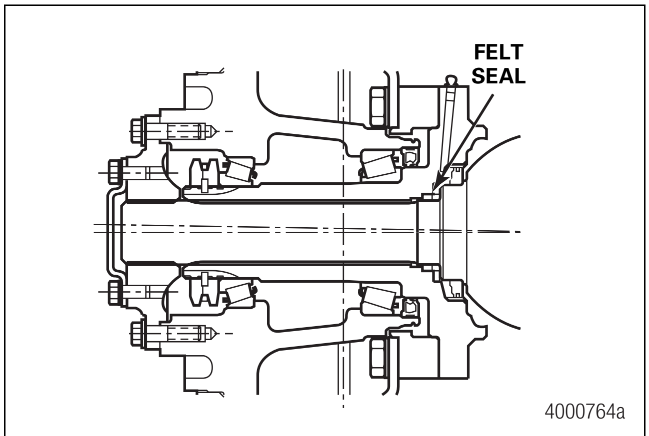


Figure 7.13

Spindle and Brake to the Steering Knuckle

1. Prepare the spindle. Figure 7.12.
   - **For a greaseable drive flange design:** If disassembled, install only the thrust washer and the seal wiper sleeve into the spindle. Figure 7.13.
   - **For a non-greaseable drive flange design:** If disassembled, install the thrust washer, seal wiper sleeve, felt seal and retainer into the spindle. Figure 7.14.

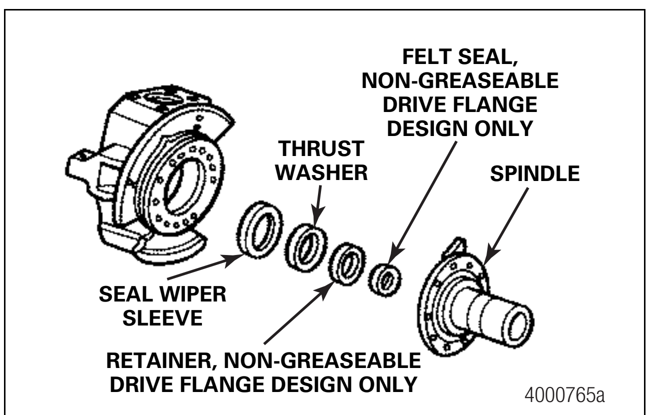


Figure 7.14

2. Install the spider assembly against the knuckle with the keyway slot for the wheel bearing adjusting nut system toward the top. On larger model axles, spindle installation will be easier if you install two temporary pilot studs into the opposite sides of the knuckle. Tighten the studs finger-tight. Figure 7.15.

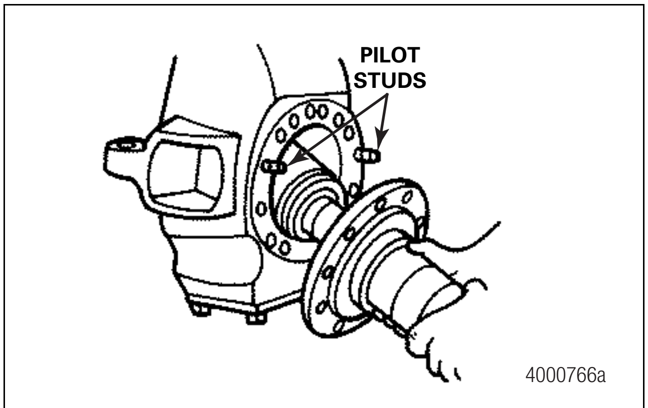


Figure 7.15

NOTE: For complete installation and service instructions for wedge brake assemblies, refer to Maintenance Manual 4R, Wedge Brakes. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

3. Install the brake spider and oil deflector onto the spindle. Fasten all parts to the knuckle with 12 capscrews and washers. Tighten to the correct torque. Refer to Section 10.

Installation

Wheel Bearings Into the Hubs

1. If wheel studs were removed from the hub, place the hub into a press with the drum side at the bottom. Align the grooves on the studs with the grooves in the stud holes in the hub. Press the studs into position. If a press is not available, use a brass hammer.
2. Use a press and sleeve to install the inner and outer bearing cups into the hub. Figure 7.16.

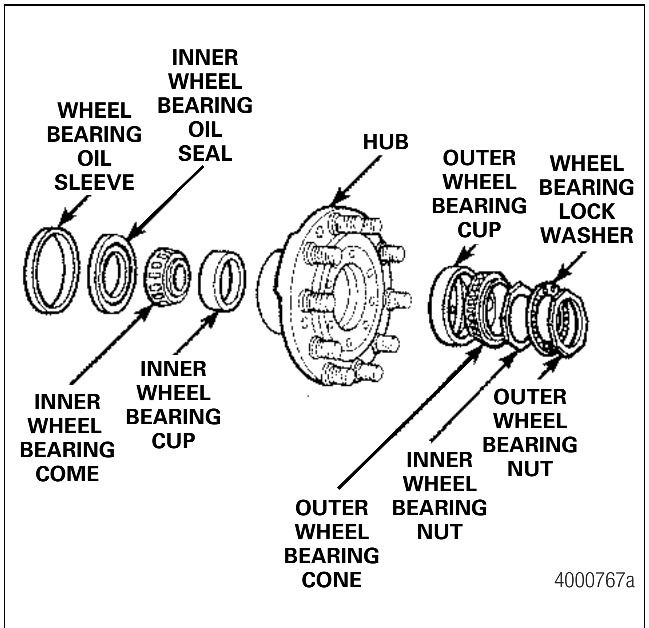


Figure 7.16

3. Fill the bearing cones and hub cavity with the correct grease up to the inside diameter of the bearing cones. Refer to Section 9.
4. Install the inner bearing cone into its cup inside the hub.
5. Install a new inner oil seal. Apply a layer of non-hardening sealing compound to the outside of the seal. Install the seal into its correct position: flat and square with hub end surface. Do not force or hit the seal. The seal can be damaged easily.
6. Use a suitable driver to install the seal wiper sleeve on the spindle.
7. Install the hub assembly onto the spindle. Be careful the oil seal is not damaged during installation. Press the hub until the inner bearing is flat against the face of the spindle.
8. Install the outer bearing cone onto the spindle and push it into its cup inside the hub.

Adjustment

Wheel Bearings

WARNING

When you adjust a wheel bearing, always use the correct socket wrench to loosen the adjusting nut. Use a torque wrench to tighten it to the correct specification. Do not attempt to tighten or loosen an adjusting nut by striking it with a hammer. Do not place a chisel or drift next to the adjusting nut and strike the chisel with a hammer.

Damage to the adjusting nut can result, which can prevent you from obtaining the correct wheel bearing adjustment. An incorrect adjustment can cause a wheel to separate from the vehicle during operation. Serious personal injury and damage to components can result.

1. Use a torque wrench to tighten the adjusting nut to 100 lb-ft (136 N•m). Figure 7.17.

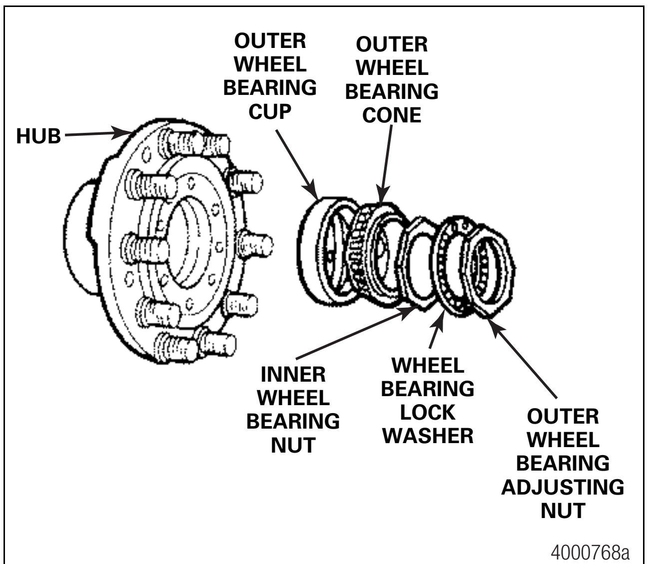


Figure 7.17

2. Rotate the hub three full turns to ensure all the bearings and seal surfaces are in contact.
3. Back off the adjusting nut 1/4 turn, 2-1/2 studs of the drum bolt circle. Do not rotate the hub assembly after backing off the adjusting nut.
4. Assemble the lock ring and jam nut. Tighten the jam nut to 250-400 lb-ft (339-542 N•m). If the lock ring does not line up with the adjusting nut, rotate the adjusting nut clockwise, tightening, to the closest lock ring hole. To make the smallest turn possible, flip the lock ring over if necessary.
5. Check the resulting end play with a dial indicator and perform the following actions.

End Play (inch)	Action
0.000-0.002	No action required.
>0.002-0.005	Remove the jam nut and lock ring. Tighten the adjusting nut 1/32 turn by flipping the lock ring over and turning the adjusting nut to align with the next hole.
>0.005-0.008	Remove the jam nut and lock ring. Tighten the adjusting nut 1/16 turn by turning the adjusting nut to align with the next hole. Do not flip the lock ring.
>0.008-0.011	Remove the jam nut and lock ring. Tighten the adjusting nut 3/32 turn by flipping the lock ring over and turning the adjusting nut to align with the second hole from the current position.
>0.011	Return to Step 1 and repeat the procedure.

Assembly

Drum and Drive Flange

WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Greaseable Drive Flange

1. Install the drum over the hub pilot. If used, tighten the drum mounting flathead screws to the correct torque. Refer to Section 10.

2. If previously removed, install the seal and retainer on the drive flange. Figure 7.18.

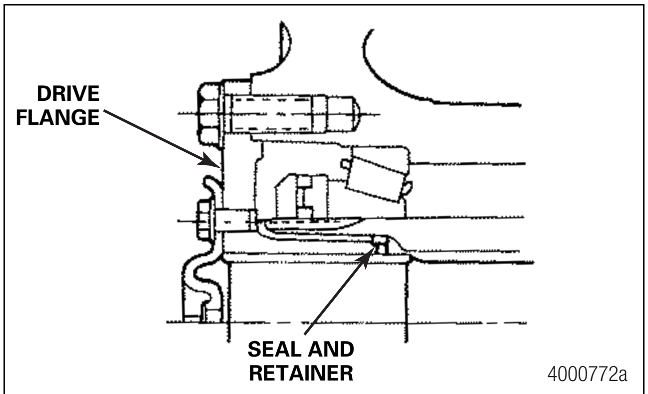


Figure 7.18

3. Apply a layer of silicone gasket material to the hub mounting surface of the new drive flange.
4. Apply Meritor specification number O-617-A or O-617-B wheel bearing grease to the inside splines of the drive flange and the splines of the drive shaft.
5. Install the drive flange on the hub and fasten with washers and capscrews. Tighten the capscrews to the correct torque. Refer to Section 10.
6. If previously removed, install the new hubcap with grease fitting to the drive flange. Apply a 0.125-inch (3.18 mm) continuous bead of silicone gasket material to either the mounting surface of the hubcap or the drive flange. Tighten the capscrews to the correct torque. Refer to Section 10.

Non-Greaseable Drive Flange

1. Install the drum over the hub pilot. If used, tighten the drum mounting flathead screws to the correct torque. Refer to Section 10.
2. If previously removed, install the seal and retainer on drive flange. Figure 7.18.
3. Apply a layer of silicone gasket material to the hub mounting surface of the new drive flange.
4. Apply Meritor specification number O-617-A or O-617-B wheel bearing grease to the inside splines of the drive flange and the splines of the drive shaft.
5. Install the drive flange onto the hub and fasten with washers and capscrews. Tighten the capscrews to the correct torque. Refer to Section 10.
6. If previously removed, install the new hubcap with grease fitting to the drive flange. Apply a 0.125-inch (3.18 mm) continuous bead of silicone gasket material to either the mounting surface of the hubcap or the drive flange. Tighten the capscrews to the correct torque. Refer to Section 10.

Adjustment

Brake

⚠ WARNING

You must manually adjust the brake after you perform maintenance or service. Do not depend on the automatic adjusters to remove the excessive clearance created when you back off the brake during service. The automatic adjusters are designed to compensate for normal lining wear. Damage to components and serious personal injury can occur.

Refer to Maintenance Manual 4R, Wedge Brakes, for complete brake adjustment procedures. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Assembly

Cross Tube to the Knuckle

1. Assemble the cross tube end assembly and clamp if these parts were disassembled. Tighten the locknuts to the correct torque. Refer to Section 10.
2. Push the stud of the tie rod end through the knuckle arm tapered hole. Tighten the cross tube nut to the correct torque. Refer to Section 10.
3. Install the slotted nut and cotter pin assembly.
   A. Tighten the nut to the initial torque specified.
   B. Advance the nut, do not back it off, to align the cotter pin.
   C. Final installed torque must not exceed the maximum specified.
      - **If the final torque exceeds the maximum:** Remove the nut and reinstall it to correct specification.
      - **If the minimum torque is not met:** Check if the stud taper is showing. If necessary, shim with a 0.125-inch (3.18 mm) washer.
4. Install the cotter pin.
5. Assemble the wheel, tire and rim, to the drum. Tighten the wheel nuts to the manufacturer's specifications.

Adjustment

Steering Stop Setting

All Meritor front drive steer axles are shipped with the steering stop screws preset at the factory according to the manufacturer's specifications. Additional adjustments can be made by the vehicle manufacturer or end user to accommodate a specific chassis design or tire size as long as the maximum angle does not exceed the U-joint capability.

NOTE: Check the adjustments of both axle steering stops and power steering units every time part of the steering system is disassembled.

Maximum Turn Angle Setting

Front Drive Steer Axle Model	Maximum Turn Angle of the U-Joint
FDS-1600	40
RF-16	35
FDS-1805, 7, 8	28
FDS-2100, 1, 2	35
FDS-2107	35
RF-21, 22, 23	35

NOTE: Do not adjust the turn angle beyond the specifications set by the vehicle manufacturer.

Manual Steering

1. Adjust both the right- and left-hand knuckle steering stops to touch the housing when the maximum turning angle specified by the vehicle manufacturer is reached. Figure 7.19.

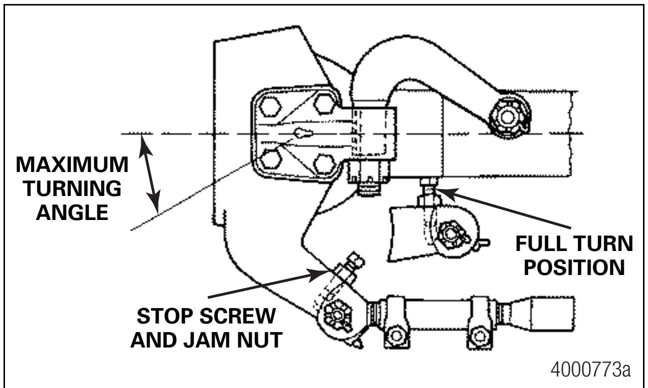


Figure 7.19

2. Lock the steering stop in position with the jam nut tightened to 180-230 lb-ft (244-312 N•m).

Power Steering

⚠ CAUTION

Meritor does not permit any power steering system that does not have a pressure relief or positive mechanical stop to be set before the maximum turn angle is reached. The power units must be stopped before the axle stop touches the housing to prevent stress to the axle components. Damage to components can result.

Mechanical Relief

Vehicles with mechanical Pitman arm stops or cylinder stops must be adjusted to end the travel of the Pitman arm or cylinder 0.125-inch (3.18 mm) before the steering stop screw touches the housing. Maximum turn angle is then controlled by the arm or cylinder stop, not the axle stop. Make the adjustments for both full-right and full-left turns. Figure 7.20.

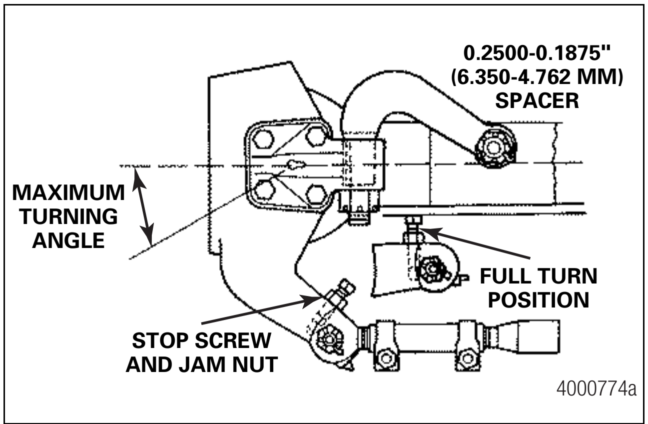


Figure 7.20

Hydraulic Relief

Hydraulic steering gears or cylinders with poppet valves must be adjusted while a 0.2500-0.1875-inch (6.350-4.762 mm) spacer is held between the housing and stop screw. The poppet valves must be adjusted to permit pressure bypass at this position with the spacer in place for full-right and full-left turns. During this setting the steering gear pressure must be at a maximum 600 psi (41.4 bar). Figure 7.21.

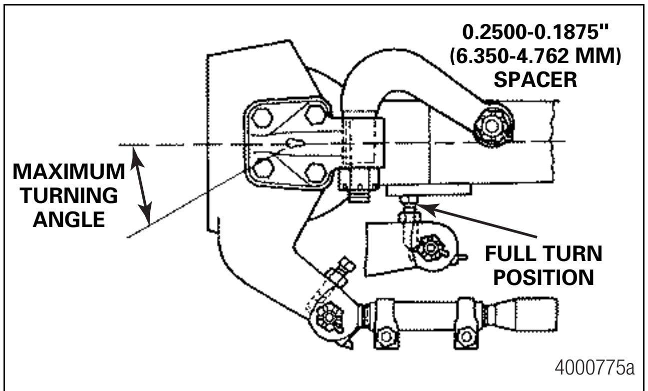


Figure 7.21

Wheel Toe-In Adjustment

Toe-in must be checked and adjusted on all front drive axles after the axle is installed in the vehicle. Figure 7.22.

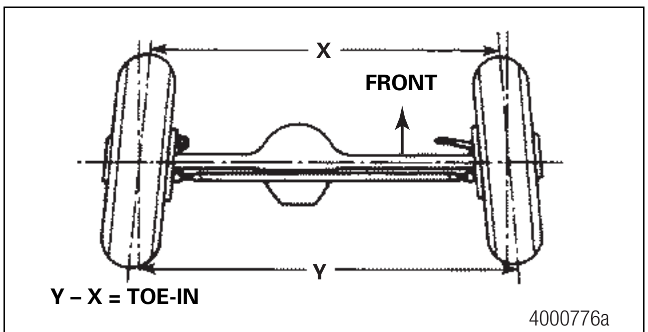


Figure 7.22

NOTE: Toe-in must be measured with the weight of the vehicle on the axle and the axle on a level floor. Use the following procedure.

1. Use a jack to raise the front axle.
2. Use a piece of chalk to mark the center area of both front tires around the complete circumference.
3. Place a scribe or pointed instrument against the center of the whitened part of each tire and rotate the tires. The scribe must be held in place so that a single straight line is marked all around the tire.
4. Place a full-floating turning radius gauge plate under each wheel. Lower the vehicle and remove the lock pins from the gauge plates.
   - **If full-floating gauge plates are not available:** Lower the vehicle to the floor and move the vehicle backward approximately six feet (1.8 m) and then forward for the same distance.
5. Set the slide scale end of a trammel bar to zero and lock the scale in place.
6. Place the trammel bar at the rear of the tires. Adjust the pointer to line up with the scribe lines on the tires. Lock the pointers in place. The sliding scale still must be set on ZERO. Figure 7.23.

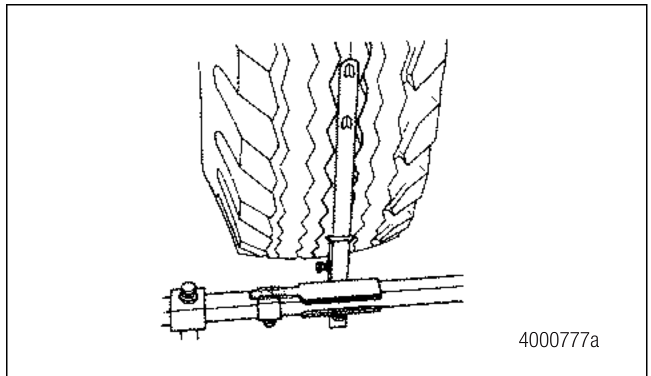


Figure 7.23

7. Place the trammel bar at the front of the tires. Adjust the pointer to line up with the scribe lines on the tire. Figure 7.24.

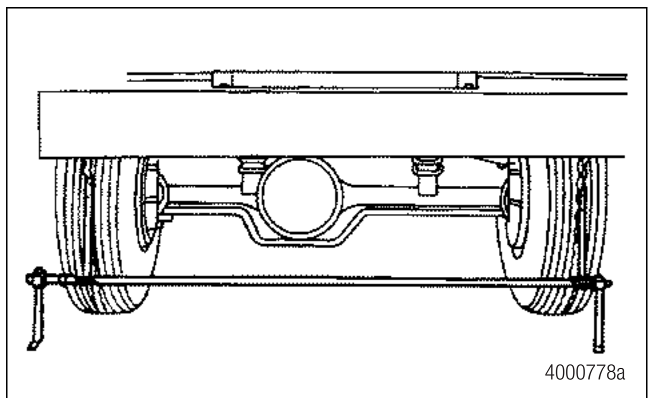


Figure 7.24

8. Read the toe-in, or toe-out, from the scale. In a vehicle, toe-in must be:
   - Unloaded: 0.06 ± 0.31-inch (1.59 ± 0.79 mm)
   - Loaded: 0.31 ± 0.31-inch (0.79 ± 0.79 mm)

9. If toe-in adjustment is necessary, use one of the following procedures. Figure 7.25.

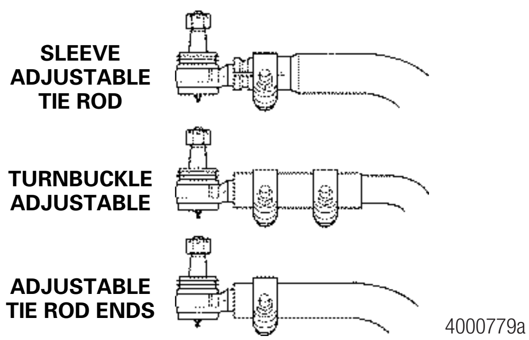


Figure 7.25

Axles with Sleeve Adjustable Cross Tubes

NOTE: Different torques are applied to clamps on the sleeve adjustable tie rods.

1. Loosen the tie rod clamp located on the sleeve side of the tie rod.
2. Rotate the sleeve to set toe-in or toe-out.
3. Rotate the clamp and position it at a 35 degree angle from horizontal with the clamp bolt behind the rod assembly. Tighten the clamp to the correct torque. Refer to Section 10. Figure 7.26.

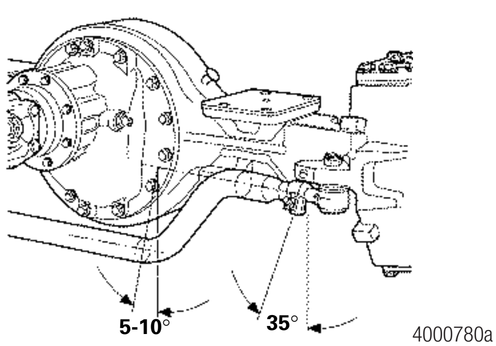


Figure 7.26

4. Verify that the cross tube drop center does not interfere with the carrier or other vehicle components. Larger axles should have the drop center inclined at 5-10 degrees to the rear for optimum clearance at maximum turn conditions. Figure 7.26.
5. Check the toe-in measurement again to make sure it is within the correct limits.

Axles with Turnbuckle Adjustable Cross Tubes

1. Loosen the turnbuckle cross tube clamps and rotate the clamp assembly as required.
2. Tighten the clamps to the correct torque. Refer to Section 10.
3. Check the toe-in measurement again to verify that it is within the correct limits

Axles with Adjustable Tie Rod Ends

1. The cross tube end on the left side of the vehicle has coarse threads and the cross tube end on the right side has fine threads.
2. If a coarse adjustment is required, loosen the cross tube clamps on the left side of the vehicle. Remove the cotter pin and nut from the knuckle arm to disassemble the cross tube end. Rotate the cross tube end assembly as required. One complete turn will change the toe-in or toe-out approximately 0.25-inch (6.35 mm).
3. If a fine adjustment is required, follow the same procedure as shown in Step 2 on the right side of the vehicle. One complete turn will change toe-in or toe-out approximately 0.1875-inch (4.76 mm).
4. Install the cross tube end assemblies and tighten the nuts to the correct torque. Refer to Section 10.
5. Verify that the drop center of the cross tube does not interfere with the other vehicle components. Tighten the cross tube locknuts or clamp bolts to the correct torque. Refer to Section 10. Larger axles should have the drop center inclined at 5-10 degrees to vertical for optimum clearance at maximum turn conditions. Figure 7.26.
6. Check the toe-in measurement again to verify that it is within correct limits.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Use a brass or leather mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off and cause serious personal injury.

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

Assembly

Axle Shaft Universal Joint

Round Bearing Yokes

1. Slide the first bushing onto the trunnion. Figure 8.1.

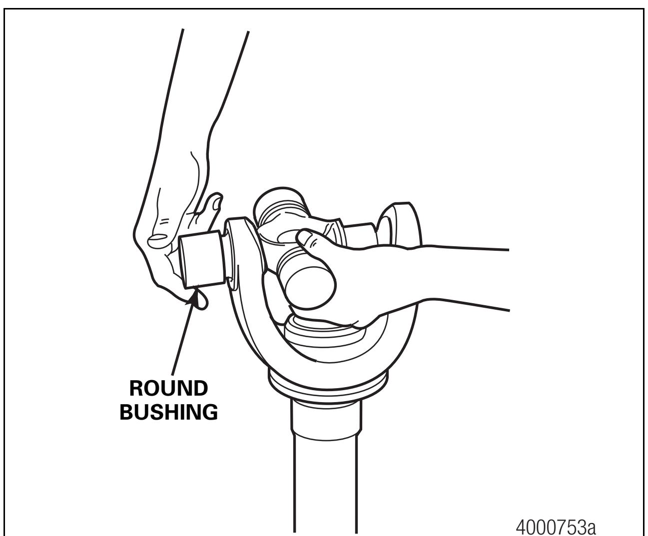


Figure 8.1

2. Press the first round bushing into the yoke slightly past the snap ring groove. Check that the bushing is aligned with the universal joint trunnion. Figure 8.2.

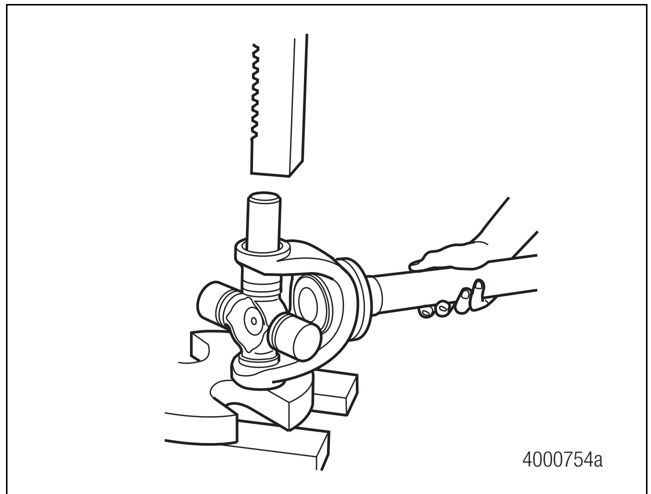


Figure 8.2

3. Use snap ring pliers to install the snap ring into the snap ring groove. You must fully seat the snap ring into the snap ring groove to avoid damage to the driveline. Figure 8.3.

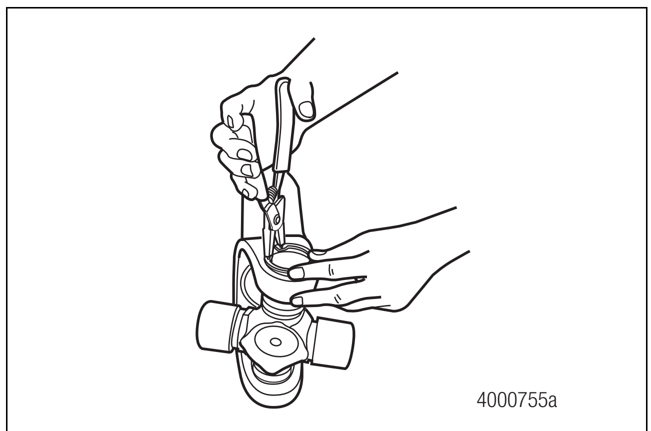


Figure 8.3

4. Use a snap ring installation gauge to check that the snap ring is fully seated in the snap ring groove. Figure 8.4.

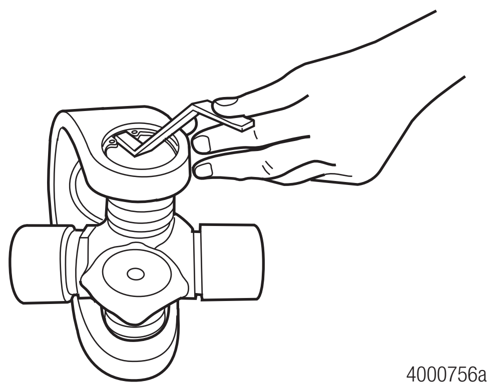


Figure 8.4

5. Repeat the previous four steps to install the remaining bushings into the yoke.
6. Lubricate the universal joint when the joint includes a grease fitting.
   - **If the universal joint does not move freely:** Strike the yoke ear with a brass or copper hammer. Figure 8.5.

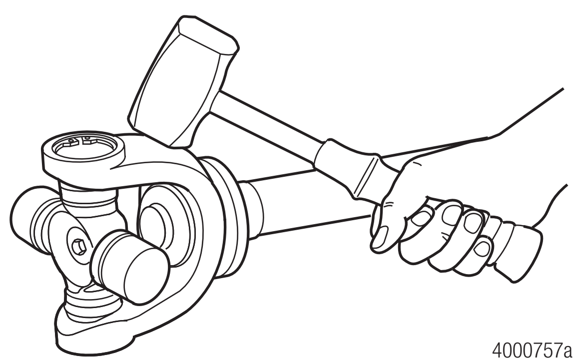


Figure 8.5

Wing Bearing Yokes

1. If the cross and cap assembly is damaged, replace all the parts with a new assembly.
2. Assemble the cross assembly to the yokes with eight capscrews and nuts. Tighten the capscrews and jam nuts to the torque listed in Table E.

Table E

Size	Capscrews lb-ft (N•m)	Jam Nuts lb-ft (N•m)
7/16"-20	70-80 (95-108)	20-30 (27-41)
1/2"-20	115-135 (155-183)	27-37 (36-50)

3. The current wing bearing yoke design utilizes a Permalube™ universal joint and does not require additional lubrication.

   Prior wing bearing yoke designs include a grease fitting and require lubrication. Refer to Section 9 for lubricant specifications.

Steering Knuckle and the Axle Shaft

1. Install a new seal onto the outer drive shaft. Figure 8.6.

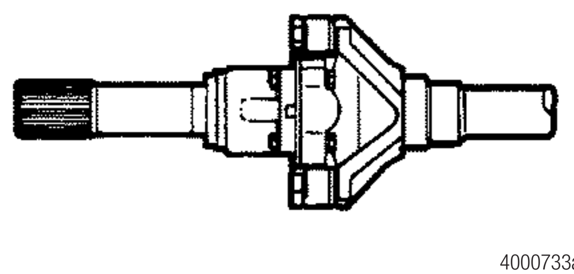


Figure 8.6

2. If required, use a correct size sleeve or driver to install a new inner drive shaft bushing, thrust washer and oil seal into the housing or housing socket adapter. Apply a layer of non-hardening sealing compound to the seal retainers before the seals are installed.

⚠ CAUTION

Do not force or hit the seal after it is correctly installed into its seat. You can damage the seal retainer.

3. If the socket plugs were removed from the housing, position the socket plugs in the housings up against the counter bore. If tack welds were used previously, carefully tack weld each plug in position with four welds.

4. Use correct size sleeve or driver to drive new bushings into the socket bores so that the bushings are level with the outside of the socket.
   - **If a press is available:** Press-in the domed socket plugs or tack weld them into position. To avoid distortion to the bushing and bushing bore diameter, do not apply too much heat to the socket during tack welding of socket plugs.
5. Inspect the housing seal and thrust washer to verify that these pieces are correctly installed. Install the universal joint into the housing. Align the inner shaft splines with the splines of the differential side gear.
6. Pack the thrust washer rollers with grease before assembly.
7. Install the thrust bearing against the journal on the lower cap.
8. Place the knuckle into its correct position over the end of the housing. Align the knuckle bores with the housing socket bores.
9. Install the lower cap assembly through the bottom bores of the knuckle and housing until the cap is against the knuckle.
10. Install the capscrews and tighten to the correct torque. Refer to Section 10.
11. Install the shims and oil seal against the base of the upper cap. Use the same thickness shim pack that was removed during disassembly. The shim pack must contain a minimum of three shims.
12. Install the cap assembly through the upper bores of the knuckle and housing until the cap is against the knuckle.
13. Install the capscrews and tighten to the correct torque. Refer to Section 10.
14. Check steering knuckle end play.
   A. Support the vehicle with safety stands under the axle housing.
   B. Place a magnetic base dial indicator into position on the housing. Figure 8.7.

   NOTE: If necessary, remove the grease fitting from the lower knuckle cap to prevent damage.

   C. Use a jack to place pressure onto the lower knuckle cap. Set the dial indicator to ZERO.
   D. Fully release the jack pressure and read the end play on the dial indicator. Correct end play is between 0.005-0.015-inch (0.127-0.381 mm). Remove or add shims from between the upper knuckle cap and steering knuckle to obtain the correct end play.

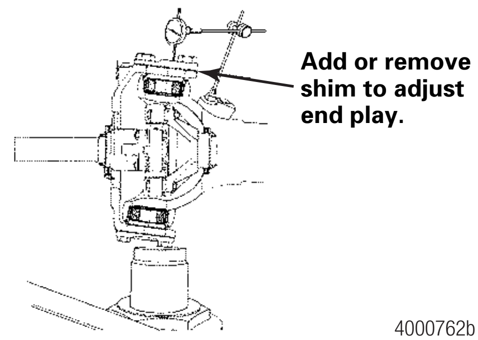


Figure 8.7

15. Check the knuckle bearing preload.
   A. Fasten a soft wire or cord to the tie rod arm. Attach a pound scale to the opposite end of the wire or cord. Hold the outer shaft of the universal joint away from the knuckle opening and pull on the pound scale to rotate the knuckle. Read the pounds on the scale. Read the pull necessary to rotate the knuckle, not the pull necessary to start the movement. Figure 8.8.
   B. The pounds shown on the scale must be between 10-30 lbs (4.5-13.5 kg). The correct rotating torque is 8-25 lb-ft (20.8-33.9 N•m).
   - **If the knuckle bearing preload is not correct:** Disassemble and inspect the knuckle.

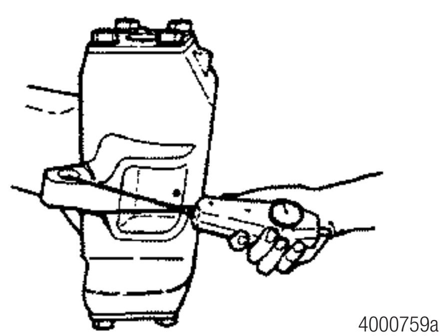


Figure 8.8

Spindle and Brake to the Steering Knuckle

1. On units equipped for ABS, if the steel sleeve for holding the ABS sensor clip and ABS sensor has been disassembled, install the sleeve with a suitable driver. Install the sleeve into the spindle until it is 0.9375-inch (23.8 mm) below the inner bearing shoulder. Install the ABS sensor clip into the sleeve. Figure 8.9.

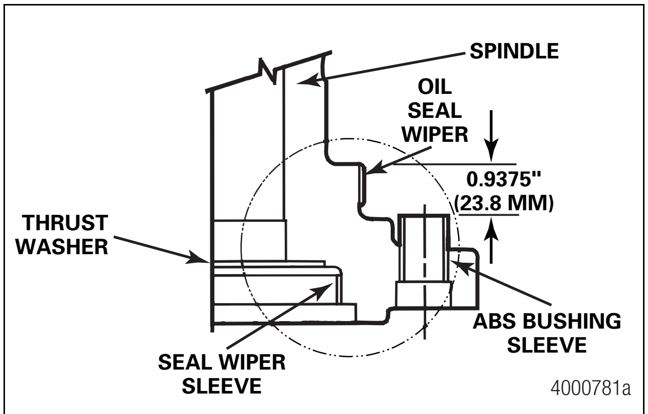


Figure 8.9

2. If disassembled, install the thrust washer and seal wiper sleeve into the spindle. Figure 8.10.

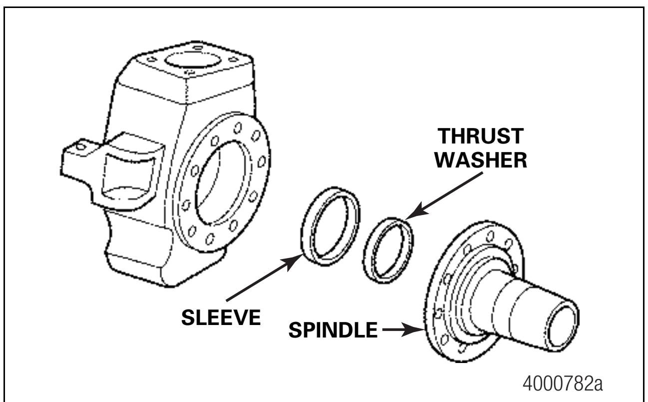


Figure 8.10

NOTE: On larger model axles, spindle installation will be easier if you install two temporary pilot studs into opposite sides of the knuckle. Tighten the studs finger-tight. Figure 8.11.

3. If the brake was removed as an assembly, install it at this time.

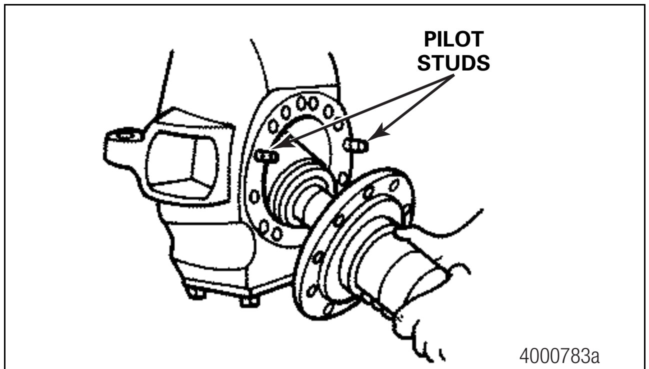


Figure 8.11

4. Install the spider assembly against the knuckle with the keyway slot for the wheel bearing adjusting nut system toward the top for ABS spindles.
5. Install the brake spider onto the spindle. Fasten all parts to the knuckle with 12 capscrews and washers. Tighten to the correct torque specified in Section 10. Figure 8.12.

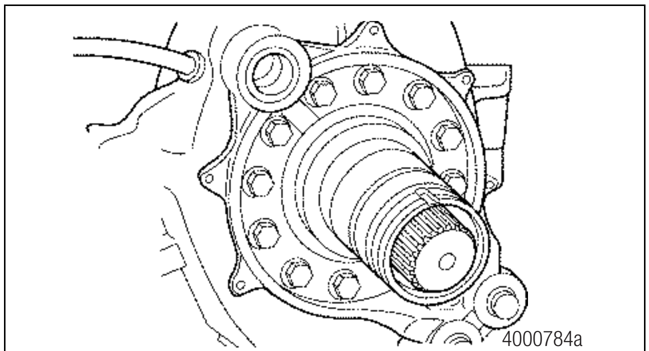


Figure 8.12

6. Check the axle shaft end play.
   A. Place a magnetic base dial indicator into position on the housing with the pointer on the shaft. Set the dial indicator to ZERO.
   B. Push DOWN on the axle shaft and read the end play on the dial indicator.
      - **If the end play is greater than 0.118-inch (3 mm):** Remove the wheel end and inspect for wear. The thrust washer thickness must be at least 0.120-inch (3.05 mm). Replace the thrust washer if necessary. Inspect the thrust surfaces on the spindle, housing and axle shaft for wear. Replace parts as necessary.

7. On units equipped for ABS, install the ABS cable and grommet into the knuckle. Install the ABS sensor into the ABS bushing in the spindle. Figure 8.12.
8. Install the camshaft bushing retainer plate and two bolts to the back side of the steering knuckle. Tighten the capscrews to the correct torque. Refer to Section 10. Figure 8.13.

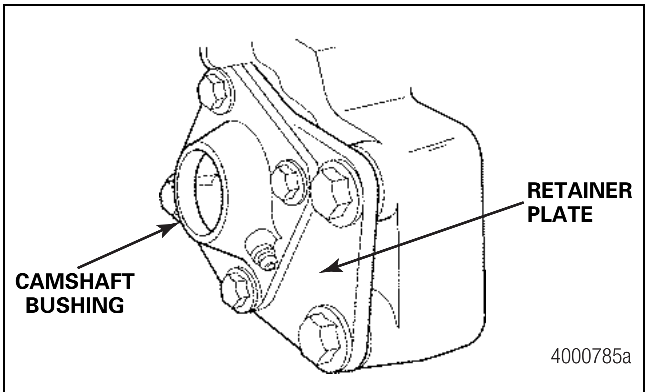


Figure 8.13

9. If the camshaft bushing was disassembled, attach it to the retainer plate with four self-tapping screws. Tighten the screws to the correct torque. Refer to Section 10.
10. Install the air brake chambers and brackets. Tighten the bracket mounting capscrews to the correct torque. Refer to Section 10. Figure 8.14.

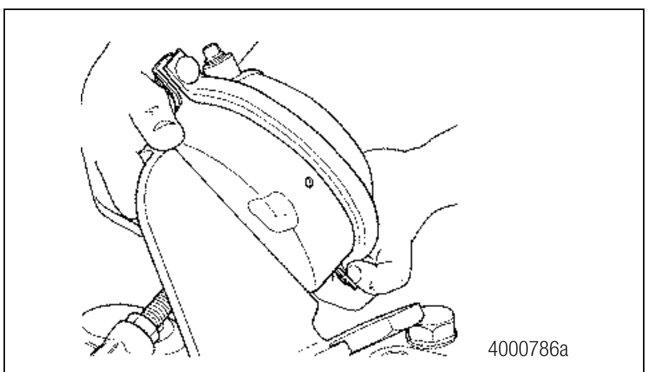


Figure 8.14

11. Install the camshaft. Figure 8.15.

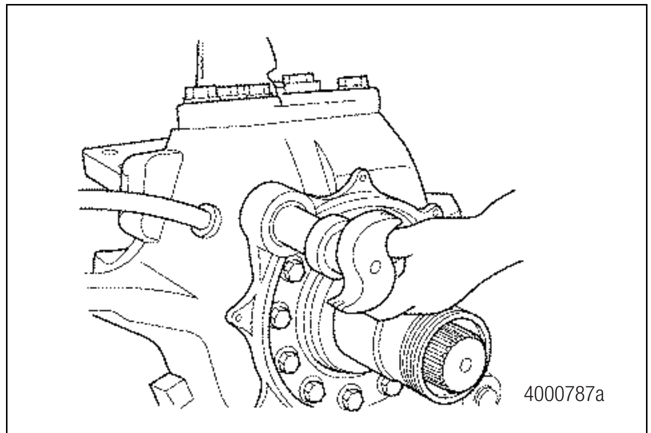


Figure 8.15

12. Install the retaining ring onto the camshaft at the back of the spider assembly. Figure 8.16.

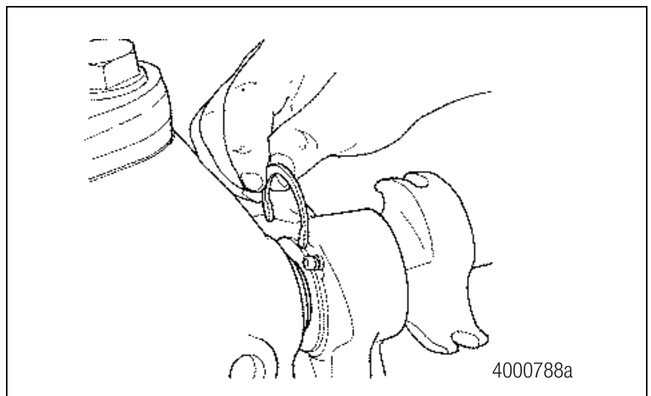


Figure 8.16

13. Install the slack adjuster onto the camshaft. Figure 8.17.

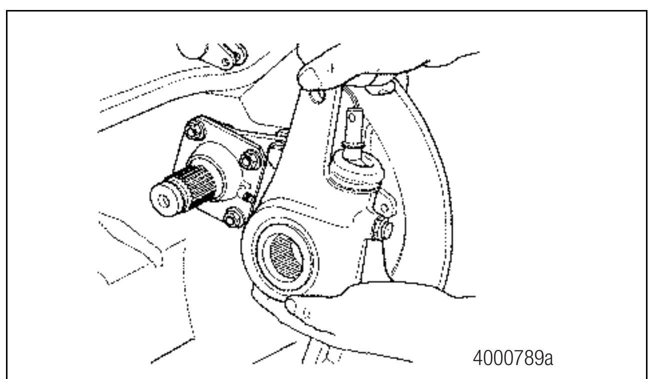


Figure 8.17

14. Install slack adjuster shims at the adjuster end of the camshaft. Figure 8.18.

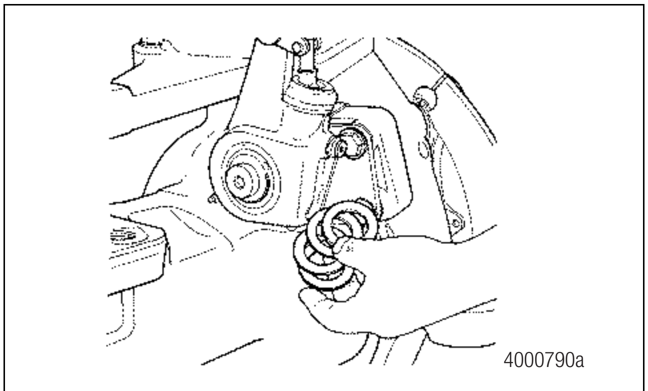


Figure 8.18

15. Install the slack adjuster retaining ring at the adjuster end of the camshaft. Figure 8.19.

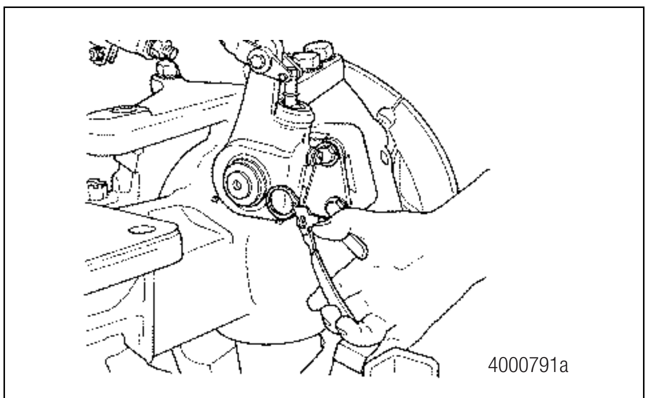


Figure 8.19

16. If disassembled, install nut and push rod yoke on air chamber push rod.

17. Install the pin and retainer that engages the push rod yoke and the slack adjuster plunger rod. Figure 8.20.

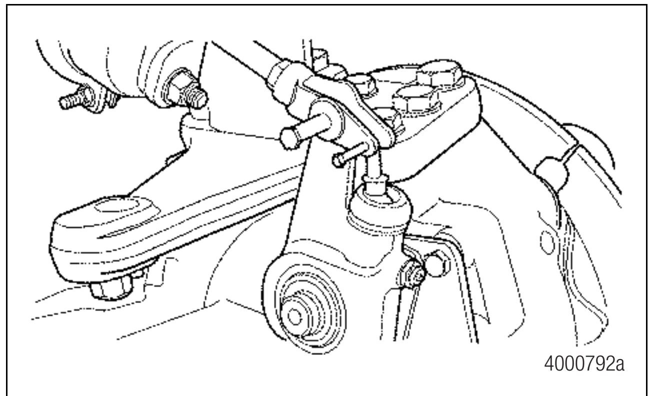


Figure 8.20

18. The distance from the back of the brake air chamber to the center of the clevis pin is the brake slack adjuster position (BSAP). Adjust slack adjuster position to obtain the correct specification in Table F.

Table F

Slack Adjuster Length	BSAP
5.5" (139.7 mm)	6.3" (160.02 mm)
6.0" (152.4 mm)	6.43" (163.32 mm)

19. Tighten the nut on the push rod to the clevis pin to the correct torque. Refer to Section 10.

20. Install the dust shields to the brake spider. Tighten the mounting screws to the correct torque. Refer to Section 10. Figure 8.21.

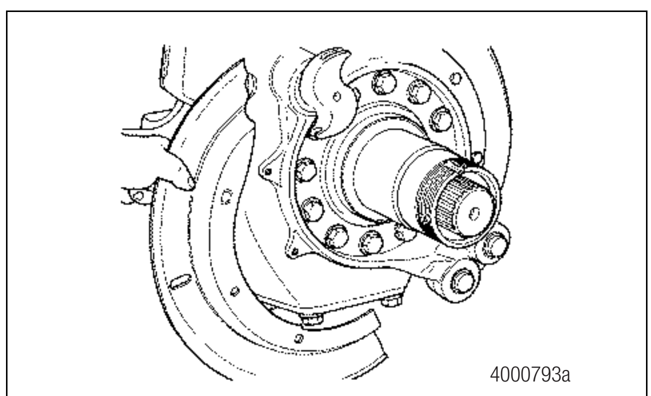


Figure 8.21

21. Connect the air lines to the brake chambers.

Installation

Wheel Bearings Into the Hubs

1. If wheel studs were removed from the hub, place the hub into a press with the drum side at the bottom. Align the grooves on the studs with the grooves in the stud holes in the hub. Press the studs into position. If a press is not available, use a brass hammer.
2. Install the inner and outer bearing cups into the hub. Use a press and sleeve.
3. Fill the bearing cones and hub cavity with the correct grease until it is level with the inside diameter of the bearing cones. Refer to Section 9.
4. Install the inner bearing cone into its cup inside the hub.
5. Install a new inner oil seal. Apply a layer of non-hardening sealing compound to the outside of the seal. Install the seal into its correct position against the bore. Do not force or hit the seal after it has touched the bottom of the bore. The seal can be damaged.
6. On units equipped for ABS, use a suitable driver to install the ABS tooth wheel on the hub. Damage to the teeth on the ABS tooth ring can create an error signal during testing and operation of the ABS system.
7. Install the oil sleeve on the spindle with a driver.
8. Install the hub assembly onto the spindle. Be careful the oil seal is not damaged during installation. Press the hub until the inner bearing is flat against the face of the spindle.
9. Install the outer bearing cone on the spindle and push it into its cup inside the hub.
10. Check the axle lubricant level and fill if required. Refer to Section 9 for lubricant specifications.

Adjustment

Brakes

WARNING

You must manually adjust the brake after you perform maintenance or service. Do not depend on the automatic adjusters to remove the excessive clearance created when you back off the brake during service. The automatic adjusters are designed to compensate for normal lining wear. Damage to components and serious personal injury can occur.

Refer to Maintenance Manual 4, Cam Brakes, for complete brake adjustment procedures. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Wheel Bearings

WARNING

When you adjust a wheel bearing, always use the correct socket wrench to loosen the adjusting nut. Use a torque wrench to tighten it to the correct specification. Do not attempt to tighten or loosen an adjusting nut by striking it with a hammer. Do not place a chisel or drift next to the adjusting nut and strike the chisel with a hammer.

Damage to the adjusting nut can result, which can prevent you from obtaining the correct wheel bearing adjustment. An incorrect adjustment can cause a wheel to separate from the vehicle during operation. Serious personal injury and damage to components can result.

1. Use a torque wrench to tighten the adjusting nut to 100 lb-ft (136 N•m). Figure 8.22.

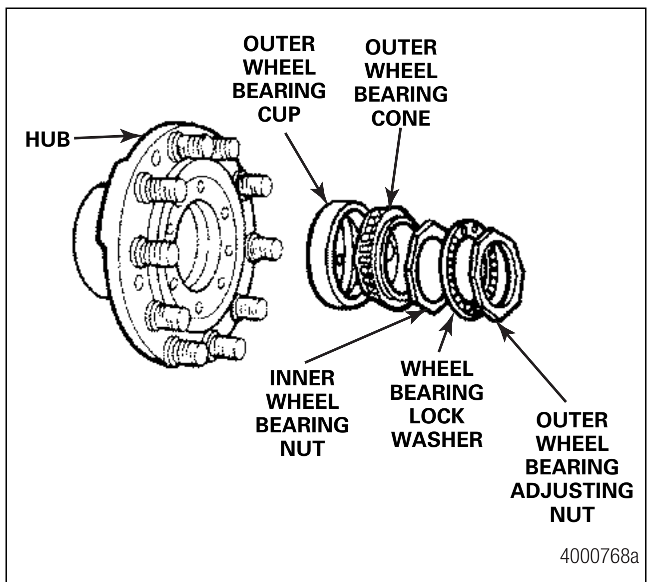


Figure 8.22

2. Rotate the hub three full turns to ensure all the bearings and seal surfaces are in contact.
3. Back off the adjusting nut 1/4 turn, 2-1/2 studs of the drum bolt circle. Do not rotate the hub assembly after backing off the adjusting nut.
4. Assemble the lock ring and jam nut. Tighten the jam nut to 250-400 lb-ft (339-542 N•m). If the lock ring does not line up with the adjusting nut, rotate the adjusting nut clockwise, tightening, to the closest lock ring hole. To make the smallest turn possible, flip the lock ring over if necessary.

5. Check the resulting end play with a dial indicator and perform the following actions.

End Play (inch)	Action
0.000-0.002	No action required.
>0.002-0.005	Remove the jam nut and lock ring. Tighten the adjusting nut 1/32 turn by flipping the lock ring over and turning the adjusting nut to align with the next hole.
>0.005-0.008	Remove the jam nut and lock ring. Tighten the adjusting nut 1/16 turn by turning the adjusting nut to align with the next hole. Do not flip the lock ring.
>0.008-0.011	Remove the jam nut and lock ring. Tighten the adjusting nut 3/32 turn by flipping the lock ring over and turning the adjusting nut to align with the second hole from the current position.
>0.011	Return to Step 1 and repeat the procedure.

ABS Sensor

1. On units equipped for ABS, push the ABS sensor completely into the sensor bearing until it contacts the tooth wheel on the hub. Figure 8.23.

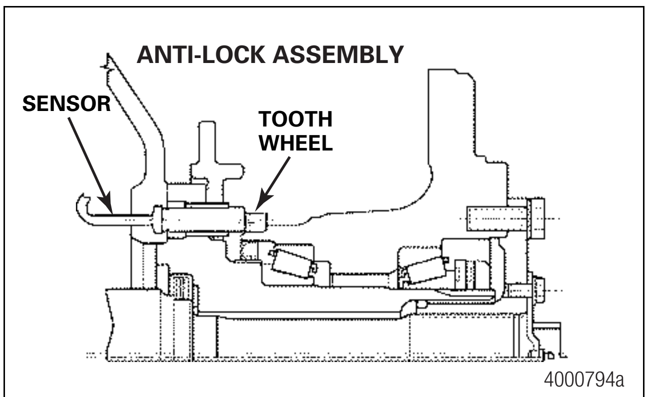


Figure 8.23

2. With the sensor in place, feed any excess cable back through the grommet on the knuckle. Do not affect the position of the sensor or allow excess cable to contact the drive shaft.

3. For service instructions for ABS braking systems, refer to Maintenance Manual 28, Anti-Lock Braking Systems (ABS) for Trucks, Tractors and Buses, For C Version ECUs; and Maintenance Manual 30, Anti-Lock Braking Systems (ABS) for Trucks, Tractors and Buses, For D Version ECUs. To obtain these publications, refer to the Service Notes page on the front inside cover of this manual.

Assembly

Drum and the Drive Flange

WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

1. Install the drum over the hub pilot. If a flat head capscrew is used for retention, fasten the drum to the hub with the flat head capscrews. Tighten the capscrews to the correct torques. Refer to Section 10.
2. Install felt seal and retainer on drive flange.
3. Apply a layer of silicone gasket material to the hub mounting surface of the drive flange only. Refer to Section 6.
4. Apply Meritor specification number O-617-A or O-617-B wheel bearing grease to the inside splines of the drive flange and the splines of the drive shaft.
5. Install the drive flange on the hub and fasten with washers and capscrews. Tighten the capscrews to the correct torque. Refer to Section 10.
6. If previously removed, install the hubcap, if used, to drive flange. Apply a 0.125-inch (3.18 mm) continuous bead of silicone gasket material around either the mounting surface of the hubcap or the drive flange. Refer to Section 6. Tighten the capscrews to the correct torque. Refer to Section 10.

Cross Tube to the Knuckle

1. Assemble the cross tube end assembly and clamp if these parts were disassembled. Tighten the locknuts to the correct torque. Refer to Section 10.
2. Push the stud of the tie rod end through the bottom of the bore in the knuckle arm tapered hole. Tighten the cross tube nut to the correct torque. Refer to Section 10.
3. Install the slotted nut and cotter pin assembly.
   A. Tighten the nut to the initial torque specified.
   B. Advance the nut, do not back it off, to align the cotter pin.
   C. Final installed torque must not exceed the maximum specified.
   - **If the final torque exceeds the maximum:** Remove the nut and reinstall it to the correct specification.
   - **If the minimum torque is not met:** Check if the stud taper is showing. If necessary, shim with a 0.125-inch (3.18 mm) washer.
4. Install the cotter pin.
5. Assemble the wheel, tire and rim, to the drum. Tighten the wheel nuts to the manufacturer's specifications.

Adjustment

Steering Stop Setting

All Meritor front drive steer axles are shipped with the steering stop screws preset at the factory according to the manufacturer's specifications. Additional adjustments can be made by the vehicle manufacturer or end user to accommodate a specific chassis design or tire size as long as the maximum angle does not exceed the U-joint capability.

NOTE: Check the adjustments of both axle steering stops and power steering units every time part of the steering system is disassembled.

Maximum Turn Angle Setting

Front Drive Steer Axle Model	Maximum Turn Angle of the U-Joint
RF-16	35
RF-21, -22, -23	35

NOTE: Do not adjust the turn angle beyond the specifications set by the vehicle manufacturer.

Manual Steering

Adjust both the right- and left-hand knuckle steering stops to touch the housing when the maximum turning angle specified by the vehicle manufacturer is reached. Lock the steering stop in position with the jam nut tightened to the correct torque. Refer to Section 10. Figure 8.24.

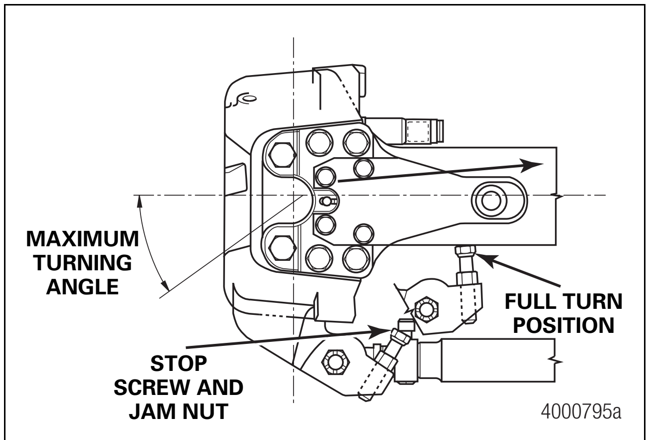


Figure 8.24

Power Steering

⚠ CAUTION

Meritor does not permit any power steering system that does not have a pressure relief or positive mechanical stop to be set before the maximum turn angle is reached. The power units must be stopped before the axle stop touches the housing to prevent stress to the axle components. Damage to components can result.

Mechanical Relief

Vehicles with mechanical Pitman arm stops or cylinder stops must be adjusted to end the travel of the Pitman arm or cylinder 0.125-inch (3.18 mm) before the steering stop screw touches the housing. Maximum turn angle is then controlled by the arm or cylinder stop, not the axle stop. Make the adjustments for both full-right and full-left turns. Figure 8.25.

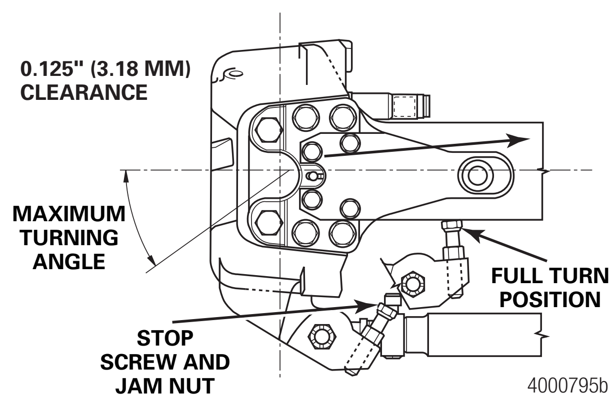


Figure 8.25

Hydraulic Relief

Hydraulic steering gears or cylinders with poppet valves must be adjusted while a 0.250-0.1875-inch (6.35-4.76 mm) spacer is held between the housing and stop screw. The poppet valves must be adjusted to permit pressure bypass at this position with the spacer in place for full-right and full-left turns. During this setting the steering gear pressure must be at a maximum 600 psi (41.4 bar). Figure 8.26.

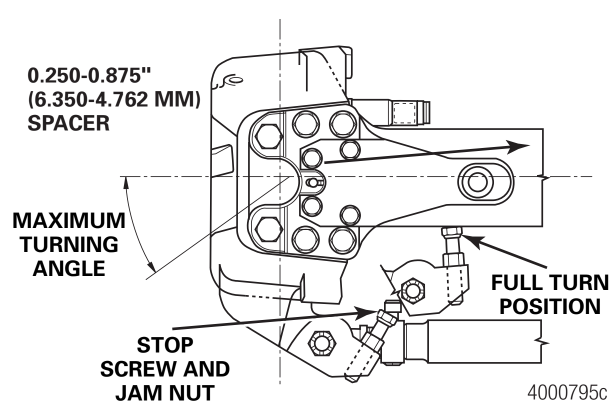


Figure 8.26

Wheel Toe-In

Toe-in must be checked and adjusted on all front drive axles after the axle is installed in the vehicle. Figure 8.27.

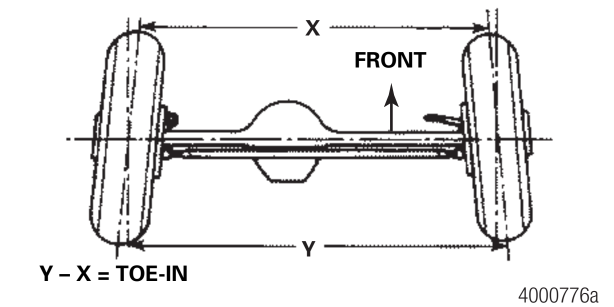


Figure 8.27

NOTE: Toe-in must be measured with the weight of the vehicle on the axle and the axle on a level floor. Use the following procedure.

1. Use a jack to raise the front axle.
2. Use a piece of chalk to mark the center area of both front tires around the complete circumference.
3. Place a scribe or pointed instrument against the center of the whitened part of each tire and rotate the tires. The scribe must be held in place so that a single straight line is marked all around the tire.
4. Place a full-floating turning radius gauge plate under each wheel. Lower the vehicle and remove the lock pins from the gauge plates.
   - **If full-floating gauge plates are not available:** Lower the vehicle to the floor and move the vehicle backward approximately six feet (1.8 m) and then forward for the same distance.
5. Set the slide scale end of a trammel bar to ZERO and lock the scale in place.
6. Place the trammel bar at the rear of the tires. Adjust the pointer to line up with the scribe lines on the tires. Lock the pointers in place. The sliding scale still must be set on ZERO. Figure 8.28.

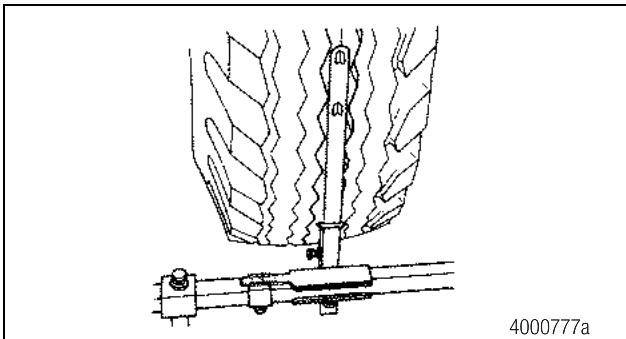
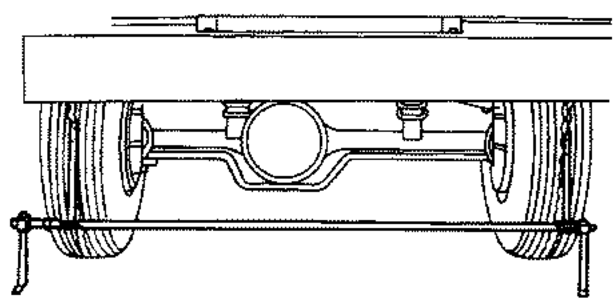


Figure 8.28

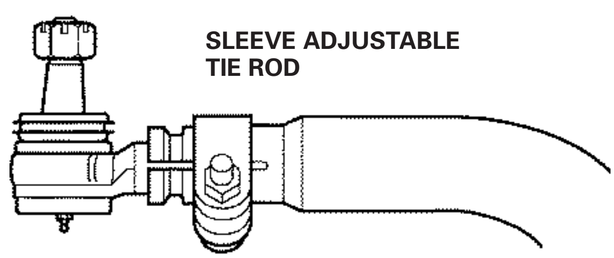
7. Place the trammel bar at the front of the tires. Adjust the pointer to line up with the scribe lines. Figure 8.29.



4000778a

Figure 8.29

8. Read the toe-in or toe-out from the scale. In a vehicle, toe-in must be:
   - Unloaded: 0.06 ± 0.31-inch (1.59 ± 0.79 mm)
   - Loaded: 0.31 ± 0.31-inch (0.79 ± 0.79 mm)
9. If toe-in adjustment is necessary, use the following procedure. Figure 8.30.

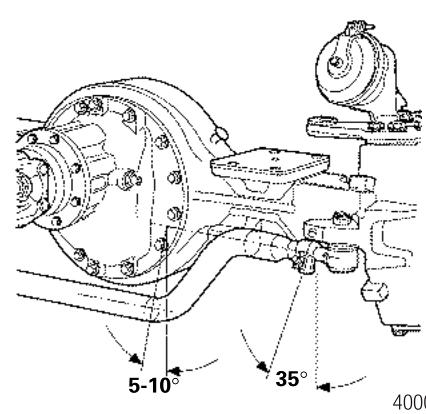


4000796a

Figure 8.30

Axles with Sleeve Adjustable Cross Tubes

1. Loosen the tie rod clamp located on the sleeve side of the tie rod.
2. Rotate the sleeve to set toe-in or toe-out.
3. Tighten the clamp to the correct torque. Refer to Section 10. Figure 8.31.



4000797a

Figure 8.31

4. Verify that the cross tube drop center does not interfere with the carrier or other vehicle components. Larger axles should have the drop center inclined at 5-10 degrees to vertical for optimum clearance at maximum turn conditions. Figure 8.31.
5. Check the toe-in measurement again to verify that it is within the correct limits.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Overview

Drive axles generate small metal wear particles at a fairly steady rate, especially during the break-in period. If these fine, but hard particles are allowed to circulate in the lubricant, along with external moisture and dirt, internal components will wear at a much faster rate than normal.

Magnets and Magnetic Drain Plugs

Front drive axles are equipped with magnetic drain plugs that have a minimum pick-up capacity of 1.5 pounds (0.7 kilograms) of low carbon steel.

The magnetic drain plug can be reused if, after cleaning, the plug has a minimum pick-up capacity of 1.5 pounds (0.7 kilograms) of low carbon steel.

Inspect the magnetic drain plug each time the oil is changed. Use the correct part. Pipe plugs will leak if used as a drain plug.

Breather

CAUTION

Cover the breather when steam cleaning the housing to prevent water from entering the housing and contaminating the oil. Damage to components will result.

Baffle-type breathers help keep axles free from external moisture and dirt which can cause premature oil and component failure.

Seals

CAUTION

Always use the correct tools and procedures when replacing seals to ensure correct installation and help prevent seals from leaking.

Seals keep lubricant in and dirt out of a component. When they are worn or damaged, seals leak and produce low lubricant levels which may damage components.

Durable triple-lip seals, standard in Meritor axles, protect the quality and levels of the lubricant and provide superior performance.

Temperature Indicators

CAUTION

Meritor axles can operate above 190°F (88°C) without damage. However, if the oil temperature reaches 250°F (121°C), stop the vehicle immediately and check for the cause of overheating. Damage to components can result.

Many Meritor axles have a tapped hole in the housing for the installation of a lubricant temperature indicator that will help reduce the failure of axle parts from overheated oil.

Check and Adjust

Oil Level

1. Park the vehicle on a level surface.
2. Remove the fill plug from the axle.
3. The oil level must be even with the bottom of the fill plug hole.
    - **If oil flows from the hole when the plug is loosened:** The oil level is high. Let the oil drain to the correct level.
    - **If the oil level is below the bottom of the fill plug hole:** Add the specified oil.
4. Install and tighten the fill plug to 35-50 lb-ft (48-67 N•m).

Drain and Replace

Oil

1. Park the vehicle on a level surface. Place a large container under the axle.
2. Remove the drain plug from the bottom of the axle. Drain and discard the oil correctly.
3. Clean, install and tighten the drain plug to 35-50 lb-ft (48-67 N•m).
4. Remove the fill plug from the axle.
5. Fill the axle to the bottom of the fill plug hole with the specified oil. Allow enough time for oil to circulate through the axle assembly.
6. Install and tighten the fill plug to 35-50 lb-ft (48-67 N•m).

Lubrication

Knuckle King Pins

With the vehicle weight on the wheel end, pump grease through the grease fittings located on the upper cap or steering arm and lower cap assemblies. Grease should purge through the seals and thrust bearing.

Camshaft Retainer Bushing and Cam Bushing

Pump grease until it purges through the seals.

Drive Axle Shaft Universal Joint

1. Permanently-lubricated Permalube™ drive shaft joints do not have a grease fitting provided. Periodic greasing is not required for these parts. For serviceable universal joints with grease fittings, follow Step 2 through Step 3.
2. Clean all grease fittings prior to lubrication.
3. Apply the specified grease at the grease fitting on the universal joint. Apply grease until new grease purges from all the seals.
   - **If new grease does not purge at every seal:** Move the drive shaft while applying grease at the fittings until new grease purges at every seal.
   - **If new grease still does not purge:** Disassemble the universal joint. Inspect the grease and the components. Service as necessary.

Axle Shaft Spline and Thrust Washer

On axles with greaseable drive flanges, pump grease through the grease fitting until it purges at the axle shaft seal. Figure 9.1.

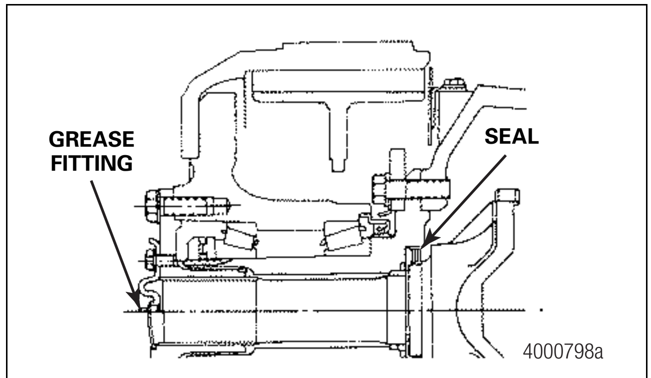


Figure 9.1

Cross Tube End Assembly

1. Check the cross tube for looseness of more than 0.060-inch (1.52 mm). Figure 9.2. If loose, service as necessary.

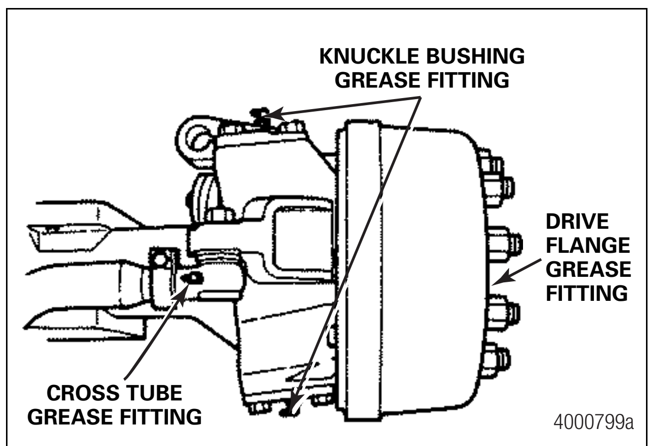


Figure 9.2

2. Apply the specified grease at the grease fitting on the cross tube. Apply grease until new grease purges from all the seals.
   - **If new grease does not purge at the seals:** Move the cross tube while applying grease at the fittings until new grease purges from all the seals.
   - **If new grease still does not purge:** Disassemble the cross tube. Inspect the grease and the components. Service as necessary.

Knuckle Bushing

1. Check the knuckle for looseness. The correct end play is 0.005-0.015-inch (0.127-0.381 mm). Figure 9.2. If loose, service as necessary.
2. Clean all grease fittings prior to lubrication.
3. Apply the specified grease at the grease fitting on the knuckle until new grease purges from all the seals. Grease the lower pin cap with the vehicle weight on the wheel end to ensure that the thrust bearing is completely greased.
   - **If new grease does not purge at the seals:** Move the knuckle while applying grease at the fittings until new grease purges at the seals.
   - **If new grease still does not purge:** Disassemble the knuckle. Inspect the grease and the components. Service as necessary.

Greasing Wheel Bearings

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Use a jack to raise the vehicle so that the wheels to be serviced are off the ground. Support the vehicle with safety stands.
3. Remove the tire and wheel assembly. Remove and disassemble the hub.
4. Use the correct cleaning solvent to remove the old grease from all parts. Discard the seals. Inspect the wheel bearings for wear and damage. Replace worn or damaged bearings.
5. Before installing the wheel bearings, lubricate the bearing journals on the spindle with the grease that is used for the bearings. Figure 9.3 and Figure 9.4.
6. Use a pressure packer to force the specified grease from the large end of the cones into the cavities between the rollers and cage. Pack the hub between the bearing cups with grease to the level of the smallest diameter of the cups.
   - **If a pressure packer is not available:** Grease the bearings by hand.

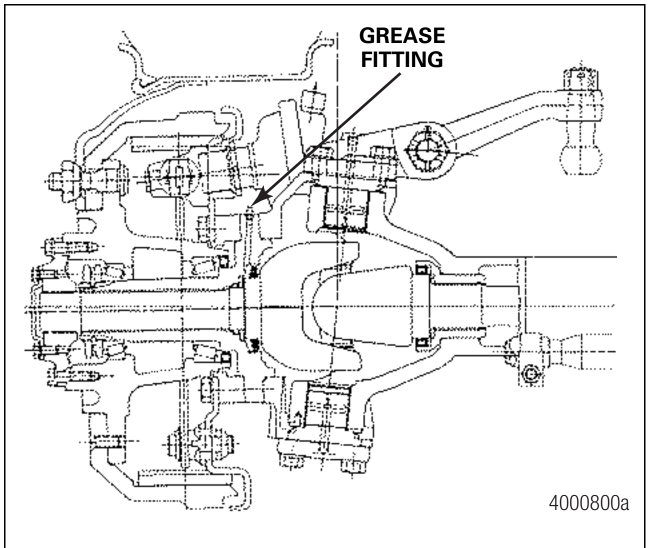


Figure 9.3

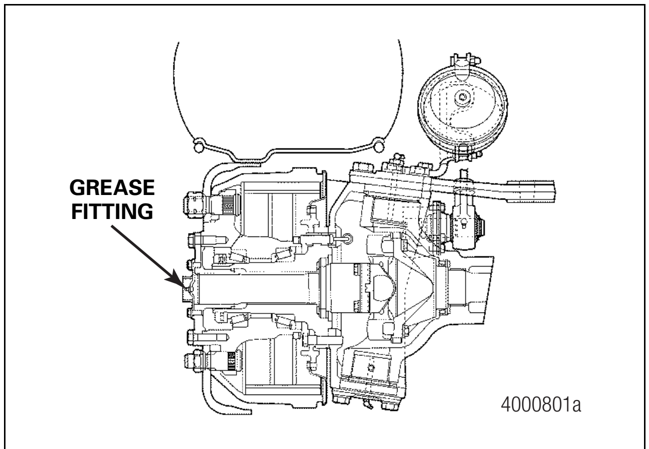


Figure 9.4

7. Install the inner and outer bearing cones into the cups in the hubs. The bearing cups must be pressed tight against the shoulder in the hubs.
8. Install new wheel seals into the hubs.
9. Install the hub and the wheel and tire assembly. Install the outer wheel bearing cone into the hub. Install the adjusting nut.
10. Adjust the wheel bearings.

Specifications

Front Drive Axle Oil Change Intervals and Specifications*

Initial Oil Change	No longer required as of January 1, 1993
Check Oil Level	Every 5,000 miles (8000 km), once a month, or the fleet maintenance interval, whichever comes first
Petroleum Oil Change	Every 25,000 miles (40 000 km) or annually, whichever comes first[1]
Synthetic Oil Change	Every 50,000 miles (80 000 km) or annually, whichever comes first

[1] For continuous heavy-duty operation, check the oil level every 1,000 miles (1600 km). Add the correct type and amount of oil as required.

			Outside Temperature			
			°F		°C	
Meritor Specifications	**Military Specification Approval**	**Oil Description**	**Min.**	**Max.**	**Min.**	**Max.**
O-76-A, Gear Oil	MIL-PRF-2105-E	GL-5, SAE 85W/140	10	None	– 12	None
O-76-D, Gear Oil	and	GL-5, SAE 80W/90	– 15	None	– 26	None
O-76-E, Gear Oil	SAE J2360	GL-5, SAE 75W/90	– 40	None	– 40	None
O-76-J, Gear Oil		GL-5, SAE 75W	– 40	35	– 40	2
O-76-L, Gear Oil		GL-5, SAE 75W/140	– 40	None	– 40	None
O-76-M, Full-Synthetic Oil		GL-5, SAE 75W/140	– 40	None	– 40	None
O-76-N, Full-Synthetic Oil		GL-5, SAE 75W/90	– 40	None	– 40	None

*If the front drive axle is the only axle on the vehicle, change the oil every 15,000 miles (24 000 km) or 1,000 hours of operation, whichever comes first.

Front Drive Axle Greasing Change Intervals and Specifications

Component	Greasing Intervals	Grease	Meritor Specification	NLGI Grade	Grease Classification	Outside Temperature
Cross Tube End Assemblies, Knuckle Bushings and Drive Flange	3,000 miles (4800 km) or 200 hours of operation, whichever comes first	Multi-Purpose Grease	O-617-A or O-617-B	1 or 2	Lithium 12-Hydroxy Stearate or Lithium Complex	Refer to the grease manufacturer's specifications for the temperature service limits.
U-Joints		U-Joint Grease	O-634-B	2	Lithium 12-Hydroxy plus molybdenum disulfide	

Wheel-End Oil Change Intervals and Specifications

Operation	On-Highway	Off-Highway
Check Oil Level	1,000 miles (1600 km)	1,000 miles (1600 km)
Petroleum Oil Change	Whichever comes first. Seals replaced. Brakes relined. 100,000 miles (160 000 km). Once a year.	Whichever comes first. Seals replaced. Brakes relined. Once a year.
Synthetic Oil Change	—	—

Meritor Specifications	Military Specifications Approval	Oil Description	Outside Temperature °F Min.	Outside Temperature °F Max.	Outside Temperature °C Min.	Outside Temperature °C Max.
O-76-A, Gear Oil	MIL-PRF-2105-E	GL-5, SAE 85W/140	10	None	– 12	None
O-76-D, Gear Oil	and	GL-5, SAE 80W/90	– 15	None	– 26	None
O-76-E, Gear Oil	SAE J2360	GL-5, SAE 75W/90	– 40	None	– 40	None
O-76-J, Gear Oil		GL-5, SAE 75	– 40	35	– 40	2
O-76-M, Full-Synthetic Oil		GL-5, SAE 75W/140	– 40	None	– 40	None
O-76-N, Full-Synthetic Oil		GL-5, SAE 75W/90	– 40	None	– 40	None
Heavy-Duty Engine Oil	MIL-L-2104D, E or F	A.P.I.-CD, -CE, -SF, or -SG, SAE, SAE 40 or 50[1]	10	None	– 12	None
Heavy-Duty Engine Oil	MIL-L-2104D, E or F	A.P.I.-CD, -CE, -SF, or -SG, SAE 30[2]	– 15	None	– 26	None

[1] Current designations are acceptable. Multi-weight engine oils are acceptable if the SAE rating ends in a 40 or 50.

[2] Current designations are acceptable. Multi-weight engine oils are acceptable if the SAE rating ends in a 30.

Wheel-End Axle Greasing Intervals and Specifications

Greasing Intervals	Grease	Meritor Specification	NLGI Grade	Grease Classification	Outside Temperature
Whichever comes first: • Replacing Seals • Relining Brakes • On-Highway: 30,000 miles (48 000 km) • On/Off Highway and Off-Highway: Twice a year	Multi-Purpose Grease	O-617-A (preferred) or O-617-B (acceptable)	1 or 2	Lithium 12-Hydroxy Stearate or Lithium Complex	Refer to the grease manufacturer's specifications for the temperature service limits.

Torque Specifications

Wedge Brake Fastener Torque Specifications

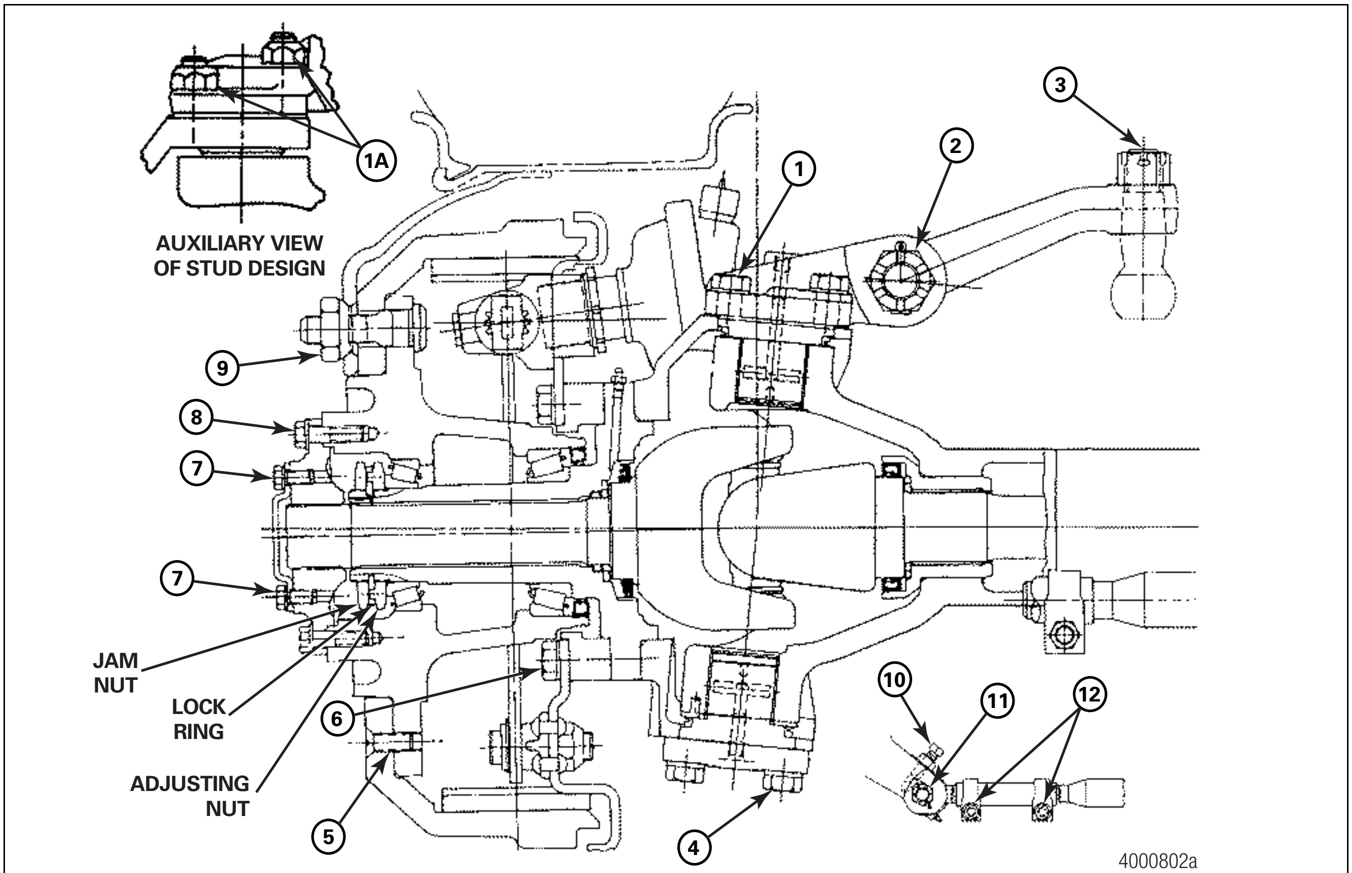


Figure 10.1

Table G: Wedge Brake Fastener Torque Chart

Item	Fastener	Thread Size (Inches)	Wrench Torque Lb-Ft	Wrench Torque N•m
1	Capscrew — Upper Knuckle Cap	3/4-10 1.0-8	310-400 775-1000	420-542 1052-1355
1A	Stud Nut — Upper Knuckle Cap	3/4-10	375-415	508-563
2[1]	Nut — Steering Arm[2]	1.0-14 1-1/4-12	390-525 (initial) 725 (after assembly) 775-1050 (initial) 1450 (after assembly)	529-712 983 1050-1424 1965
3[1]	Nut — Steering Arm Ball	3/4-16 7/8-14	90-120 (initial) 170 (after assembly) 160-215 (initial) 300 (after assembly)	122-163 231 217-292 407

Table G: Wedge Brake Fastener Torque Chart (cont'd.)

			Wrench Torque	
Item	Fastener	Thread Size (Inches)	Lb-Ft	N•m
4	Capscrew — Lower Knuckle Cap	3/4-10	310-400	420-542
5	Flathead Screw — Drum Mounting	1/2-13	15-30	20-41
6	Capscrew — Brake Mounting	5/8-11	180-230	244-312
7	Capscrew — Hubcap	3/8-24	40-55	54-75
8	Capscrew — Drive Flange	1/2-13 5/8-11	85-115 180-230	115-156 244-312
9	Wheel Nut	1-5/16-12	Refer to manufacturer's specifications.	
10	Jam Nut — Stop Screw	3/4-10	180-230	244-312
11[1]	Nut — Cross Tube End	7/8-14	160-215 (initial) 300 (after assembly)	217-292 407
12	Locknut — Cross Tube Clamp	1/2-20 1/2-13 5/8-18 5/8-11	35-50 40-50 35-50 50-60	47-68 54-68 47-68 68-81

[1] Refer to the slotted nut and cotter pin assembly procedure below.

[2] IMPORTANT: The correct torque must be reached on steering arms. Torques below minimum will not seat the tapers correctly and will reduce service life.

Wheel Bearing Adjustment

1. Tighten the adjusting nut to 50 lb-ft (68 N•m) while the hub is being rotated to be sure that all bearing surfaces are in contact. Figure 10.1.
2. Back off the adjusting nut 1/6 to 1/3 turn.
3. Assemble the lock ring and jam nut. Tighten the jam nut to the torque specified in Table H. The resulting end play must be within 0.001-0.005-inch (0.025-0.127 mm).

Table H

Nut Size	Torque, lb-ft (N•m)
1-1/8–2-5/8″	200-300 (272-407)
Over 2-5/8″	250-400 (340-542)

Slotted Nut and Cotter Pin Assembly Procedure

1. Tighten the nut to the initial torque specified.
2. Advance the nut to align the cotter pin. Do not back it off.
3. Final installed torque must not exceed the maximum specified.
   - **If final torque exceeds the maximum:** Remove the nut and reinstall to the correct specification.

Cam Brake Fastener Torque Specifications

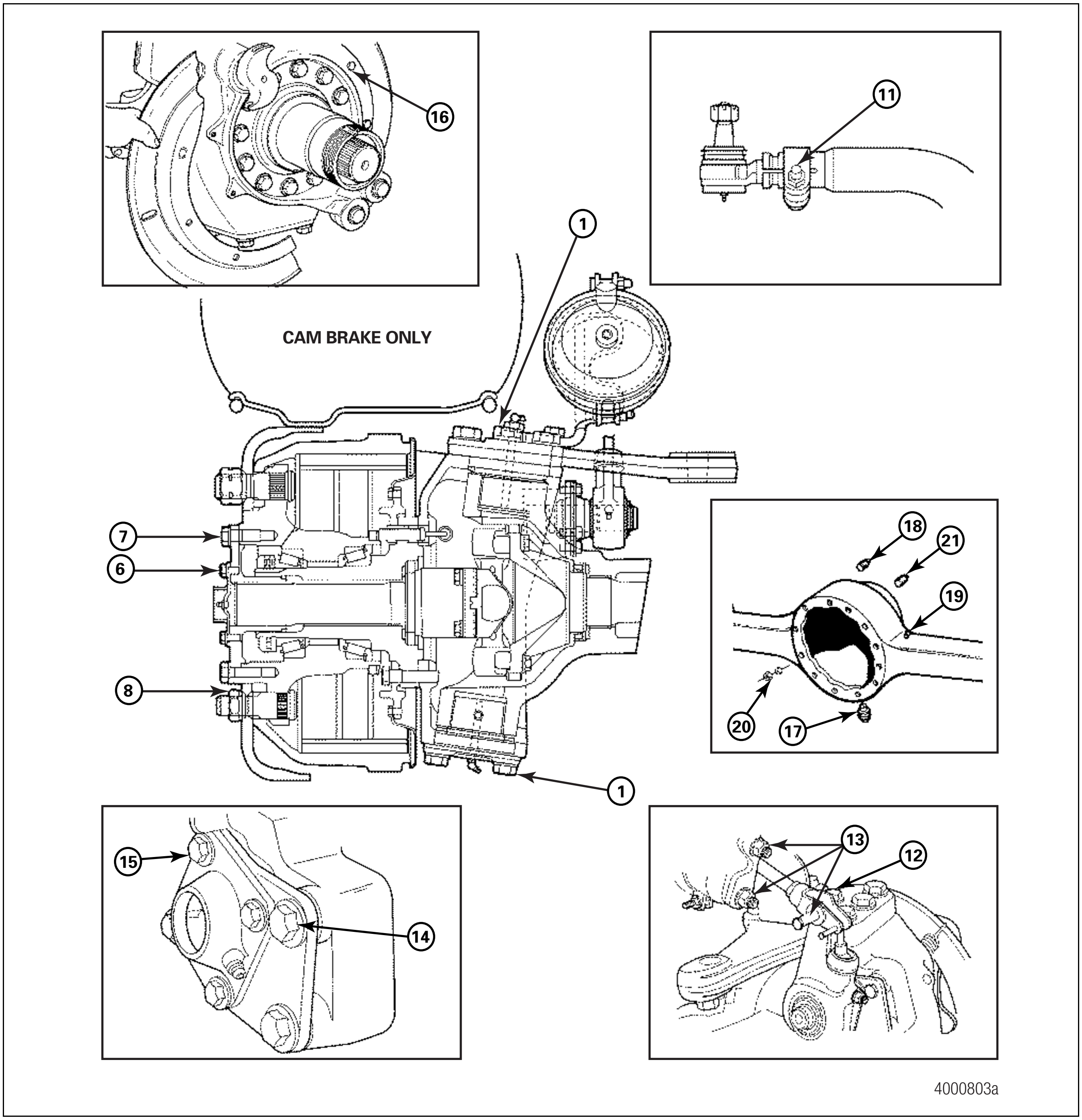


Table I: Cam Brake Fastener Torque Chart

Item	Fastener	Thread Size (Inches)	Wrench Torque Lb-Ft	Wrench Torque N•m
1	Upper Knuckle Cap	3/4-10	310-400	420-542
	Lower Knuckle Cap	1-8	775-1000	1052-1355
2	Steering Arm Nut	1-1/4-12	775-1050 (initial)	1050-1424
			1450 (after assembly)	1965
3	Steering Arm Ball Nut	7/8-14	160-215 (initial)	217-292
			300 (after assembly)	407
4	Drum Mounting Flathead Screw	1/2-13	15-30	20-41
5	Spindle and Brake Attachment Capscrew	5/8-11	180-230	244-312
6	Hubcap	3/8-16	35-50	47-68
7	Drive Flange	5/8-11	180-230	244-312
8	Wheel Nut	1-1/8-16	Refer to manufacturer's specifications.	
		1-3/16-12		
9	Stop Screw Jam Nut	3/4-10	180-230	244-312
10	Tie Rod End Nut	7/8-14	160-215 (initial)	217-292
			300 (after assembly)	407
11	Tie Rod Clamp Sleeve Adjuster Locknut	5/8-11	80-90	108-122
12	Brake Chamber Bracket Capscrew	5/8-11	180-230	244-312
13	Brake Chamber Attachment Nut	5/8-11	100-115	136-156
14	Camshaft Retainer Bracket Capscrew	1/2-13	90-120	122-163
15	Camshaft Retainer Self-Tapping Screw	3/8-16	35-50	47-68
16	Dust Shield Attachment Capscrew	3/8-16	35-50	47-68
17	Housing Drain Plug	3/4-14	25 minimum	34
18	Heat Indicator	3/4-14	25 minimum	34
19	Breather Assembly	3/8-18	20 minimum	27
20	Carrier Bolts	5/8-11	185-235	251-319
		5/8-18	210-270	285-366
21	Housing Oil Fill Plug	3/4-14	35 minimum	47.5

NOTE: The correct torque must be reached on steering arms. Torques below minimum will not seat the tapers correctly and will reduce service life.

Meritor Heavy Vehicle Systems, LLC
2135 West Maple Road
Troy, MI 48084 USA
800-535-5560
arvinmeritor.com

Printed in USA

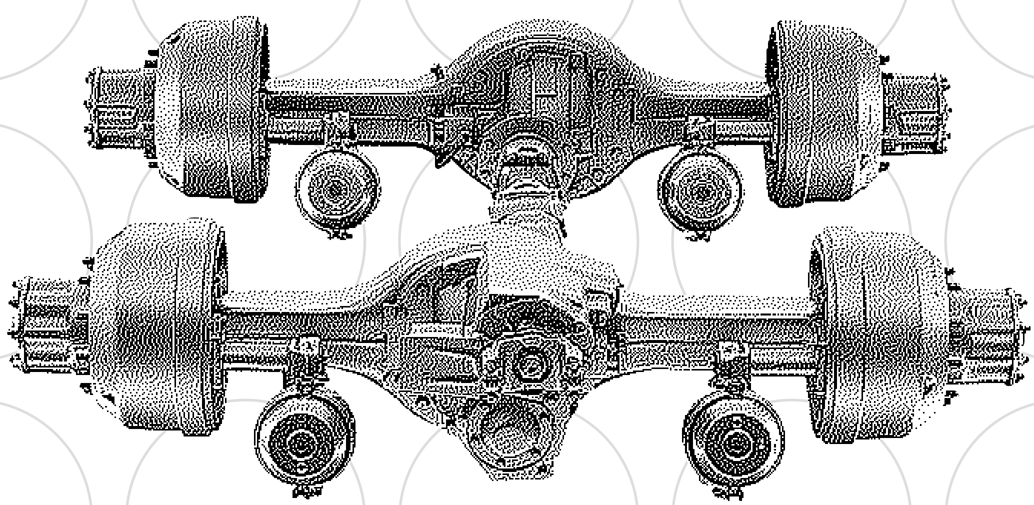
Revised 10-07
Maintenance Manual 12 (16579/22882)

MERITOR®

Maintenance Manual 5L

Single-Reduction Forward Differential Carriers on Tandem and Tridem Axles

Revised 11-06



About This Manual

This manual provides maintenance and service information for the Meritor forward tandem drive axles, including the RT-140; -144; -145; -149; -160; -169; RZ-166; -186 and -188 Series models.

Before You Begin

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Hazard Alert Messages and Torque Symbols

WARNING

A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.

CAUTION

A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components.

This symbol alerts you to tighten fasteners to a specified torque value.

How to Obtain Additional Maintenance and Service Information

On the Web

Visit Literature on Demand at meritorhvs.com to access product, service, aftermarket, and warranty literature for ArvinMeritor's truck, trailer and specialty vehicle components.

ArvinMeritor's Customer Service Center

Call ArvinMeritor's Customer Service Center at 800-535-5560.

Technical Electronic Library DVD

The DriveTrain Plus™ by ArvinMeritor Technical Electronic Library DVD contains product and service information for most Meritor and Meritor WABCO products. Specify TP-9853.

How to Obtain Tools and Supplies Specified in This Manual

Call ArvinMeritor's Commercial Vehicle Aftermarket at 888-725-9355 to obtain Meritor tools and supplies.

SPX Kent-Moore, 28635 Mound Road, Warren, Michigan, 48092. Call the company's customer service center at 800-345-2233, or visit their website at spxkentmoore.com.

Kiene Diesel Accessories, Inc., 325 S. Fairbanks Street, Addison, IL 60101. Call the company's customer service center at 800-264-5950, or visit their website at kienediesel.com.

SPX/OTC Service Solutions, 655 Eisenhower Drive, Owatonna, MN 55060. Call the company's customer service center at 800-533-6128, or visit their website at otctools.com.

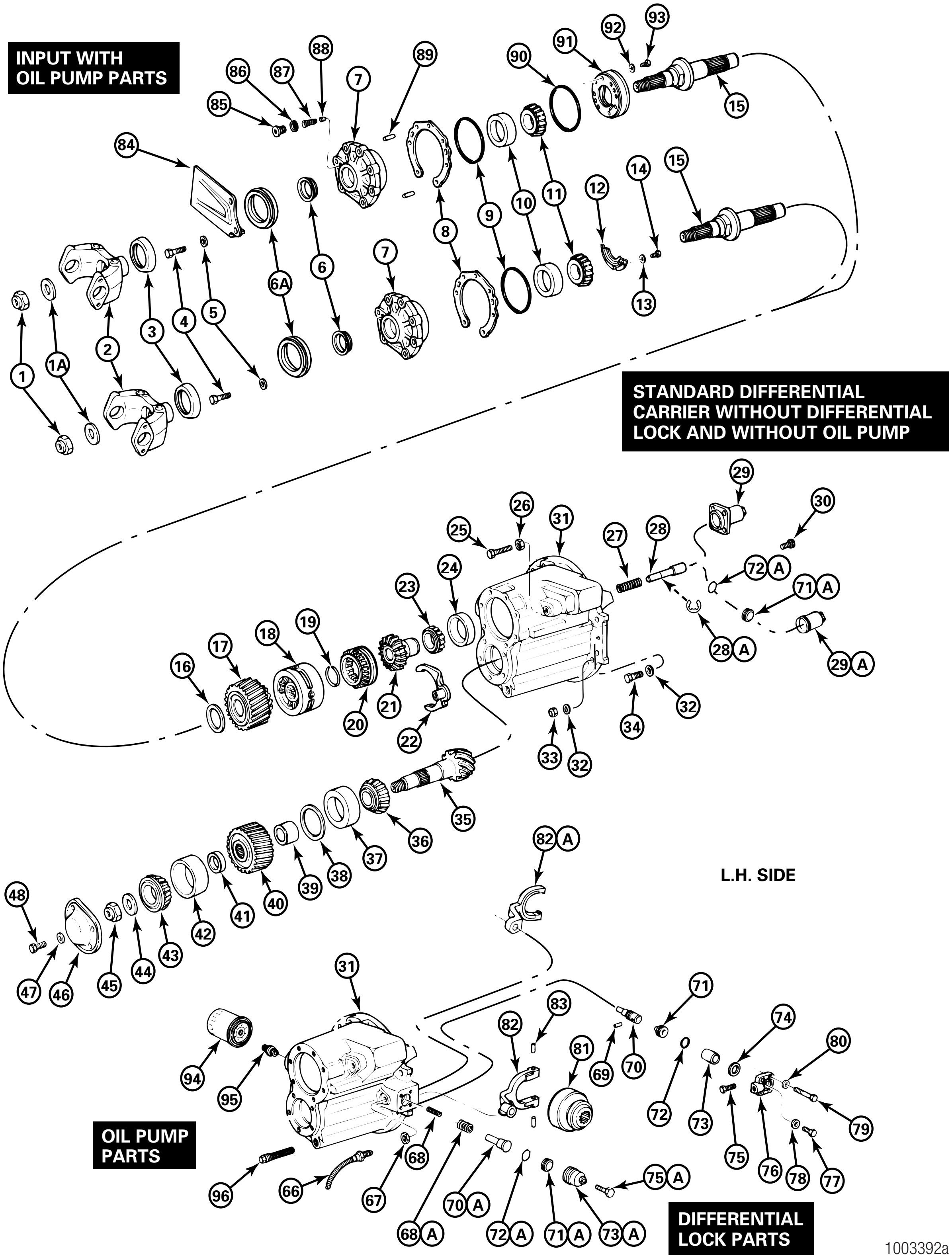
Contents

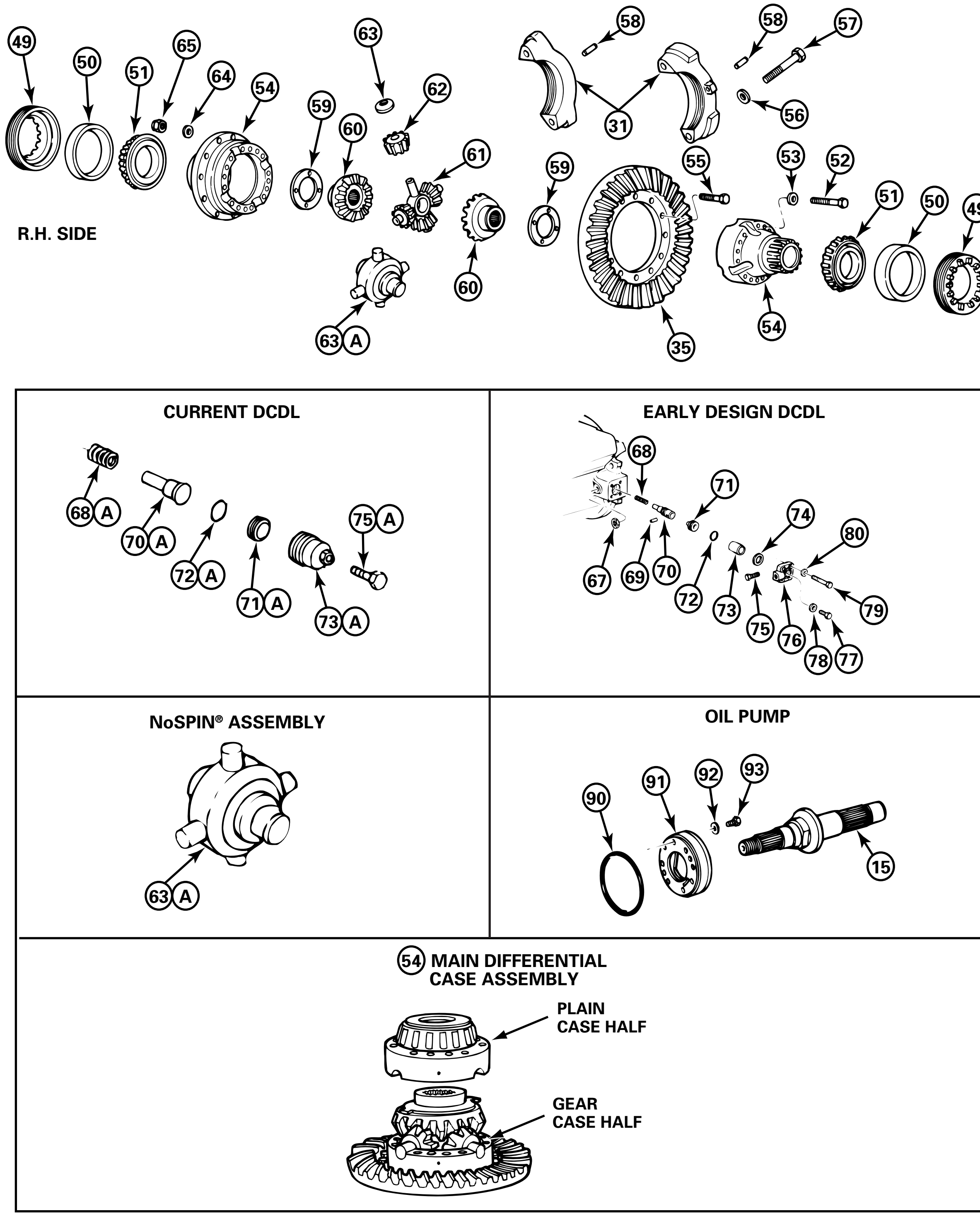
Contents

Single-Reduction Forward Differential Carrier

Item	Description
1	Nut — Input Yoke
1A	Washer — Input Yoke
2	Input Yoke
3	Deflector
4	Capscrew — Cage-to-Carrier
5	Washer — Cage-to-Carrier
6	Oil Seal — Triple-Lip (Main) Seal
6A	POSE™ Seal
7	Input Bearing Cage
8	Shims
9	O-Ring — Input Bearing Cage
10	Bearing Cup — Input Shaft
11	Bearing Cone — Input Shaft
12	Oil Baffle (Units Without Oil Pump)
13	Washer — Oil Baffle
14	Capscrew — Oil Baffle
15	Input Shaft
16	Thrust Washer — Helical Drive Gear
17	Helical Drive Gear
18	Inter-Axle Differential Case Assembly
19	Snap Ring — Inter-Axle Differential Case
20	Clutch Collar — Inter-Axle Differential Case
21	Rear Side Gear
22	Shift Fork
23	Bearing Cone — Rear Side Gear
24	Bearing Cup — Rear Side Gear
25	Adjusting Screw — Shift Shaft
26	Jam Nut — Adjusting Screw
27	Spring — Shift Shaft
28	Shift Shaft and Piston
28A	"E" Clip (Reverse Shift IAD Only)
29	Air Shift Chamber Assembly — Bolt-On IAD
29A	Air Shift Chamber Assembly — Screw-In IAD
30	Capscrew — Air Shift Chamber Assembly
31	Differential Carrier and Caps
32	Washer — Differential Carrier-to-Axle Housing
33	Nut — Differential Carrier-to-Axle Housing
34	Capscrew — Differential Carrier-to-Axle Housing
35	Ring Gear and Drive Pinion
36	Inner Bearing Cone — Drive Pinion
37	Inner Bearing Cup — Drive Pinion
38	Shims
39	Inner Spacer
40	Helical Driven Gear
41	Outer Spacer
42	Outer Bearing Cup — Drive Pinion
43	Outer Bearing Cone — Drive Pinion
44	Washer — Drive Pinion
45	Nut — Drive Pinion
46	Cover — Drive Pinion
47	Washer — Drive Pinion Cover
48	Capscrew — Drive Pinion Cover
49	Bearing Adjusting Ring
50	Cup — Main Differential Bearing
51	Cone — Main Differential Bearing
52	Capscrew — Main Differential Case Halves
53	Washer — Main Differential Case Halves
54	Main Differential Case Assembly
55	Bolt — Ring Gear (145 and 160 Series)
56	Washer — Differential Bearing Cap
57	Capscrew — Differential Bearing Cap
58	Roll Pin, Cotter Pin or Capscrew — Differential Bearing Cap
59	Thrust Washer — Main Differential Side Gear
60	Side Gear — Main Differential
61	Spider — Main Differential
62	Pinion Gear — Main Differential
63	Thrust Washer — Main Differential
63A	NoSPIN® Main Differential*
64	Washer — Ring Gear (145 and 160 Series)
65	Nut — Ring Gear (145 and 160 Series)
66	Sensor Switch — Main Differential Lock
67	Locknut — Main Differential Lock Sensor Switch (Early Design)
68	Spring — Main Differential Lock
68A	Spring — Main Differential Lock — Current Design
69	Lock Pin — Spring Retaining (Early Design)
70	Shift Shaft — Main Differential Lock
70A	Shift Shaft — Main Differential Lock — Current Design
71	Piston — Main Differential Lock
71A	Piston — Main Differential Lock — Current Design
72	O-Ring — Piston
72A	O-Ring — Piston — Current Design
73	DCDL Cylinder — Shift Shaft
73A	DCDL Cylinder — Shift Shaft — Current Screw-In DCDL Design
74	Copper Gasket — Cover (160 Series)
75	Capscrew — Manual Engaging
75A	Capscrew — Manual Engaging — Current Design
76	Cover — Main Differential Lock (Early Design)
77	Plug — Manual Engaging (Early Design)
78	Washer — Manual Engaging Capscrew
79	Capscrew — Cover (Early Design)
80	Washer — Cover (Early Design)
81	Shift Collar — Main Differential Lock
82	Shift Fork — Main Differential Lock
82A	Shift Fork — Main Differential Lock — Current Design
83	Roll Pin — Shift Fork (Early Design)
84	Oil Filter Shield
85	Plug — Oil Pressure Relief Valve
86	Washer — Oil Pressure Relief Valve
87	Spring — Oil Pressure Relief Valve
88	Oil Pressure Relief Valve
89	Dowel — Input Cage to Oil Pump (Early Design)
90	O-Ring — Oil Pump
91	Oil Pump
92	Washer — Oil Pump
93	Capscrew — Oil Pump
94	Oil Filter
95	Adapter — Oil Filter
96	Oil Screen and Plug Assembly

* NoSPIN® is a registered trademark of Tractech, a division of Dyneer Corp.


INPUT WITH
OIL PUMP PARTS
STANDARD DIFFERENTIAL
CARRIER WITHOUT DIFFERENTIAL
LOCK AND WITHOUT OIL PUMP
L.H. SIDE
OIL PUMP
PARTS
DIFFERENTIAL
LOCK PARTS
1003392a


49
50
51
65
64
54
63
59
60
62
61
58
31
58
57
56
59
55
53
52
51
50
49
R.H. SIDE
60
63 A
35
54
CURRENT DCDL
68 A
70 A
72 A
71 A
73 A
75 A
EARLY DESIGN DCDL
68
71
74
80
67
69
70
72
73
75
76
78
77
79
NoSPIN® ASSEMBLY
63 A
OIL PUMP
90
91
92
93
15
54 MAIN DIFFERENTIAL CASE ASSEMBLY
PLAIN CASE HALF
GEAR CASE HALF

1002701c

Description

Forward Tandem Axle

The inter-axle differential is located behind the helical gear on the input shaft. The forward side gear of the inter-axle differential is part of the upper helical gear hub. The thru-shaft is splined to the rear side gear of the inter-axle differential. Figure 2.1.

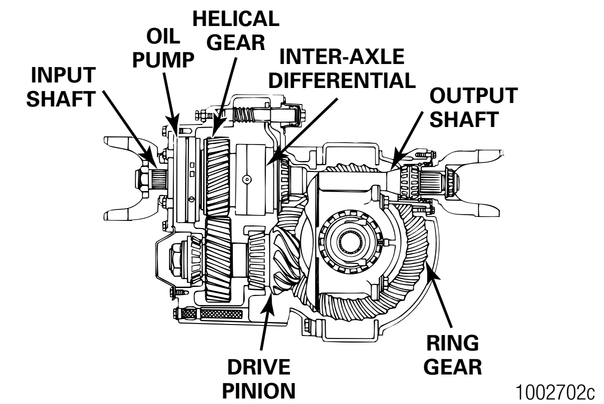


Figure 2.1

The Meritor 140, 145 and 160 forward tandem axles use a single-reduction, thru-drive carrier. The drive gearing is a two-helical gear train and a hypoid ring gear and pinion. Bevel gears are used in the main differential and the inter-axle differential. Figure 2.1 and Figure 2.2.

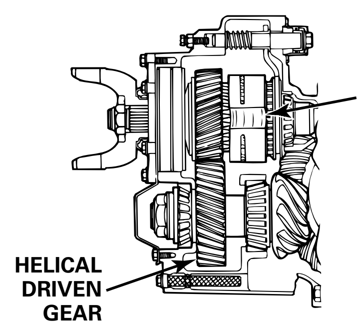


Figure 2.2

Axle Models Covered in This Manual

Tandem Models		
RT-34-140	RT-40-145P	RT-46-160
RT-34-144	RT-40-149	RT-46-160EH
RT-34-145	RT-40-160	RT-46-160P
RT-34-145P	RT-40-169	RT-46-169
RT-40-140	RT-44-145	RT-50-160
MT-40-143	RT-44-145P	RT-50-160P
RT-40-145	RT-46-16H EH	RT-52-160P
RT-40-145A		
Tridem Models		
RZ-166	RZ-186	RZ-188

NOTE: For service procedures on rear carriers, refer to Maintenance Manual 5, Single-Reduction Differential Carriers, for models preceding RS-, RT- and RF-Series, and Maintenance Manual 5A, Single-Reduction Differential Carriers, for MX-, RS-, RT- and RF-Series. To obtain these publications, refer to the Service Notes page on the front inside cover of this manual.

Optional Pressurized Lubrication System

The forward axles can be equipped with an optional pressurized lubrication system. This filtered system has an oil pump driven by the input shaft. The pump circulates lubricant to the journals in the forward and rear input shaft bearings and directly to the inter-axle differential.

Optional Driver-Controlled Main Differential Lock (DCDL)

Both the forward and rear axles can be equipped with an optional driver-controlled main differential lock (DCDL). The differential lock is operated by an air-actuated shift unit located on the forward axle carrier.

- When the differential lock is activated, the shift collar moves along the splines of the axle shaft toward the differential case.
- When the collar splines engage with the splines on the differential case, the axle shaft and the differential assembly lock together.
- When the carrier operates with the DCDL in the locked position, there is no differential action between the wheels.
- When the carrier is operated in the unlocked position, there is normal differential action between the wheels at all times.

Inter-Axle Main Differential (IAD)

The Meritor inter-axle differential (IAD) is a driver-controlled, air-actuated traction device. The IAD allows for speed differences between the forward and rear axles in a tandem while also providing equal pulling power from each axle of the tandem. By activating the IAD switch located in the vehicle dash, improved traction is provided for each axle.

The inter-axle differential is also known as a power divider or third differential.

Stall-Testing Can Damage a Drive Axle

Stall-testing is a procedure used to troubleshoot transmissions, evaluate vehicle performance, and test the service and park brakes.

During stall-testing, or any similar procedure, the drive axle input receives multiplied torque, which can exceed the specified torque rating. Excessive torque can damage a drive axle, which will affect axle performance and component life. A drive axle damaged by stall-testing will void Meritor's warranty.

Call ArvinMeritor's Customer Service Center at 800-535-5560 if you have questions regarding stall-testing.

Use of Traction Chains

Meritor recommends that if you are using traction chains, you should install chains on both tires on each side of all drive axles on the vehicle.

Identification

Model Number

An identification tag is riveted on the axle housing or on the differential carrier. Figure 2.3 and Figure 2.4. Use the model number and the ratio number marked on the identification tag and the number on the carrier to order replacement parts.

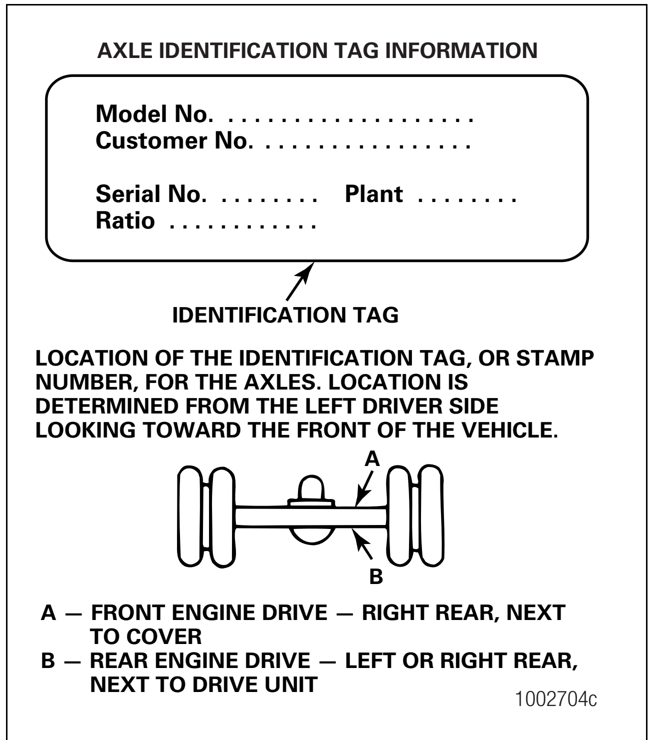


Figure 2.3

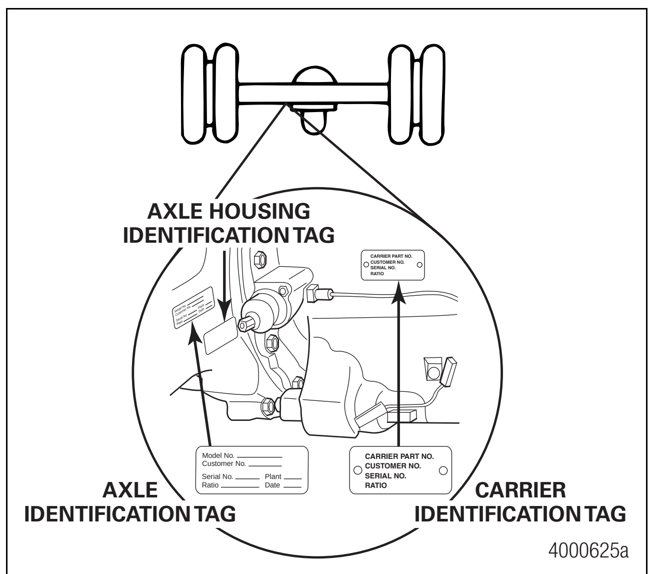


Figure 2.4

Refer to Figure 2.5 for an explanation of the model number.

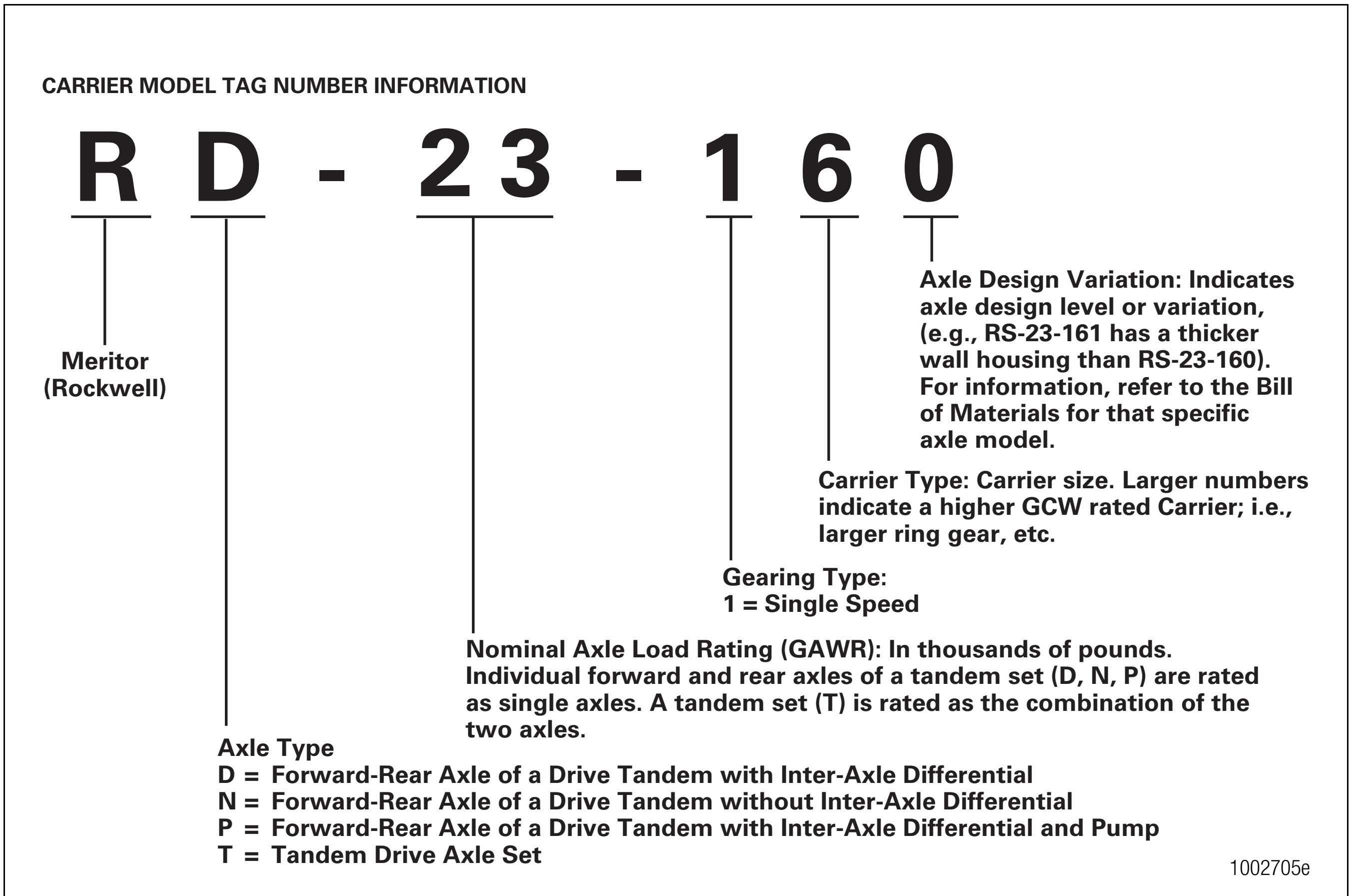


Figure 2.5

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Use a brass or synthetic mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off. Serious personal injury and damage to components can result.

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

Removal

Axle Shaft Removal Methods

Use Special Tools Recommended by Meritor

To help prevent serious personal injury and damage to components when you remove the axle shaft from the housing, Meritor recommends that you use the following tools in the table below. Refer to the Service Notes page at the front inside cover of this manual for information on how to contact the manufacturers to obtain the tools.

- **If the tools are not available when you remove the axle shaft:** Follow procedures for using the Brass Drift Method or the Air Vibration Method.

Tool	Part Number	Manufacturer
Axle Shaft Remover	K-1280	Kiene Diesel Accessories, Inc.
Axle Stud Cone Plier	7077	SPX OTC

Brass Drift Method

⚠ WARNING

Do not strike the round driving lugs on the flange of an axle shaft. Pieces can break off and cause serious personal injury.

1. Hold a 1-1/2-inch diameter brass drift or brass hammer against the center of the axle shaft, inside the round driving lugs. Figure 3.1.

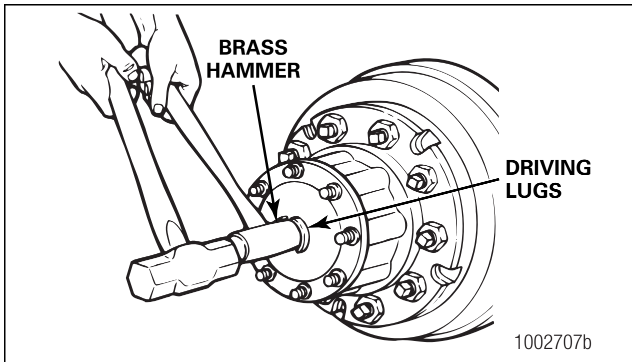


Figure 3.1

2. Strike the end of the drift with a large hammer, five to six pounds, and the axle shaft and tapered dowels will loosen.
3. Mark each axle shaft before it is removed from the axle assembly.
4. Remove the tapered dowels and separate the axle shafts from the main axle hub assembly. Figure 3.2.

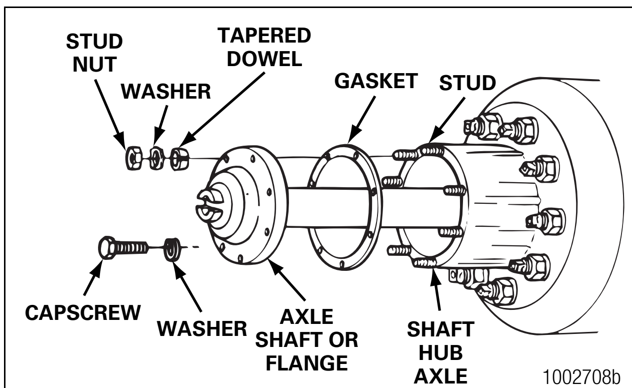


Figure 3.2

5. Install a cover over the open end of each axle assembly hub where an axle shaft was removed.

Air Hammer Vibration Method

WARNING
Wear safe eye protection when using an air hammer. When using power tools, axle components can loosen and break off causing serious personal injury.

CAUTION
Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. Using a chisel or wedge can result in damage to the axle shaft, the gasket and seal, and the axle hub.

1. Use a round hammer bit and an air hammer to loosen the tapered dowels and axle shaft.
2. Place the round hammer bit against the axle shaft or flange between the hub studs. Operate the air hammer at alternate locations between the studs to loosen the tapered dowels and axle shaft from the hub. Figure 3.3.

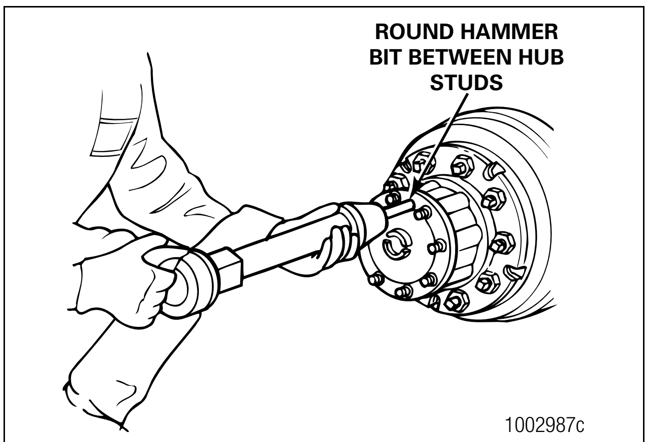


Figure 3.3

3. Mark each axle shaft before it is removed from the axle assembly.
4. Remove the tapered dowels and separate the axle shaft from the main axle hub assembly. Figure 3.2.

Axle Shafts from the Axle Housing

WARNING
Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip or fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Set the parking brake.
2. Use a jack to raise the vehicle so that the wheels to be serviced are off the ground. Support the vehicle with safety stands.
3. Remove the oil drain plug from the bottom of the axle housing. Drain the axle lubricant from the housing assembly.
4. For axles with an oil pump, remove the oil filter shield from the input bearing cage.
5. Use a filter strap wrench to remove the oil filter. Be careful that the oil inside does not spill when removing the filter. Discard the filter. Figure 3.4.

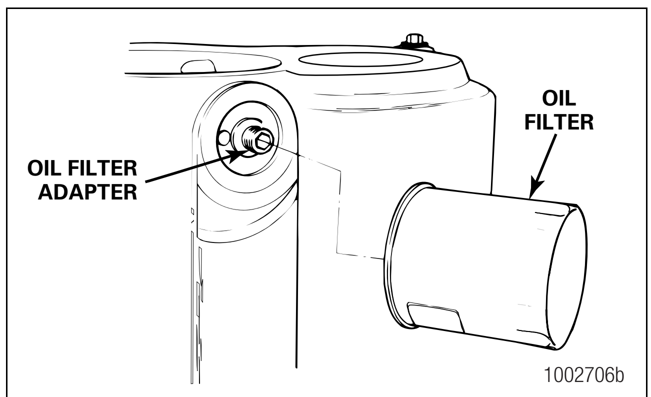


Figure 3.4

6. Inspect the oil filter adapter threads.
   - **If the adapter threads are damaged:** Remove and replace the oil filter adapter.

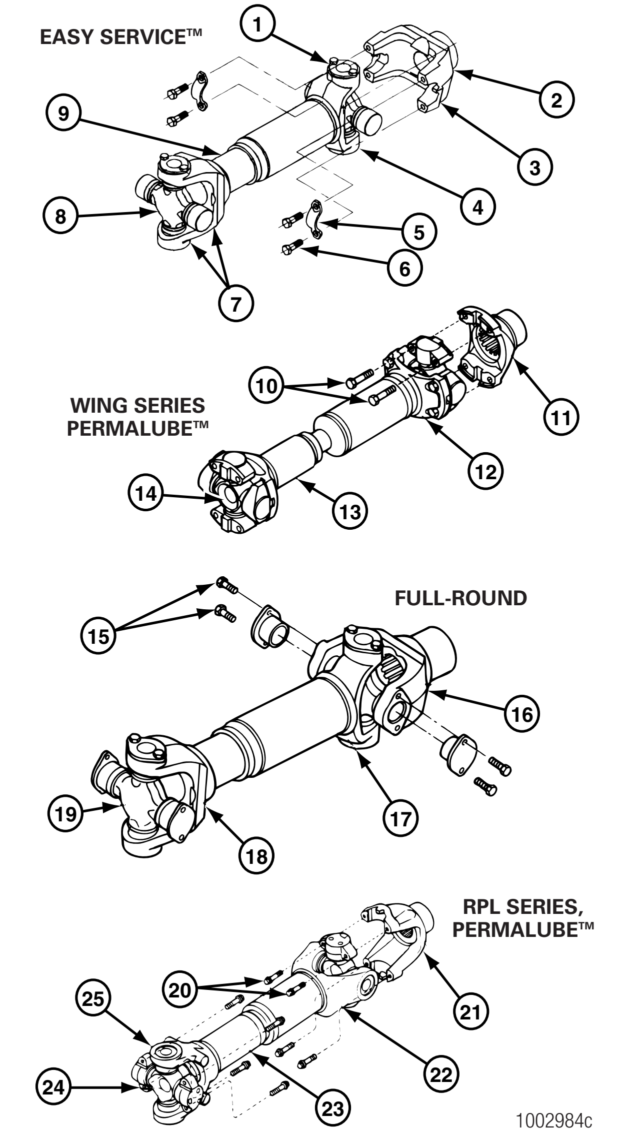
7. On an axle with a driver-controlled main differential lock, shift the lock into and hold the lock in the locked or engaged position. The locked position provides enough clearance between the shift collar and the axle housing for carrier removal. Refer to Section 6.

   An alternate method to obtain clearance is to remove the cover of the air shift unit from the differential carrier. Remove the piston. Remove the shift shaft and spring from the fork. The fork and the clutch collar will fall into the carrier and the carrier can be removed. Remove the fork and the clutch collar after the carrier is removed.

8. Disconnect the driveline universal joint from the pinion input yoke or flange on the carrier. Figure 3.5.

9. Remove the capscrews and washers or stud nuts and washers, if equipped, from the flanges of both axle shafts.

10. Loosen the tapered dowels, if equipped, in the axle flanges of both axle shafts using one of the following methods. Refer to the procedures in this section.



1	FULL-ROUND BEARING CUPS	14	U-JOINT CROSS
2	END YOKE	15	CAPSCREWS
3	YOKE SADDLE	16	END YOKE
4	WELD YOKE	17	WELD YOKE
5	BEARING STRAP	18	SLIP YOKE
6	CAPSCREWS	19	U-JOINT CROSS
7	EASY SERVICE™ BEARING CUPS	20	CAPSCREWS
8	U-JOINT CROSS	21	END YOKE
9	SLIP YOKE	22	SLIP YOKE
10	CAPSCREWS	23	TUBING
11	END YOKE	24	U-JOINT CROSS
12	WELD YOKE	25	WELD YOKE
13	SLIP YOKE		

Figure 3.5

Thru-Shaft

1. Disconnect the forward and rear drive shafts.

⚠ CAUTION

Always use a flange or yoke bar during removal and installation of the flange yoke nut to prevent damage to the gearing.

2. Attach a flange bar to the flange or place a yoke bar over the input or output yoke to hold the yoke or flange while you remove the pinion nut. Figure 3.6. Refer to Section 10 to make a yoke bar.

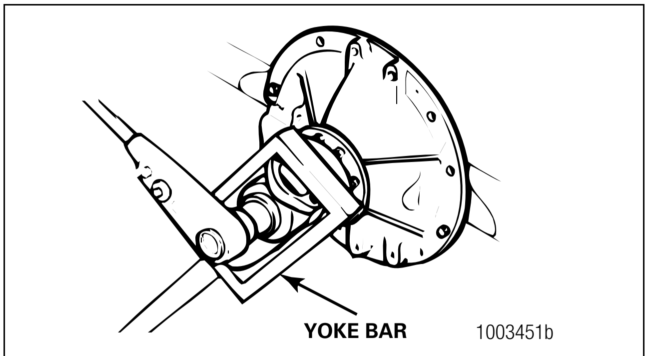


Figure 3.6

3. Disconnect the air lines at the inter-axle differential shift unit.
4. Remove the thru-shaft nut, washer and yoke or flange. Use a puller tool to remove the yoke or flange from the shaft. Figure 3.7.

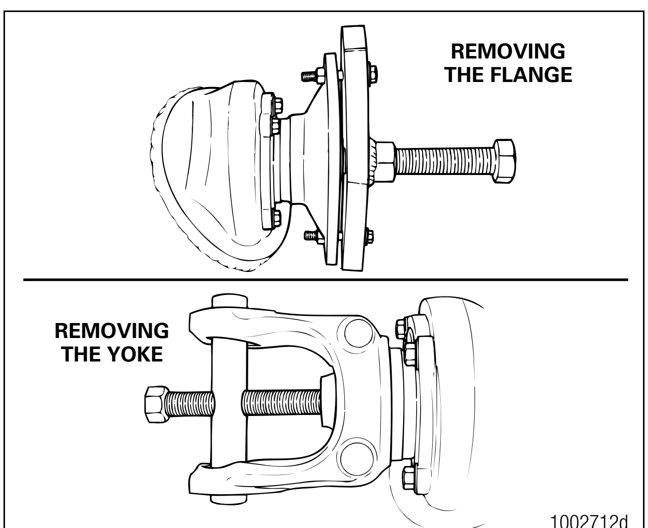


Figure 3.7

5. Remove the thru-shaft bearing cage capscrews and washers.
6. Pull the bearing cage, bearings and shaft assembly from the axle housing. If necessary, loosen the cage from the housing with a soft mallet. Figure 3.8.

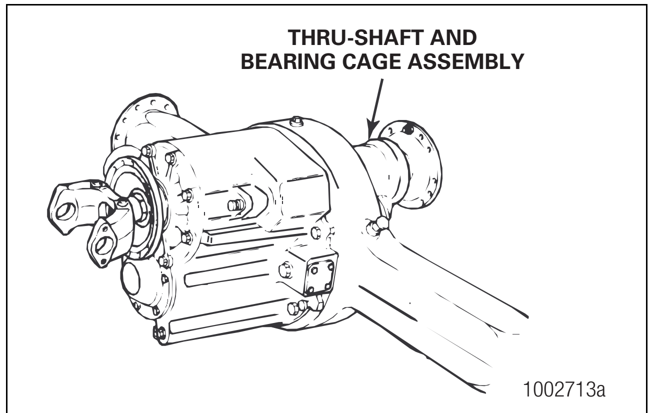


Figure 3.8

Differential Carrier from the Axle Housing

1. Place a hydraulic roller jack under the differential carrier to support the assembly. Figure 3.9.

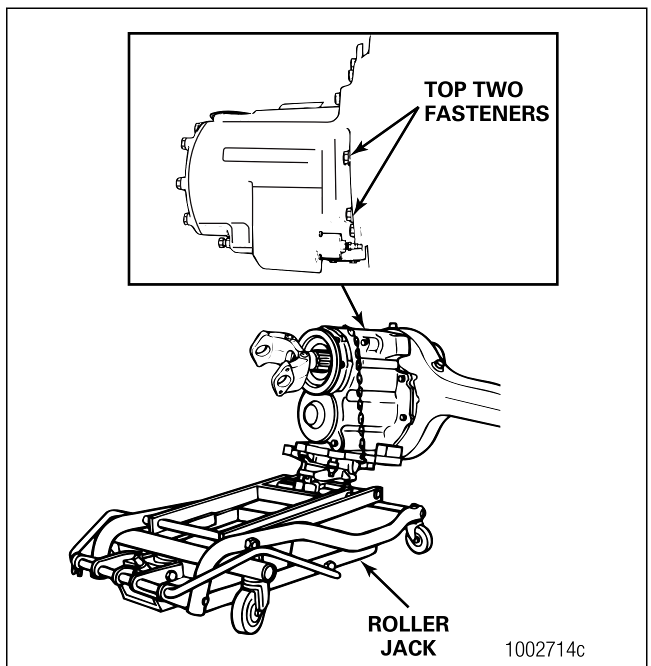


Figure 3.9

2. Remove all but the top two carrier-to-housing capscrews or stud nuts and washers. Figure 3.9.

3. Loosen, but do not remove, the top two carrier-to-housing fasteners. The fasteners will hold the carrier in the housing.
4. Loosen the differential carrier in the axle housing. Use a plastic mallet to hit the carrier mounting flange at several points.
5. After the carrier is loosened, remove the top two stud nuts and washers that hold the assembly in the axle housing.

CAUTION
When using a pry bar, be careful not to damage the carrier or housing flange. Damage to these surfaces will cause oil leaks.

6. Use the hydraulic roller jack to remove the carrier from the axle housing. Use a pry bar that has a round end to help remove the carrier from the housing.
7. On axles with a driver-controlled main differential lock, if air pressure is used to shift the differential to the locked or engaged position, release the air pressure. Disconnect the air hose from the shift unit.

NOTE: A carrier stand is available from SPX Kent-Moore. Refer to the Service Notes page on the front inside cover of this manual to obtain the stand.

8. Use a lifting tool to lift the differential carrier by the input yoke or flange and place the assembly in a repair stand. Do not lift by hand. Refer to Section 10 to make a carrier repair stand. Figure 3.10.

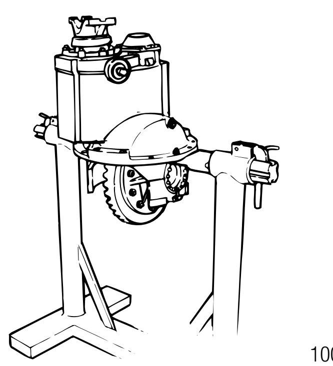


Figure 3.10

Disassembly

Thru-Shaft and Output Bearing Cage Assembly

1. Remove and discard the original oil seal. Use a new triple-lip or main oil seal when the carrier is assembled. Figure 3.11.

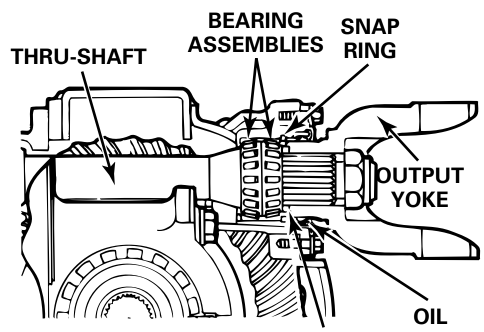


Figure 3.11

NOTE: If you replace either the bearing cup or the cone, replace both parts in a fully-matched set from the same manufacturer.

2. Remove the external snap ring or yoke-to-cone spacer from the thru-shaft.
3. Remove the internal snap ring that holds the bearing cup in the output cage. Figure 3.12.

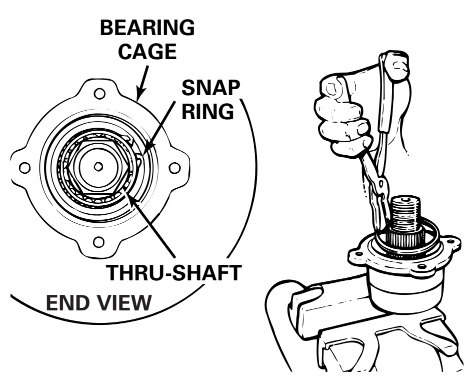


Figure 3.12

NOTE: When you press the thru-shaft from the cage, the inner cup remains in the cage. The outer cup is removed with the thru-shaft and the cones.

4. If necessary, remove the thru-shaft and the bearing cones as an assembly from the output bearing cage.
   A. Place the thru-shaft and the output bearing cage in a press. Figure 3.13.
   B. Press the thru-shaft and cones from the bearing cage.
   C. Remove the outer cup from the thru-shaft.

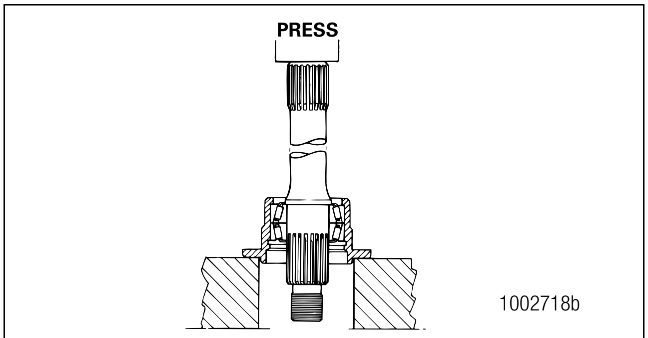


Figure 3.13

5. Use a press or a bearing puller to remove the bearing cones from the thru-shaft. Refer to the procedure in this section.

Removal

Bearing Cone from the Thru-Shaft

Press Method

1. Place a used bearing cup on the inner bearing cone.
2. Place the thru-shaft into a press. Figure 3.14. The used bearing cup supports the thru-shaft.

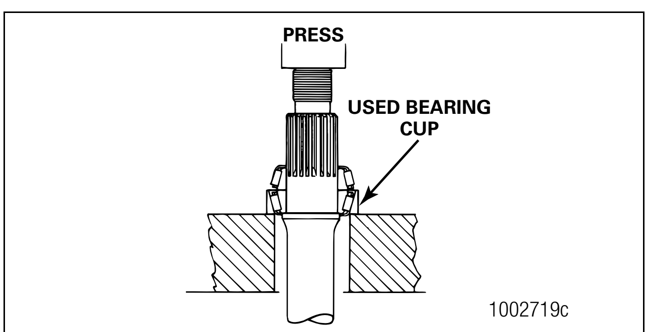


Figure 3.14

3. Press the thru-shaft through the bearing cones. Discard the bearing cones.

Bearing Puller Method

1. Place a used bearing cup on the inner bearing cone.
2. Install a bearing puller tool onto the thru-shaft. Figure 3.15. The bearing cup supports the thru-shaft.

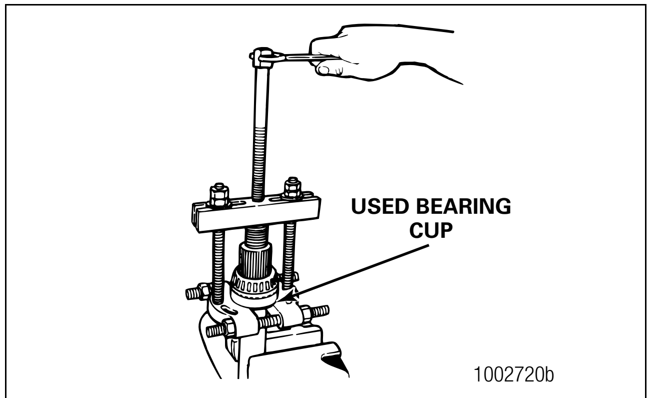


Figure 3.15

3. Remove the bearing cones from the thru-shaft. Discard the bearing cones.
4. If necessary, use a brass drift and hammer to carefully tap the inner cup from the cage. Discard the cup. Figure 3.16.

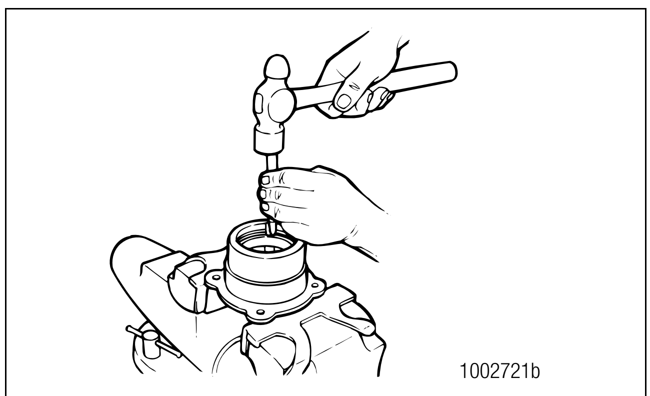


Figure 3.16

Measure Ring Gear Backlash

Before the carrier is disassembled, use a dial indicator to measure and record ring gear backlash at three locations on the ring gear. This will help you to correctly reassemble the ring gear and drive pinion.

1. Rotate the carrier in the stand to access the ring gear teeth.
2. Install a dial indicator onto the flange of the carrier. Place the tip of the indicator against the drive side of a ring gear tooth. Adjust the dial indicator to ZERO. Figure 3.17.

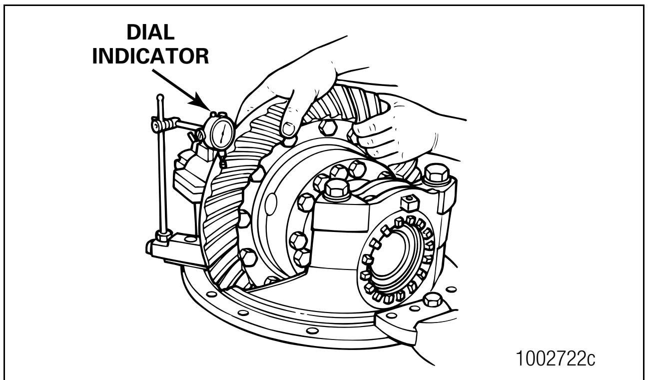


Figure 3.17

3. Read the dial indicator while you slightly rotate the ring gear in both directions. When you rotate the ring gear to measure the backlash, the drive pinion must not move. Record the reading on the dial indicator.
4. Repeat the procedure at two more locations on the ring gear.
   - **If the smallest of the three measurements is not 0.008-0.018-inch (0.20-0.46 mm) for 145 Series or 0.010-0.020-inch (0.25-0.51 mm) for 160 Series:** Replace the ring gear and drive pinion as a set.

Input Shaft and Inter-Axle Differential Assembly

1. Rotate the carrier in the stand to access the input shaft.
2. Remove the capscrews and the washers that fasten the drive pinion cover to the differential carrier. Remove the cover. Remove all gasket material from the cover and the differential carrier. Figure 3.18.

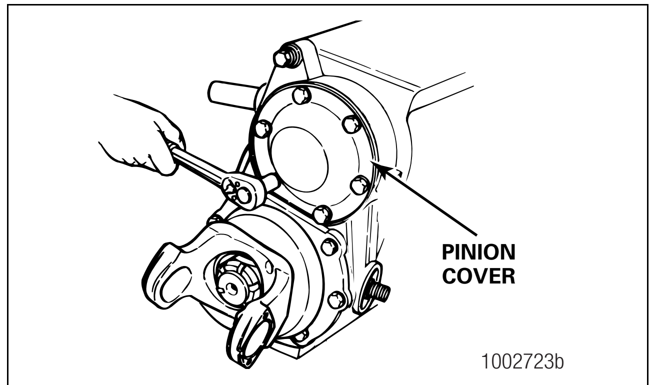


Figure 3.18

3. Use the correct tool to hold the input yoke or flange. Loosen, but do not remove, the drive pinion nut. Figure 3.19.

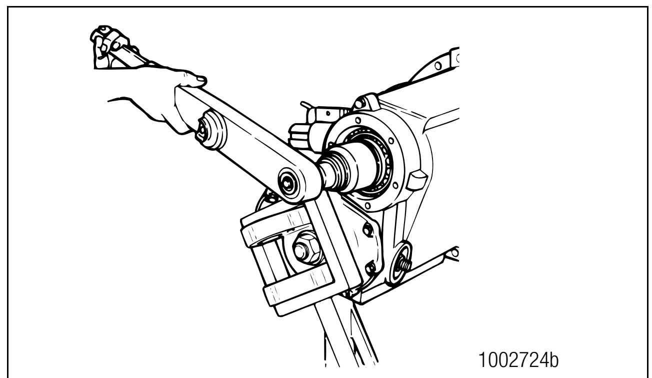


Figure 3.19

4. Use the correct tool to hold the input yoke or flange. Loosen, but do not remove, the nut that fastens the yoke or flange to the input shaft. Figure 3.20.

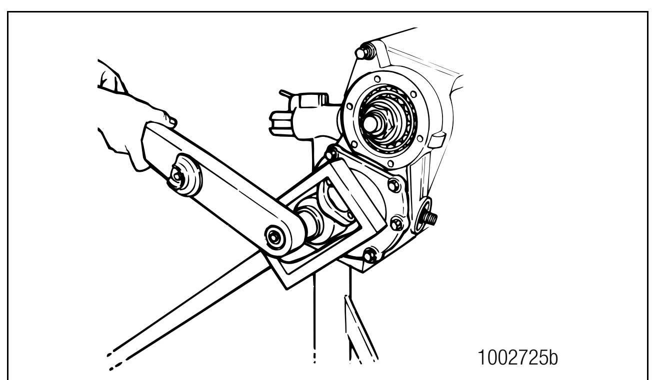


Figure 3.20

5. Remove the capscrews and washers that fasten the input bearing cage to the differential carrier. Figure 3.21.

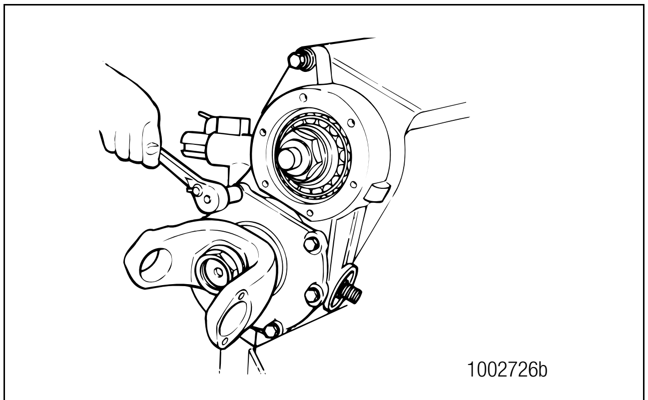


Figure 3.21

6. Rotate the carrier in the stand until the yoke or flange is on top. Connect a lifting device to the input yoke.

NOTE: Paint alignment marks on the helical drive gear and the helical driven gear before you remove the input shaft assembly from the carrier. This will ensure exact reassembly for the original mesh of the mated gears.

7. Paint alignment marks on the helical drive gear and the helical driven gear.
   - **For a driven gear:** Paint the ends of two adjacent teeth.
   - **For a drive gear:** Paint the top land of the matching tooth and guide it into the two painted teeth of the driven gear.

⚠ CAUTION

On all 160 Series carriers and 145 Series carriers manufactured before September 1998, there are two notches on the side of the inter-axle differential case. One of the notches on the case must be aligned with the helical driven gear. If the notch is not aligned over the gear, the gear will prevent the removal of the input shaft assembly and cause damage to the assembly.

8. Remove the input shaft, oil pump, if used, and inter-axle differential from the carrier.
   A. Lift the input shaft assembly until the bearing cage is separated from the carrier. If necessary, tap on the bearing cage with a brass or plastic mallet to separate the cage from the carrier. Figure 3.22.
   B. For 160 Series carriers and 145 Series carriers manufactured after September 1998, slowly lift the input shaft assembly.
      - **If the input shaft assembly comes out of the carrier easily:** Remove the assembly.
      - **If the input shaft assembly cannot be removed easily:** The inter-axle differential case must be rotated. Rotate the input shaft until one of the notches on the case is aligned over the helical driven gear. Remove the input shaft assembly from the carrier. Figure 3.23 and Figure 3.24.
   C. Place the input shaft assembly on a bench.

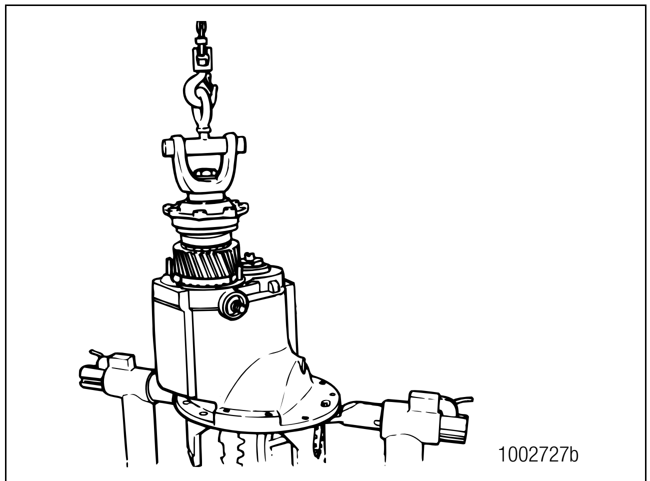


Figure 3.22

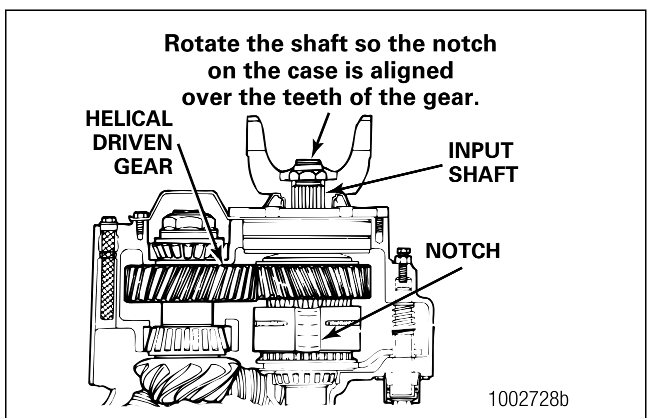


Figure 3.23

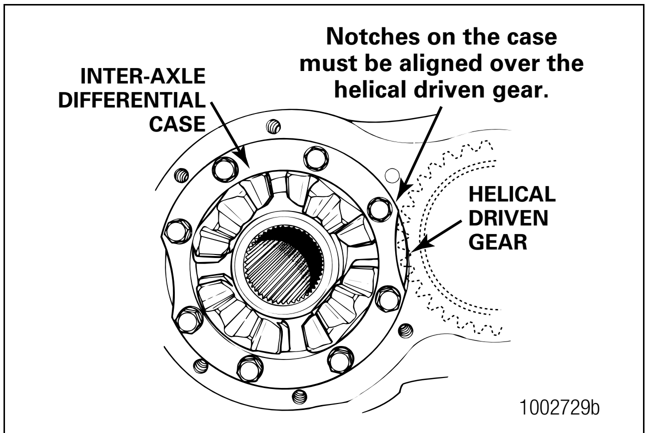


Figure 3.24

9. Remove the shims from between the bearing cage and the differential carrier.
10. Remove the rear side gear and the bearing cone from the carrier. Remove the collar. Figure 3.25.

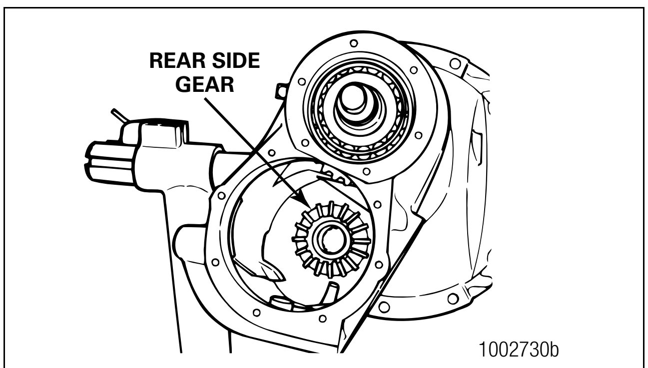


Figure 3.25

NOTE: If you replace either the bearing cup or the cone, replace both parts in a fully-matched set from the same manufacturer.

11. Use a press, sleeve and bearing puller to remove the cone from the rear side gear. Figure 3.26.

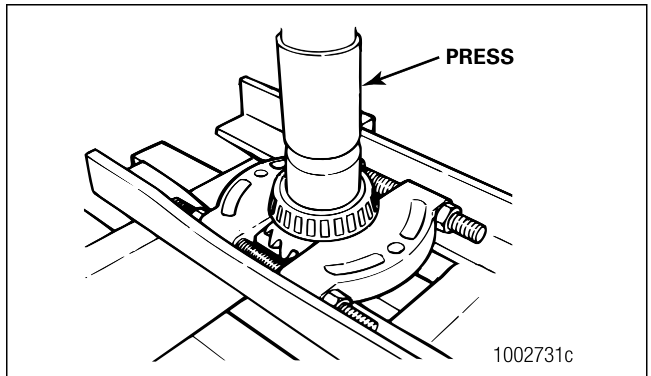


Figure 3.26

12. Use a brass drift and hammer to remove the cup of the rear side gear cone from the differential side of the carrier.

Disassembly

Input Shaft, Bearing Cage, Oil Pump and Inter-Axle Differential

1. Use the correct tool to remove the yoke or flange from the input shaft. Figure 3.27. If the carrier is not equipped with an oil pump, remove the bearing cage from the input shaft. Figure 3.28.

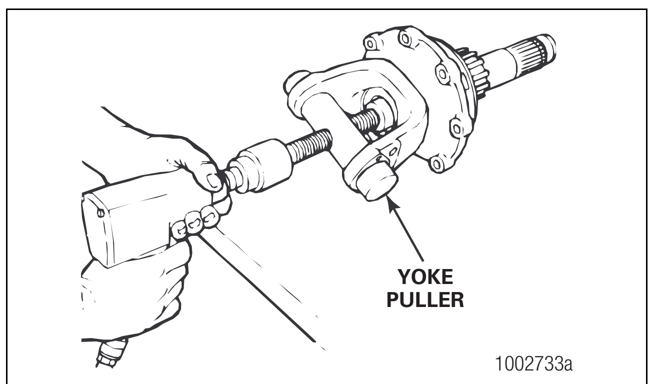
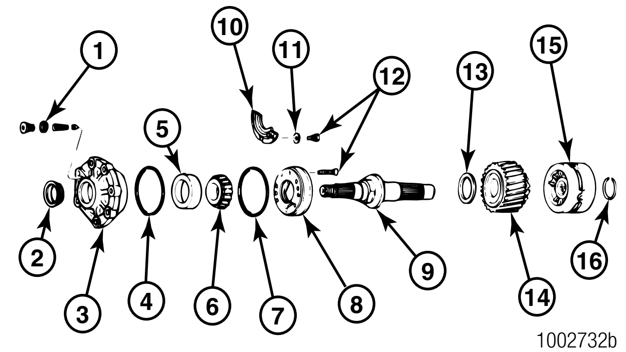


Figure 3.27



1	PRESSURE RELIEF VALVE ASSEMBLY	9	INPUT SHAFT
2	OIL SEAL	10	OIL BAFFLE — UNITS WITHOUT OIL PUMP
3	BEARING CAGE	11	WASHER
4	O-RING	12	CAPSCREWS
5	BEARING CUP	13	THRUST WASHER
6	BEARING CONE	14	HELICAL DRIVE GEAR
7	O-RING	15	INTER-AXLE DIFFERENTIAL
8	OIL PUMP — UNITS WITH OIL PUMP	16	SNAP RING

Figure 3.28

⚠ CAUTION

Carefully remove the pinion seal from the yoke or carrier. Do not damage the seal bore when you remove the seal. Damage to components can result.

NOTE: Meritor recommends replacing all seals with the triple-lip or main oil seal. The addition or replacement of a POSE™ seal is also highly recommended.

2. Pry under the oil seal flange to remove the oil seal from the input bearing cage. Discard the oil seal. Figure 3.29.

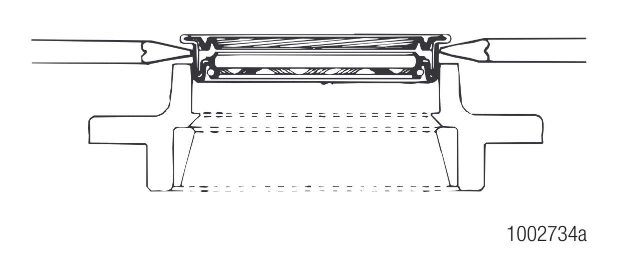


Figure 3.29

3. Remove the snap ring that fastens the inter-axle differential assembly to the input shaft. Remove the inter-axle differential assembly from the input shaft. Figure 3.30.

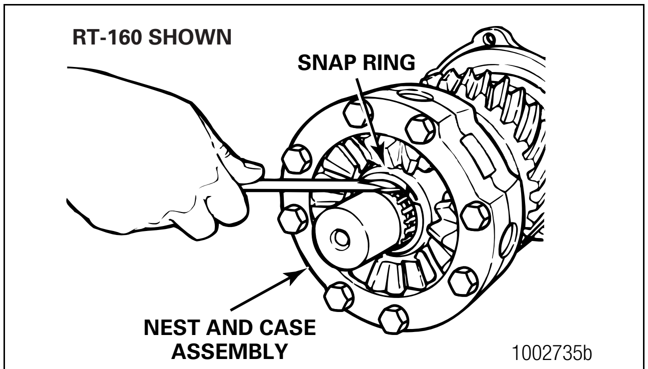


Figure 3.30

NOTE: Disassemble the bolted inter-axle differential and inspect the components. The welded inter-axle differential is serviced as an assembly and cannot be disassembled.

4. Disassemble the bolted inter-axle differential case. Inspect the components. Replace any damaged components.
   A. Use a punch and hammer to place an alignment mark on each half of the inter-axle differential case. The alignment marks will help you mate the case halves correctly during assembly. Figure 3.31.
   B. Remove the capscrews that fasten the case halves of the inter-axle differential. Separate the case halves.
   C. Remove the spider assembly from the case halves. Remove the four pinion gears and the four thrust washers from the spider.

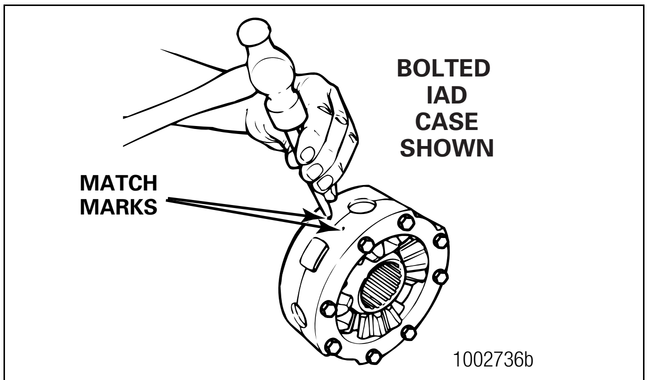


Figure 3.31

5. Remove the helical drive gear from the input shaft. Remove the thrust washer from the gear. Figure 3.32.

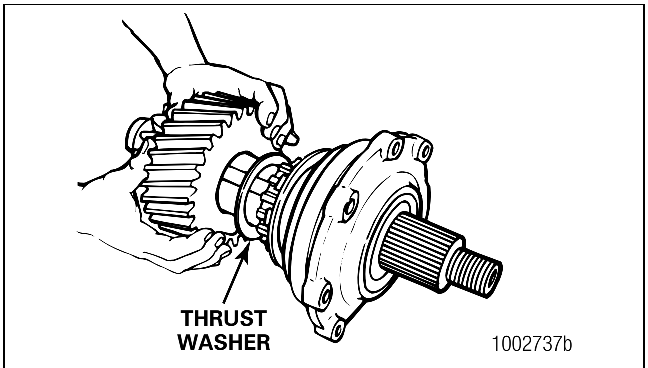


Figure 3.32

⚠ CAUTION

If the following procedure is not followed, the oil pump or the bearing cage will be damaged during removal. Never apply direct pressure to the surface of the pump or the bearing cage.

6. If an oil pump is used, remove the input bearing cage and the oil pump from the input shaft.
   A. Place a bearing puller under the oil pump. The rivets on the back of the pump must not touch the bearing puller. The bearing puller provides a level surface so that the shaft can be pressed straight out of the assembly. Figure 3.33.
   B. Place the assembly on a press so that it rests on the puller. Figure 3.34.
   C. Place a protector on top of the threaded part of the shaft. Press the input shaft from the assembly. Remove the bearing puller. Figure 3.34.
   D. Remove the capscrews that fasten the oil pump to the input bearing cage. Separate the oil pump from the cage. Figure 3.35.
   E. If the pump is worn or damaged, replace the pump. If the drive flats or the splines in the pump do not move, replace the pump.

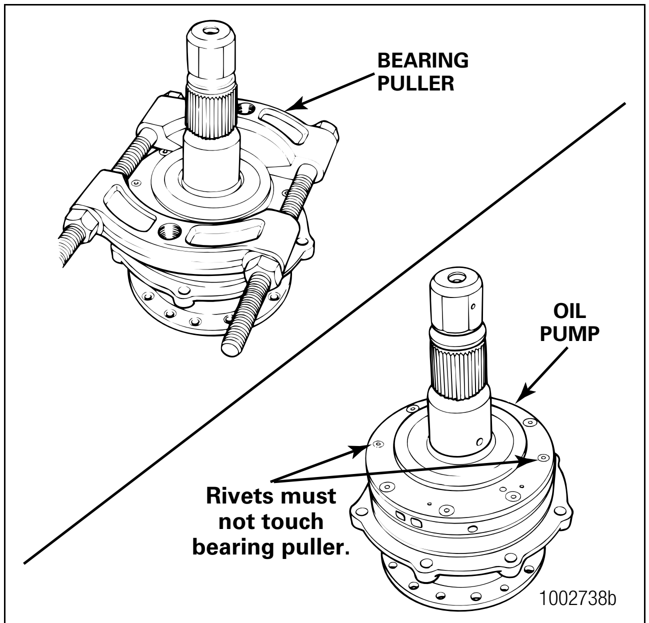


Figure 3.33

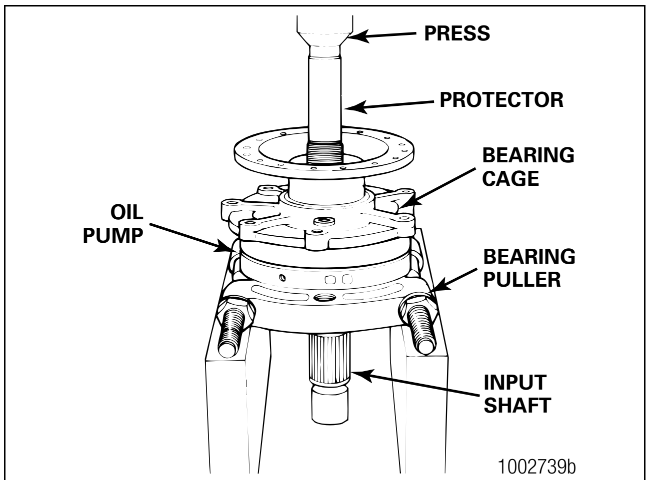


Figure 3.34

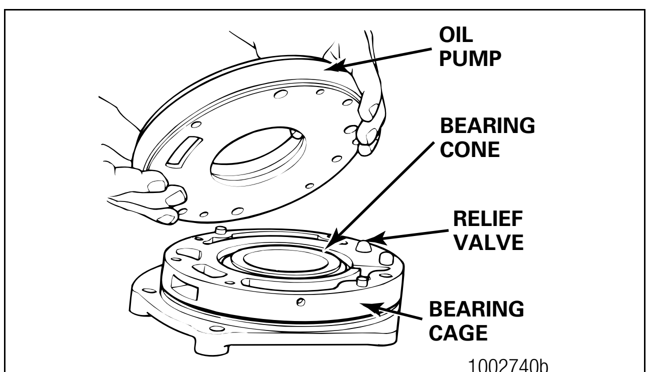


Figure 3.35

7. Remove the O-rings from the bearing cage and, if used, the oil pump assembly.
8. Remove the cone from the input bearing cage.

NOTE: If you replace either the bearing cup or the cone, replace both parts in a fully-matched set from the same manufacturer.

9. If necessary, use a press and sleeve to remove the cup from the input bearing cage.
10. If necessary, remove the pressure relief valve assembly from the front of the bearing cage. Remove the plug, spring and relief valve from the bore. Figure 3.36.

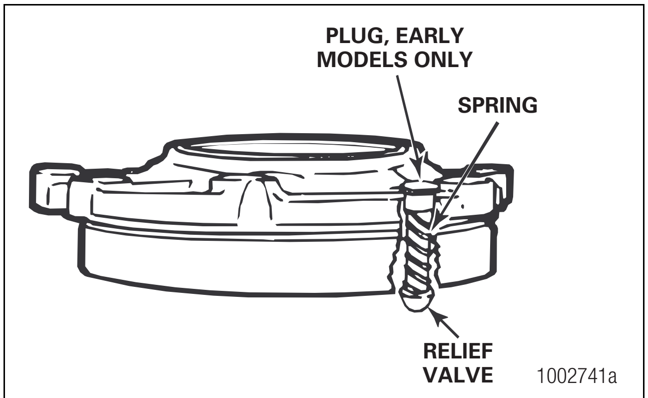


Figure 3.36

11. Remove the oil screen and plug assembly from the suction line at the front of the carrier. Figure 3.37.

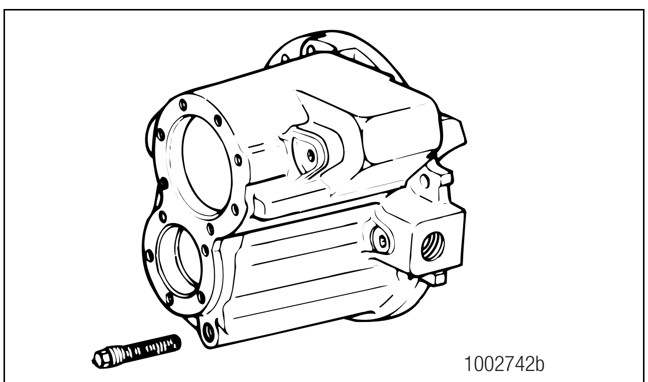


Figure 3.37

12. Clean the oil screen. Refer to Section 4.

Removal

Inter-Axle Differential Lock IAD Shift Unit

Air Applied and Spring Release Models, Standard

1. Remove the cylinder.
   A. For flange-type cylinders, remove the capscrews that fasten the cylinder to the carrier. Remove the cylinder.
   B. For threaded cylinders, remove the cylinder.
2. Remove the piston from the shift shaft. Figure 3.38.

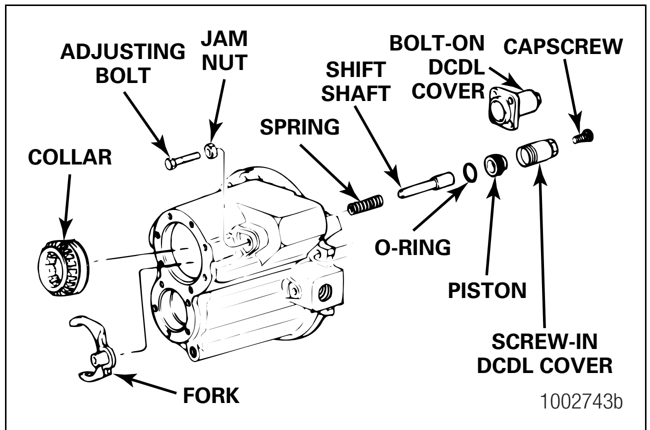


Figure 3.38

3. Remove the shift shaft from the differential carrier. When you remove the shift shaft, the fork and the spring may fall.
   - **If the shift shaft cannot be removed by hand:** Remove the adjusting bolt and jam nut. Place a brass drift through the adjusting bolt hole against the rear of the shift shaft. Use a hammer on the brass drift to remove the shift shaft. Inspect the shift shaft for damage.
4. From the input shaft bore, remove the collar and fork.
5. If necessary, remove the jam nut and the adjusting bolt.

Spring Applied and Air Release Models, Reverse Shifter

1. Remove the four capscrews that fasten the shift cylinder cover to the differential carrier.
2. Remove the two capscrews and washers that fasten the cover to the shift cylinder. Remove the cover and spring. Figure 3.39.

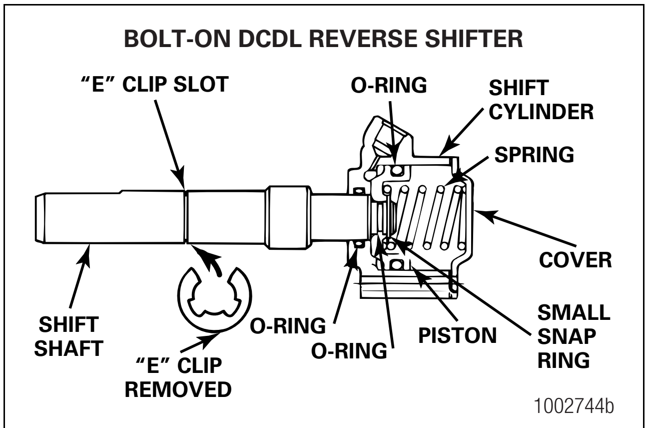


Figure 3.39

3. Remove the small snap ring from the cover end of the shift shaft.
4. Remove the cylinder assembly from the shaft.
5. Rotate the shift shaft until the "E" clip ahead of the shift fork is at approximately the five o'clock position. Figure 3.40.

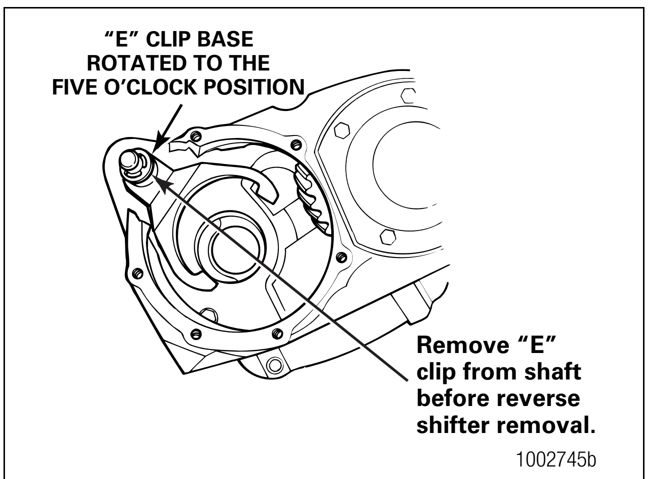


Figure 3.40

6. With the "E" clip base in the five o'clock position, use needlenose vise grips or equivalent to remove the "E" clip.
7. Remove the shift shaft from the carrier. When you remove the shaft, the fork may fall.
8. Remove the piston from the shift cylinder. Inspect the O-rings for wear and damage. Replace the O-rings, if necessary.

Driver-Controlled Main Differential Lock (DCDL)

If the axle is equipped with a driver-controlled main differential lock, refer to Section 6 for removal procedures.

Main Differential Case and Ring Gear Assembly

1. Rotate the carrier in the stand until the ring gear is toward you.
2. Use a punch and hammer to mark the position of each bearing cap on the differential carrier legs. The marks help you correctly match the caps to the carrier legs during assembly. Figure 3.41.

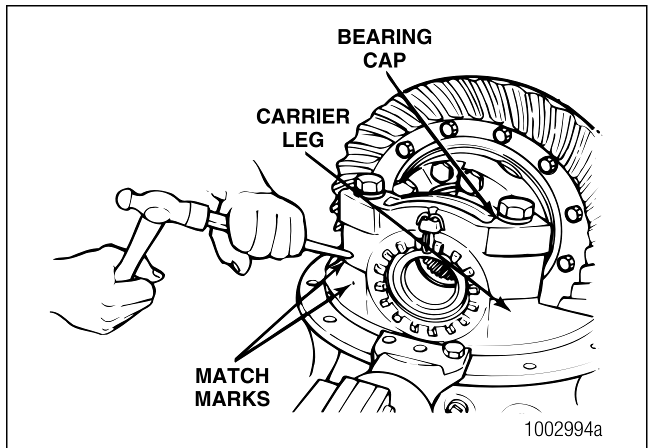


Figure 3.41

3. Remove the capscrews, cotter pins, roll pins or lock plates, if equipped, that hold the bearing adjusting rings in position. Use a small drift and hammer to remove the pins. Each lock plate is held in position by two capscrews. Figure 3.42.

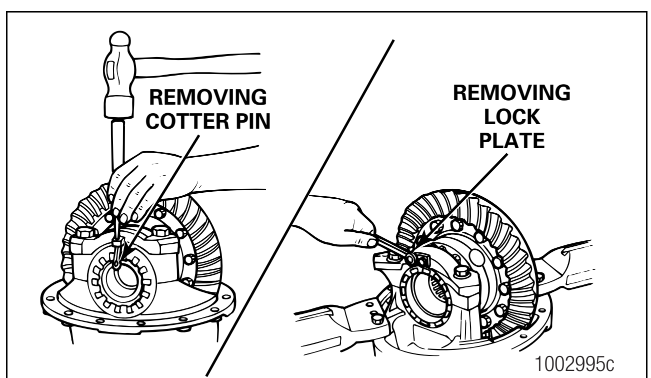


Figure 3.42

⚠ CAUTION

Do not hit the adjusting ring with a hammer. Do not use a hammer and a drift to loosen the adjusting rings. Using these methods will damage the adjusting rings.

4. Use a T-bar wrench or equivalent tool to loosen the adjusting rings. Do not remove the adjusting rings. If necessary, loosen, but do not remove, the capscrews on the bearing caps to move the adjusting rings. Figure 3.43.

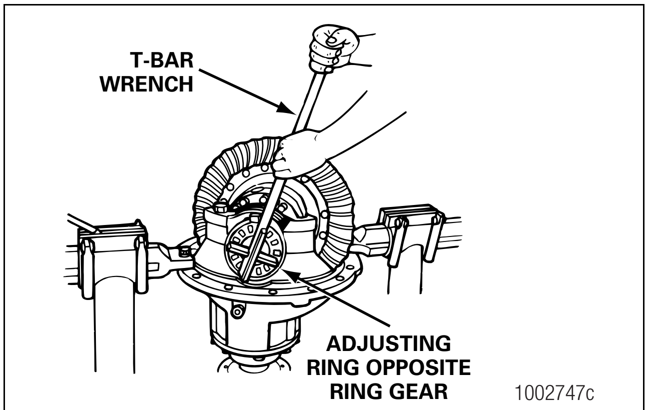


Figure 3.43

5. Remove the capscrews and washers that fasten the bearing caps to the differential carrier. Mark the bearing caps and the carrier to help you correctly assemble the caps into the carrier.

NOTE: Each bearing cap must be installed on the carrier leg from which it was removed. The caps are matched to the carrier legs. Do not mix bearing caps on carrier legs.

6. Remove the bearing caps, adjusting rings and bearing cups from the differential carrier. Figure 3.44.

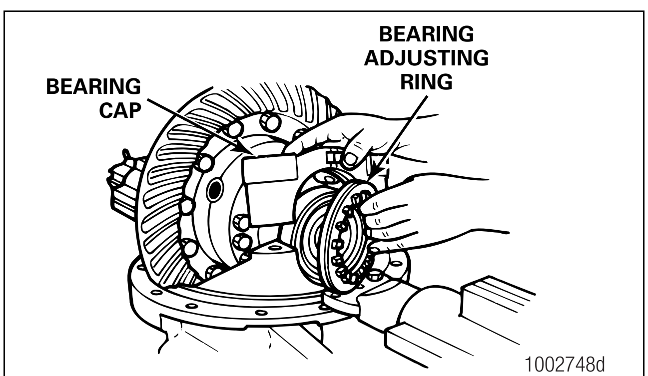


Figure 3.44

7. Use an appropriate lifting device to remove the main differential case and ring gear assembly from the carrier. Figure 3.45.

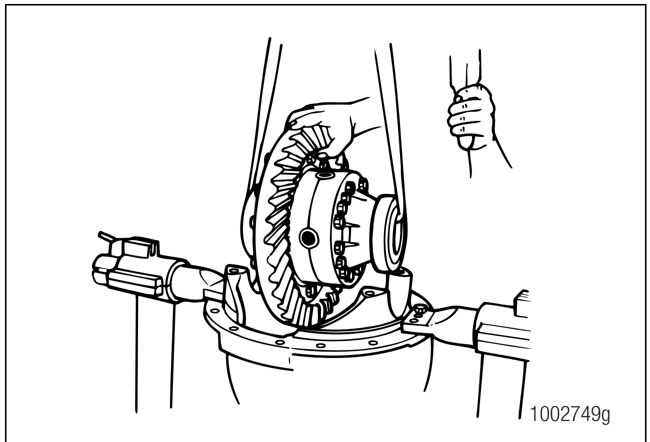


Figure 3.45

NOTE: If you replace either the bearing cup or the cone, replace both parts in a fully-matched set from the same manufacturer. The bearing cones are not interchangeable.

8. If the bearing cones on the main differential case need to be replaced, use a bearing puller to remove the cones. Figure 3.46.

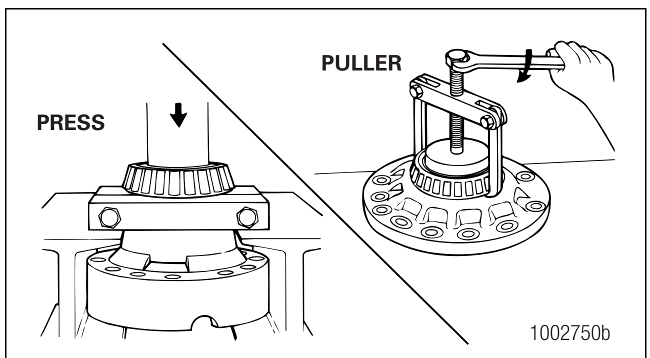


Figure 3.46

Disassembly

Main Differential Case and Ring Gear

1. Use a punch and hammer to mark the case halves. The marks will help you correctly align the case halves during assembly. Figure 3.47.

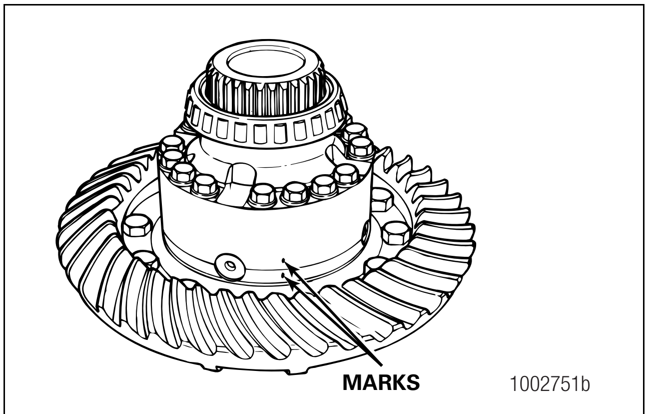


Figure 3.47

2. Remove the capscrews and washers that fasten the halves of the main differential together.
3. Remove the spider, pinions, thrust washers and side gears from the separated case assembly. Figure 3.48.

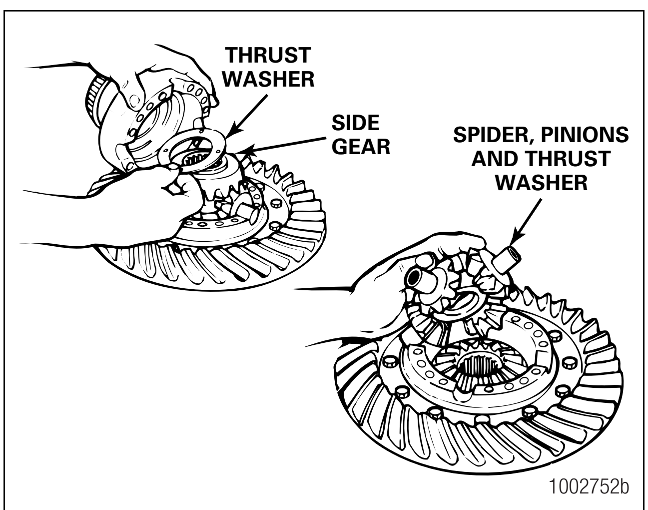


Figure 3.48

Removal

Ring Gear from the Differential Case

1. For 145 and 160 Series axles, remove the bolts, washers and nuts that fasten the ring gear to the differential case.

⚠ CAUTION

Do not remove the rivets or the rivet heads with a chisel and hammer. A chisel and hammer can damage the differential case.

2. For 140 Series axles, remove the rivets that fasten the ring gear to the differential case.
   A. Carefully center-punch each rivet head in the center on the ring gear side of the assembly.
   B. Drill each rivet head on the ring gear side of the assembly to a depth equal to the thickness of one rivet head. Use a drill bit that is 0.0312-inch (0.8000 mm) smaller than the body diameter of the rivets. Figure 3.49.

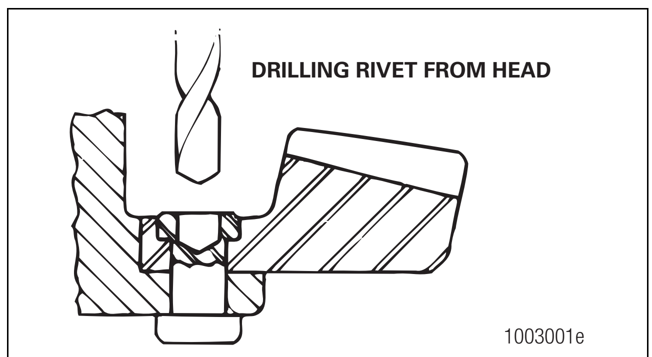


Figure 3.49

   C. Press the rivets through the holes in the ring gear and the differential case. Press on the drilled rivet head.
3. Place the ring gear and case assembly on a press so that the teeth of the gear are toward you. Place supports under the gear.
4. Place a sleeve or a flat metal plate on top of the case. Press the main differential case from the ring gear. Figure 3.50.

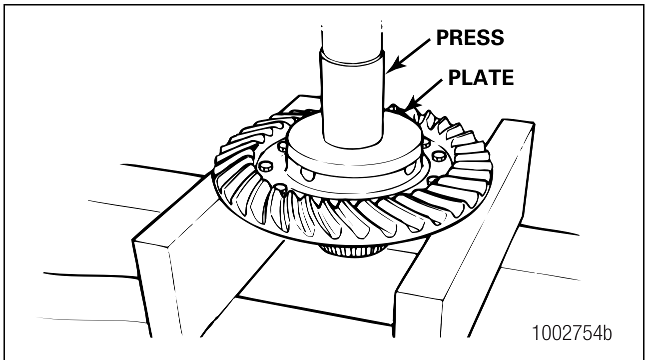


Figure 3.50

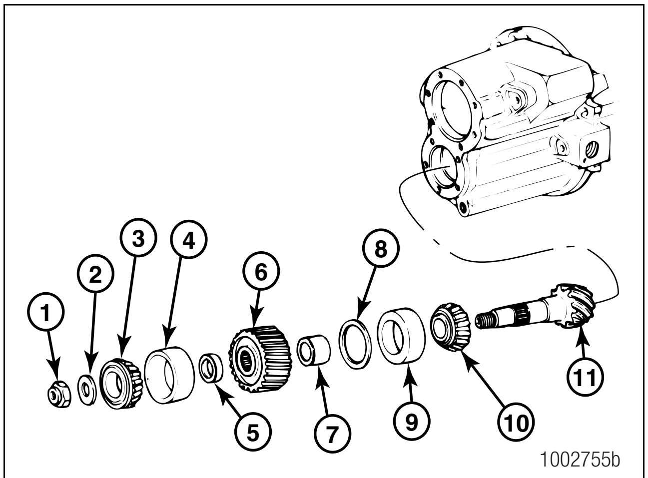
Drive Pinion Assembly

Before You Work on a Differential Carrier

Inspect the hypoid ring gear set for damage. If it is not damaged, you can reuse the ring gear set at assembly. Measure and record the gear set backlash. Figure 3.17. Refer to Measure Ring Gear Backlash in this section.

Assembly Procedures

1. Remove the nut and washer from the drive pinion. You loosened the drive pinion nut when you removed the input shaft assembly. Figure 3.51.



1	NUT	7	INNER SPACER
2	WASHER	8	SHIMS
3	OUTER BEARING CONE	9	INNER BEARING CUP
4	OUTER BEARING CUP	10	INNER BEARING CONE
5	OUTER SPACER	11	DRIVE PINION
6	HELICAL DRIVEN GEAR		

Figure 3.51

2. Remove the drive pinion from the carrier.
   A. Place the differential carrier into a press so that the threaded end of the drive pinion is facing UP. Place supports under the carrier mounting flange.
   B. Place a protector onto the top of the drive pinion shaft. Figure 3.52.

⚠ CAUTION

The drive pinion must not fall on the floor when the drive pinion is pressed from the carrier. If the drive pinion falls to the floor, the gear teeth may be damaged.

   C. Press the pinion through the outer bearing cone and the helical driven gear. Remove the drive pinion from the bottom of the carrier.
   D. Remove the outer spacer, outer bearing cone and helical driven gear from the carrier. Remove the inner spacer from the drive pinion.

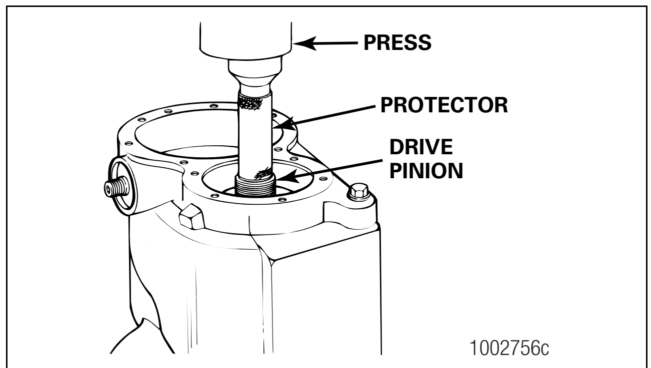


Figure 3.52

NOTE: If you replace either the bearing cup or the cone, replace both parts in a fully-matched set from the same manufacturer.

NOTE: If a new ring gear and drive pinion are being installed, the inner bearing cup must be removed to change the shim pack between the cup and the carrier.

3. If necessary, remove the inner and the outer bearing cups from the carrier. Use a hammer and drift to remove the cups from the carrier. Replace any shims that are damaged. Measure and record the thickness of the shim pack for assembly. Figure 3.53.

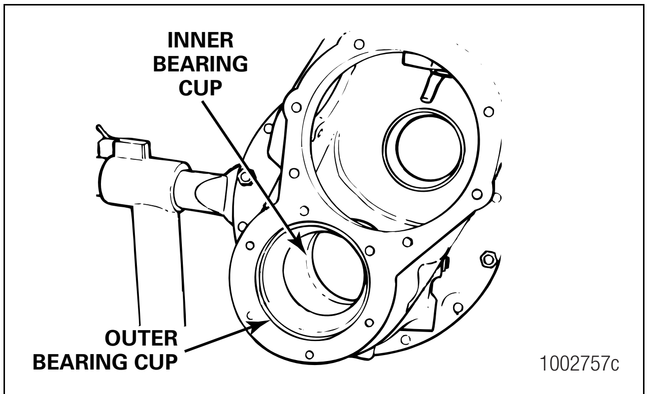


Figure 3.53

4. If necessary, remove the inner bearing cone from the drive pinion. Place a bearing puller under the inner race to support the bearing. Place a protector on top of the pinion shaft and press the drive pinion out of the bearing cone. Figure 3.54.

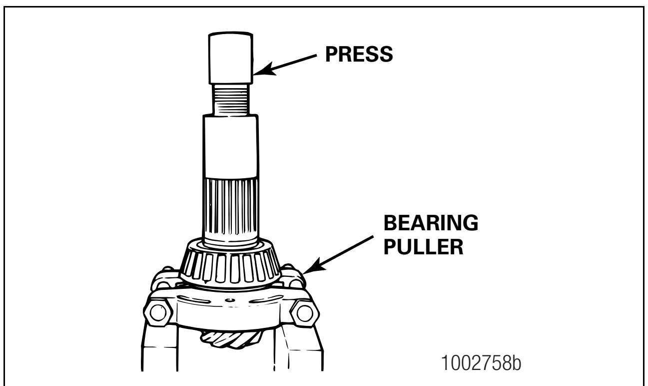


Figure 3.54

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin. If Loctite® adhesive material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Clean, Dry and Inspect Parts

Clean and Inspect Yokes

CAUTION

Do not install a press-on shaft excluder or POSE™ seal after you install a unitized pinion seal. The use of a POSE™ seal will prevent correct seating of the unitized pinion seal on the yoke and will result in lubricant leakage at the seal. POSE™ seal installation is recommended only for triple-lip and other previous design seals.

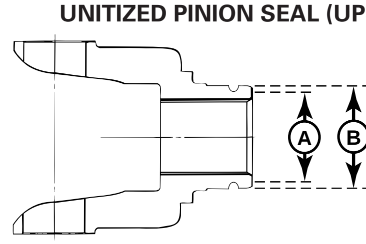
Do not use thin metal wear sleeves to refresh the yoke surface. Wear sleeves pressed onto the yoke will prevent correct seating of the pinion seal and damage the pinion seal assembly. Wear sleeve usage will cause the seal to leak.

1. Clean the ground and polished surface of the yoke journal using a clean shop towel and a safe cleaning solvent. Do not use abrasive cleaners, towels or scrubbers to clean the yoke or flange surface. Do not use gasoline.

NOTE: The unitized seal features a rubber inner sleeve that is designed to seal and rotate with the yoke. This feature allows you to reuse a yoke with minor grooves.

2. Inspect the yoke seal surface for grooves.
   - **If you find grooves on yoke hubs used with single or triple-lip seals:** Replace the yokes.
   - **If you find grooves on the yoke:** Use calipers to measure the groove diameters. If any groove diameter measures less than the dimensions shown in Figure 4.1, replace the yoke.

UNITIZED PINION SEAL (UPS)



Yoke Seal Diameter	Minimum Yoke Diameter at Groove (Inches)
3.000/3.005"	2.990"
3.250/3.255"	3.240"

1003390e

A MINIMUM GROOVE DEPTH — DIAMETER
B YOKE SEAL DIAMETER

Figure 4.1

Clean Ground and Polished Parts

1. Use a cleaning solvent, kerosene or diesel fuel to clean ground or polished parts or surfaces. Do not use gasoline.
2. Use a tool with a flat blade if required, to remove sealant material from parts. Be careful not to damage the polished or smooth surfaces.

⚠ CAUTION

Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts can result.

3. Do not clean ground or polished parts with water or steam. Do not immerse ground or polished parts in a hot solution tank or use strong alkaline solutions for cleaning, or the smooth sealing surface may be damaged.

Clean Rough Parts

1. Clean rough parts with the same method as cleaning ground and polished parts.
2. Rough parts can be cleaned in hot solution tanks with a weak or diluted alkaline solution.
3. Parts must remain in hot solution tanks until heated and completely cleaned.
4. Parts must be washed with water until all traces of the alkaline solution are removed.

Clean Axle Assemblies

1. A complete axle assembly can be steam cleaned on the outside to remove dirt.
2. Before the axle is steam cleaned, close or place a cover over all openings in the axle assembly. Examples of openings are breathers or vents in air chambers.

Drying Parts After Cleaning

1. Parts must be dried immediately after cleaning and washing.
2. Dry the parts using soft, clean paper or cloth rags.

⚠ CAUTION

Damage to bearings can result when they are rotated and dried with compressed air.

3. Except for bearings, parts can be dried with compressed air.

Prevent Corrosion on Cleaned Parts

1. Apply axle lubricant to cleaned and dried parts that are not damaged and are to be assembled.
2. To store parts, apply a special material that prevents corrosion to all surfaces. Wrap cleaned parts in a special paper that will protect the parts from moisture and prevent corrosion.

Inspect Parts

It is very important to inspect all parts carefully and completely before the axle or carrier is assembled. Check all parts for wear and replace damaged parts.

1. Inspect the cup, cone, rollers and cage of all tapered roller bearings in the assembly. If any of the following conditions exist, replace the bearing.
   - The center of the large-diameter end of the rollers is worn level with or below the outer surface. Figure 4.2.
   - The radius at the large-diameter end of the rollers is worn to a sharp edge. Figure 4.2.
   - There is a visible roller groove in the cup or cone inner race surfaces. The groove can be seen at the small- or large-diameter end of both parts. Figure 4.3.
   - There are deep cracks or breaks in the cup, cone inner race or roller surfaces. Figure 4.3.
   - There are bright wear marks on the outer surface of the roller cage. Figure 4.4.
   - There is damage on the rollers and on the surfaces of the cup and cone inner race that touch the rollers. Figure 4.5.
   - There is damage on the cup and cone inner race surfaces that touch the rollers. Figure 4.6.

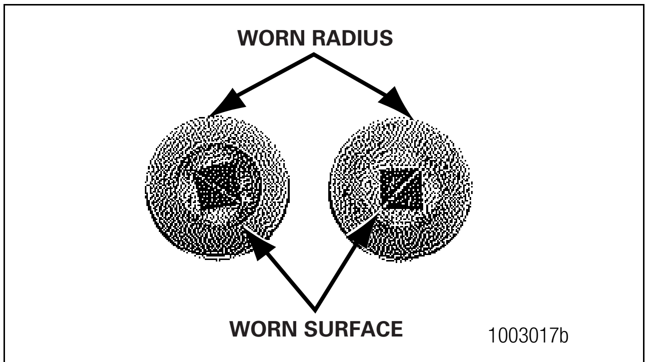


Figure 4.2

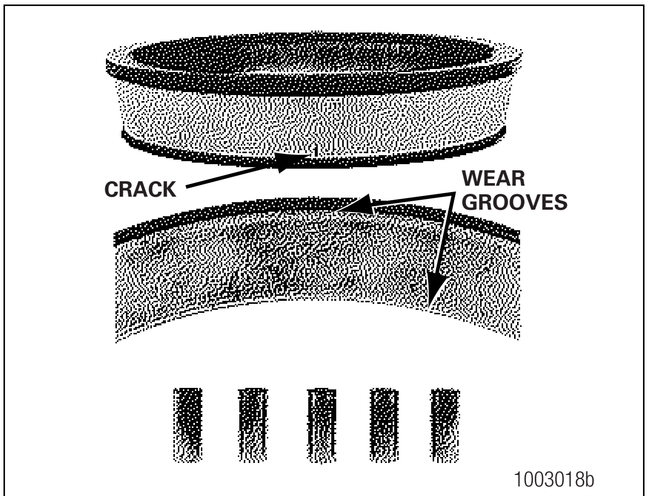


Figure 4.3

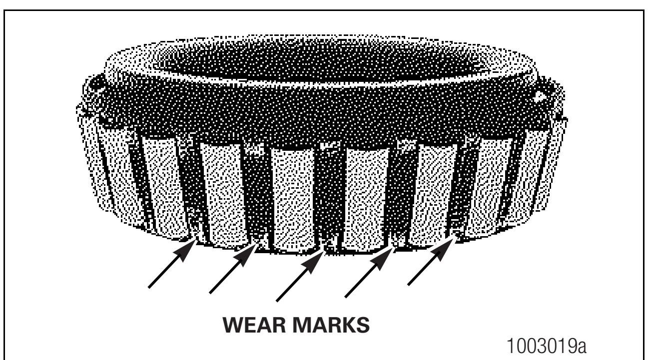


Figure 4.4

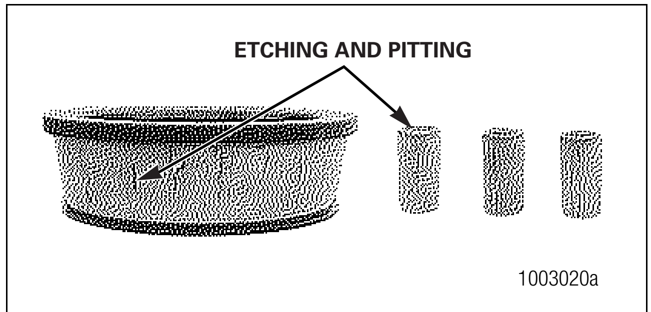


Figure 4.5

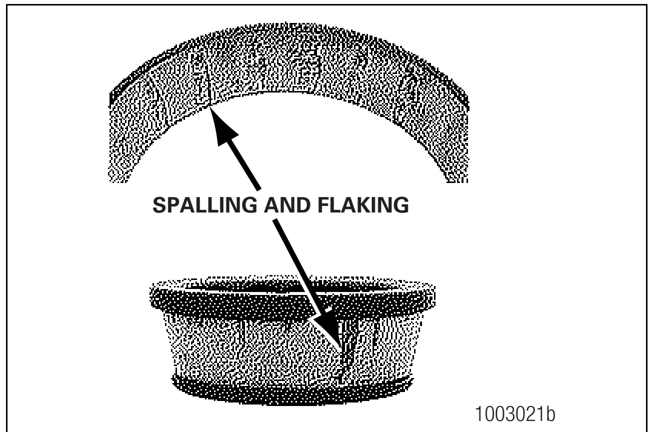


Figure 4.6

⚠ CAUTION

A drive pinion and ring gear are machined as a matched set. When you replace either a drive pinion or a ring gear, you must replace both parts as a matched set. Do not mix old and new parts. Damage to components can result.

2. Inspect hypoid pinions and gears for wear and damage. Replace gears that are worn or damaged.

⚠ CAUTION

A thrust washer, differential side gear and pinion gear are machined as a matched set. When you replace any of these parts, you must install a new matched set. Do not mix old and new parts. Damage to components can result.

3. Inspect the following main differential assembly parts for wear or stress. Replace parts that are damaged. Figure 4.7.
   - Inside surfaces of both case halves
   - Both surfaces of all thrust washers
   - The four trunnion ends of the spider or cross
   - Teeth and splines of both differential side gears
   - Teeth and bore of all differential pinions

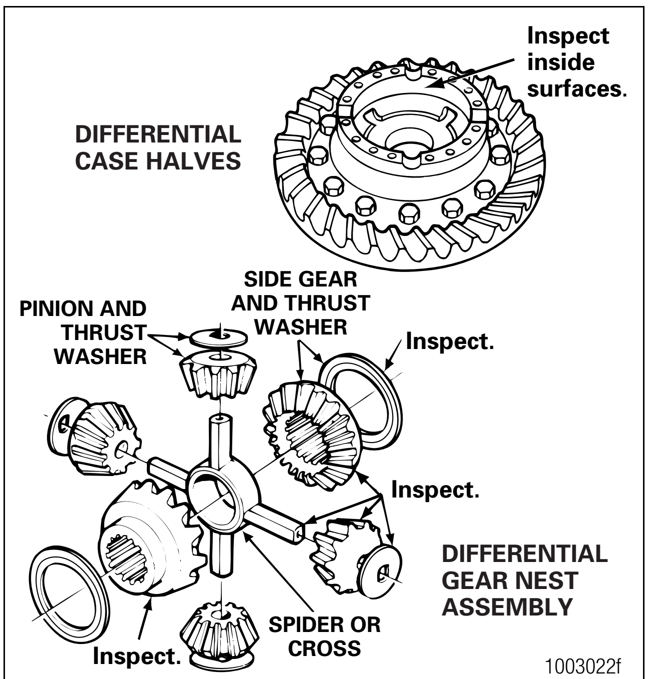


Figure 4.7

4. Inspect the axle shafts for wear and cracks at the flange, shaft and splines. Replace the axle shafts, if required.

5. Inspect the breather.
   A. Remove the breather from the axle housing.
   B. Clean the breather.
      - **If the breather remains dirty after cleaning:** Replace the breather.

   C. Apply compressed air to the breather.
      - **If compressed air does not pass through the breather:** Replace the breather.

   D. Install the breather in the axle housing.

Repair or Replace Parts

Threads must be without damage and clean so that accurate adjustments and correct torque values can be applied to fasteners and parts.

1. Replace any fastener if the corners of the head are worn.
2. Replace the washers if damaged.
3. Replace the gaskets, oil seals or grease seals at the time of axle or carrier repair.
4. Clean the parts and apply new silicone gasket material where required when the axle or carrier is assembled. Figure 4.8.

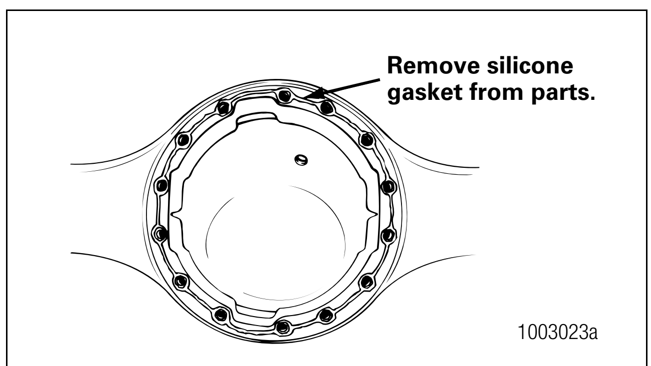


Figure 4.8

5. Remove nicks, mars and burrs from parts with machined or ground surfaces. Use a fine file, india stone, emery cloth or crocus cloth.
6. Clean and repair the threads of fasteners and holes. Use a die or tap of the correct size or a fine file.

Welding on Axle Housings

⚠ WARNING
Wear safe clothing and eye protection when you use welding equipment. Welding equipment can burn you and cause serious personal injury. Follow the operating instructions and safety procedures recommended by the welding equipment manufacturer.

Axle weld locations and welding procedures must adhere to Meritor standards. Welding at locations other than those authorized by Meritor will void the warranty and can reduce axle beam fatigue life. Serious personal injury and damage to components can result.

Refer to Maintenance Manual 8, Drive Axle Housings. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Meritor permits drive axle housing assembly repair welding in the following locations only.

- Housing-to-cover weld joints
- Snorkel welds
- Housing seam welds between the suspension attaching brackets
- Bracket welding to the drive axle housing

Prepare the Axle

⚠ WARNING
The high temperature caused by the open flame from the cutting torch can ignite the oil in the axle housing and can cause serious personal injury.

1. Remove the oil drain plug from the bottom of the axle housing and drain the lubricant from the assembly.

⚠ CAUTION
Remove the differential carrier from the axle housing before you weld onto an axle. Do not weld onto an axle with the differential carrier installed. Electrical arcing and damage to components can result.

2. Remove the differential carrier from the axle housing. Refer to the correct Meritor carrier maintenance manual or the vehicle manufacturer's instructions.

⚠ CAUTION
Remove the brake air chambers before you weld onto an axle. Do not expose a brake air chamber to more than 250°F (121°C). Damage to the air chamber can result.

3. Remove the wheel-end components and brake air chambers from the axle. Refer to the correct Meritor brake maintenance manual or the vehicle manufacturer's instructions.
4. For housing-to-cover welds, clean the outside housing-to-cover weld area two-three-inches (50.8-76.2 mm) past each end or side of the crack. Clean the inside area where the cover mates with the housing. Clean the area completely around the cover. Use a wire brush and a cleaning solvent that will remove dirt and grease from these areas.
5. For suspension bracket welds, clean both lower and upper suspension brackets and the areas of the axle housing around each bracket. Use a wire brush and a cleaning solvent that will remove dirt and grease from these areas.

⚠ WARNING
The axle housing must be 70°F (21°C) or warmer before you weld onto the axle. Do not weld onto a cold axle or weld cold parts onto an axle. Cracks in the weld area, damage to components and serious personal injury can result.

6. Ensure that the axle housing temperature measures 70°F (21°C) or warmer.
   - **If the axle housing temperature measures less than 70°F (21°C):** Store the axle in a heated room until the housing reaches the correct temperature.
7. Heat the damaged area to approximately 300°F (149°C) before you begin welding.
8. Use suitable weld wire electrodes when you weld. Suitable weld wire electrodes include either BS EN 499 – E 42 2 B 32 H5 or BS EN 440 – G 42 2 M GSi (American Welding Society equivalents E7018 and ER70S3, respectively).
9. For complete welding instructions, refer to Maintenance Manual 8, Drive Axle Housings. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Do Not Bend or Straighten a Damaged Drive Axle Housing

⚠ WARNING

Replace damaged or out-of-specification axle components. Do not bend, repair or recondition axle components by welding or heat-treating. A bent axle beam reduces axle strength, affects vehicle operation and voids Meritor's warranty. Serious personal injury and damage to components can result.

Always replace a damaged drive axle housing. Do not bend or straighten a damaged housing, which can misalign or weaken it, and void Meritor's warranty.

Removing Fasteners Secured with Adhesive

If it is difficult to remove fasteners secured with Dri-Loc®, Meritor adhesive or Loctite® 277 adhesive, use the following procedure.

When you remove fasteners secured with adhesive, slowly heat the fastener to 350°F (177°C). Do not exceed this temperature, or heat fasteners quickly. Damage to components can result.

1. Heat the fastener for three to five seconds. Try to loosen the fastener with a wrench. Do not use an impact wrench or hit the fastener with a hammer.
2. Repeat Step 1 until you can remove the fastener.

New Fasteners with Pre-Applied Adhesive

1. Use a wire brush to clean the oil and dirt from threaded holes.
2. Install new fasteners with pre-applied adhesive to assemble parts. Do not apply adhesives or sealants to fasteners with pre-applied adhesive, or to fastener holes.
3. Tighten the fasteners to the required torque value for that size fastener. No drying time is required for fasteners with pre-applied adhesive.

Original or Used Fasteners

1. Use a wire brush to clean the oil, dirt and old adhesive from all threads and threaded holes.
2. Apply four or five drops of Meritor liquid adhesive 2297-C-7049, Loctite® 638 or 680 liquid adhesive or equivalent inside each threaded hole or bore. Do not apply adhesive directly to the fastener threads. Figure 4.9.

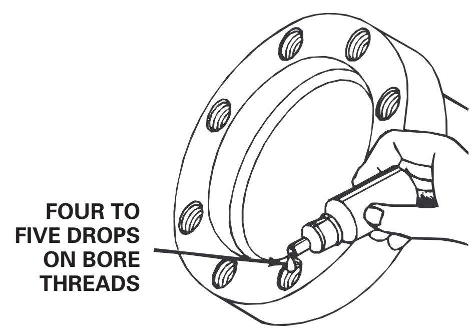


Figure 4.9

3. Tighten the fasteners to the required torque value for that size fastener. There is no drying time required for Meritor liquid adhesive 2297-C-7049, Loctite® 638 or 680 liquid adhesive or equivalent.

Meritor Specification 2297-T-4180 Adhesive in the Differential Bearing Bores

NOTE: Use Meritor specification 2297-T-4180 adhesive for all axles.

1. Clean the oil and dirt from the outer diameters of the bearing cups and bearing bores in the carrier and bearing caps. There is no special cleaning required.
2. Apply axle lubricant to the bearing cones and the inner diameters of the bearing cups of the main differential. Do not get oil on the outer diameter of the bearing cup and do not permit oil to drip onto the bearing bores.

NOTE: Meritor specification 2297-T-4180 adhesive will dry in approximately two hours. You must complete the procedure within two hours from the time you apply the adhesive. If two hours have passed since application, clean the adhesive from the parts and apply new adhesive.

3. Apply a single continuous bead of the adhesive to the bearing bores in the carrier and bearing caps. Apply the adhesive around the circumference of the smooth, ground surfaces only. Do not place the adhesive on the threaded areas. Figure 4.10.

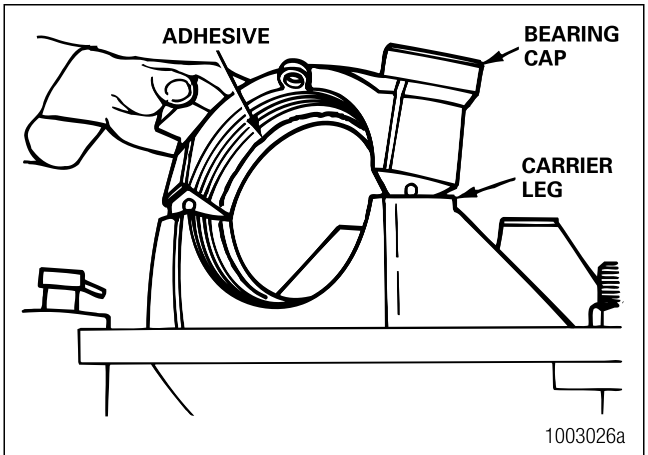


Figure 4.10

4. Install the main differential assembly, bearing cups and bearing caps into the carrier. Refer to Section 5.
5. Adjust the preload of the differential bearings, backlash and tooth contact patterns of the gear set as required. Refer to Section 5.

Carrier-to-Housing Joint Sealing Procedure

1. Remove the carrier from the housing. Refer to Section 3.
2. Remove all debris from inside the housing.
3. Use a rotary tool with a scour pad to clean all silicone residue from the housing and carrier faces. Figure 4.11. Surfaces must be clean, dry and free of foreign matter. The surfaces must not be oily to the touch.

Figure 4.11

4. Remove metal filings from the magnets inside the housing.
5. Use solvent to clean the inside of the housing.
6. Use Loctite® ODC Free cleaner or brake cleaner to clean the housing and carrier faces.
7. Dry the housing and carrier faces.

⚠ CAUTION

New capscrew kits have blue Dri-Loc® STS threadlocker, an equivalent to Loctite® 242 threadlocker, applied to the capscrews. Do not remove the blue Dri-Loc® STS threadlocker from the capscrews. Damage to components can result.

8. If you reuse the carrier-to-housing capscrews, use a rotary wire brush to remove any threadlocker material and clean the capscrew threads. Use a clean cloth to wipe the threads.
9. Use a tap to clean the internal threads in the housing.

⚠ CAUTION

Apply silicone gasket material in a continuous 0.125-inch (3 mm) bead. If you use more than this amount, gasket material can break off and plug lubrication passages. Damage to components can result.

10. Apply a 0.25-inch (6 mm) bead of Loctite® 5699 silicone gasket material to the housing face. Do not use ThreeBond 1216E silicone products. Figure 4.12.

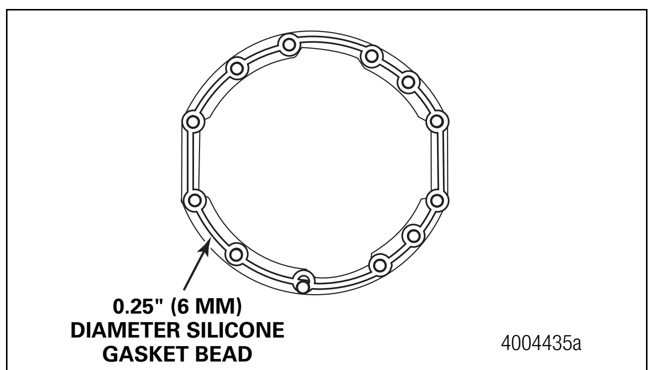


Figure 4.12

11. Install two long studs in the carrier to guide the carrier into the housing.

12. Immediately install the carrier into the housing to enable the silicone gasket material to compress evenly between the faces. If using a new capscrew kit with blue Dri-Loc® STS pre-applied threadlocker, skip the next step.

CAUTION

Apply silicone gasket material in a continuous 0.25-inch (6 mm) bead. If you use more than this amount, gasket material can break off and plug lubrication passages. Damage to components can result.

13. Apply a 0.125-inch (3 mm) bead of Loctite® 242 threadlocker around the capscrew threads approximately 0.25-inch (6 mm) from the end. Apply a 0.125-inch (3 mm) bead of Loctite® 242 threadlocker across the length of the threads. Figure 4.13.

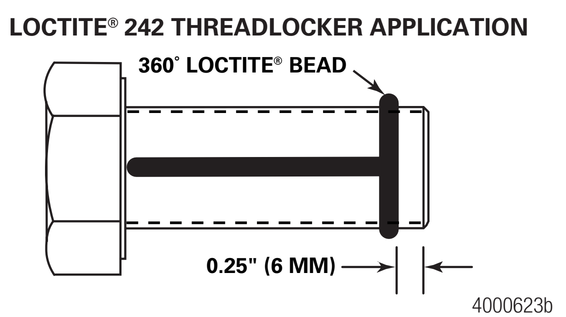


Figure 4.13

14. Install the capscrews. Use a crossing pattern to tighten the capscrews evenly. The capscrews must be tightened within 10 minutes of initial application of Loctite® 242 threadlocker.
    - Tighten the 1/2-inch capscrews to 140 lb-ft (190 N•m).
    - Tighten the 5/8-inch capscrews to 225 lb-ft (306 N•m).
15. Wait a minimum of 60 minutes before filling the assembly with lubricant. Refer to Section 7.

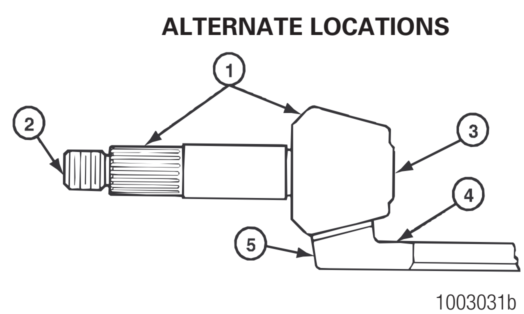
General Yoke and U-Joint Reassembly

Install the end yoke hub capscrews by hand after seating the U-joint. Tighten the capscrews according to the manufacturer's torque specifications.

Identification

Gear Sets

Refer to Table A, Table B, Table C and Table D for information on identifying gear sets with matched parts. Always check match numbers to verify that the gear set you will install has matched parts. Figure 4.14.



1 PART NUMBER, TOOTH COMBINATION NUMBER, GEAR SET MATCH NUMBER, PINION CONE VARIATION NUMBER
2 PART NUMBER, TOOTH COMBINATION NUMBER
3 GEAR SET MATCH NUMBER, PINION CONE VARIATION NUMBER
4 PART NUMBER, TOOTH COMBINATION NUMBER, GEAR SET MATCH NUMBER
5 PART NUMBER, TOOTH COMBINATION NUMBER, GEAR SET MATCH NUMBER

Figure 4.14

Examples

Table A: Gear Set Part Numbers

Part	Number	Location
Conventional ring gear	36786	On the front face or outer diameter
Conventional drive pinion	36787	At the end at threads
Generoid ring gear	36786 K or 36786 K2	On the front face or outer diameter
Generoid drive pinion	36787 K or 36787 K2	At the end at threads

Table B: Gear Set Tooth Combination Number

Gear Set Teeth	Drive Pinion Location	Ring Gear Location
5-37 = gear set has a five-tooth drive pinion and a 37-tooth ring gear	At the end at threads	On the front face or outer diameter

NOTE: Meritor drive pinions and ring gears are only available as matched sets. Each gear in a set has an alphanumeric match number.

Table C: Gear Set Match Number

Match Number	Drive Pinion Location	Ring Gear Location
M29	At the end of the gear head	On the front face or outer diameter

NOTE: Don't use the pinion cone variation number when you check for a matched gear set. Use this number when you adjust the pinion depth of the carrier. Refer to Section 5.

Table D: Pinion Cone Variation Number

Pinion Cone (PC) Variation Number	Drive Pinion Location	Ring Gear Location
PC+3	At the end of the pinion gear head	On the outer diameter
+2		
+0.01 mm		
PC–5		
–1		
–0.02 mm		

Check for Mismatched Ratios on Tandem Axles

For a tandem axle pair to function correctly, the forward and rear axles must operate with axle ratios within one percent. A mismatched tandem axle pair can cause carrier overheating, hypoid gear set wear, metal debris to collect on the magnetic drain plug, carrier lubricant additive depletion, excessive inter-axle wear and noise.

To determine if the tandem axle ratios operate within allowable limits, refer to one of the following procedures. Perform the procedure that will work best for the vehicle you are servicing.

Hypoid Gear Set Ratios Listed on the Identification Tags

1. Locate the identification tags riveted to the forward and rear axle differential carriers. Figure 4.15.

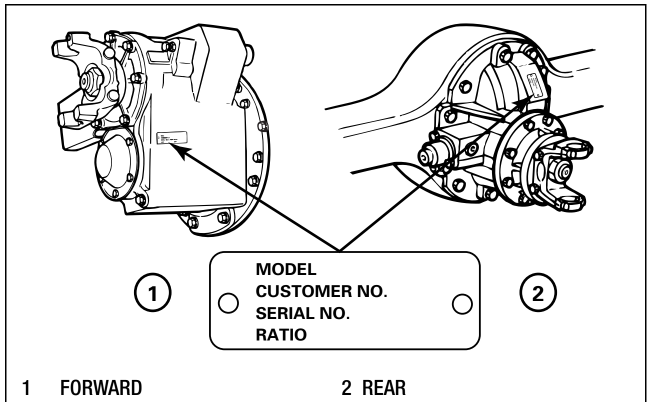


Figure 4.15

2. Compare the axle ratios shown on both tags. To operate correctly, the axle ratios for both axles must be within one percent of each other. To calculate the percentage difference between the axle ratios, refer to the equation in Table E.

Table E

$$\frac{\text{Larger Ratio} - \text{Smaller Ratio}}{\text{Smaller Ratio}} \times 100 = \text{Percentage Difference Between Axle Ratios}$$

- **If the axle ratios shown on the identification tags are not within one percent of each other:** Refer to the vehicle manufacturer for further information.

Rotate the Forward Driveshaft to Check the Hypoid Gear Set Ratio

⚠ WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface.
2. Engage the power divider and shift the transmission into NEUTRAL.
3. Block the wheels to prevent the vehicle from moving.

4. Use a jack to raise the vehicle until all the tandem drive axle wheels clear the ground. Support the vehicle with safety stands.
5. Mark the forward and rear tires at identical relative positions. Figure 4.16.

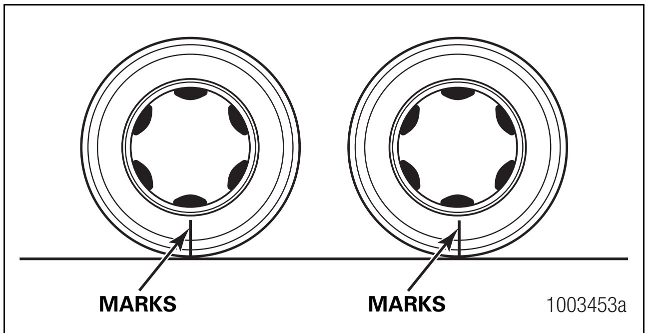


Figure 4.16

6. Turn the forward driveshaft in one direction by hand until the forward tire completes two rotations. Figure 4.17. The forward tire must rotate two times only. If the forward tire rotates more than or less than two rotations, the angle measurements you make in Step 7 will be inaccurate.

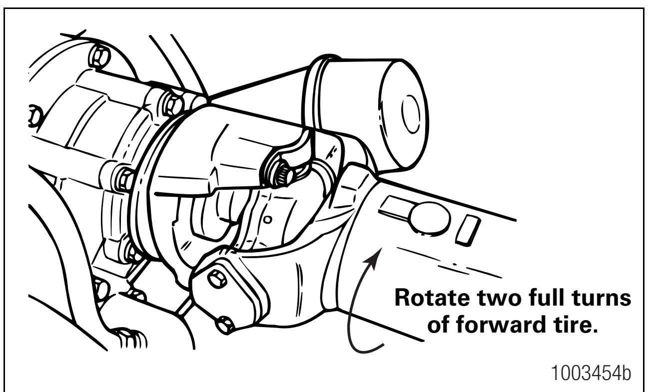


Figure 4.17

7. Note the positions of the tire marks you previously made. On a correctly matched tandem axle gear set, both tire marks will be within ± 3.6 degrees of each other. Figure 4.18.
   - **If the positions of the tire marks are more than 3.6 degrees from each other:** Refer to the vehicle manufacturer for further information.

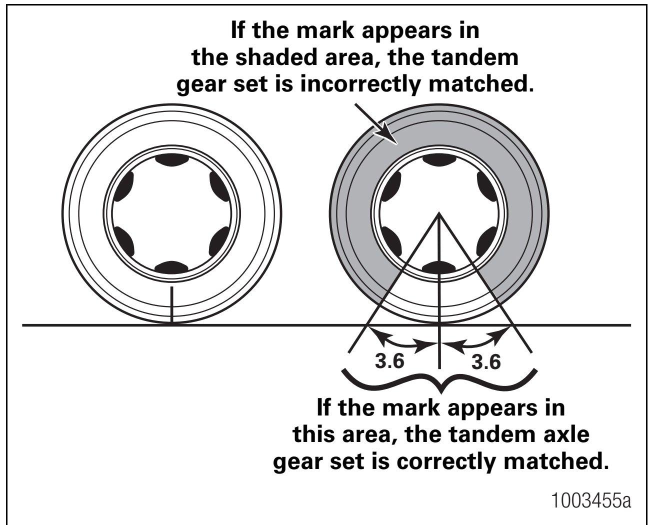


Figure 4.18

8. Remove the safety stands and lower the vehicle.

Hypoid Gear Set Teeth Numbers Stamped on the Forward and Rear Axle Drive Pinions

When the inter-axle driveline or differential carrier are removed for service, you can check the hypoid gear set teeth numbers stamped on the forward and rear axle drive pinions.

⚠ WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface.
2. Block the wheels to prevent the vehicle from moving.

To Identify the Gear Teeth Number on the Forward Axle Drive Pinion

1. Remove the forward carrier pinion cover. Refer to the vehicle manufacturer's procedures.
2. Look into the carrier housing. Identify and record the gear set teeth numbers stamped on the drive pinion end. Figure 4.19.

3. Calculate the hypoid gear set ratio by dividing the larger number by the smaller number. Figure 4.19.

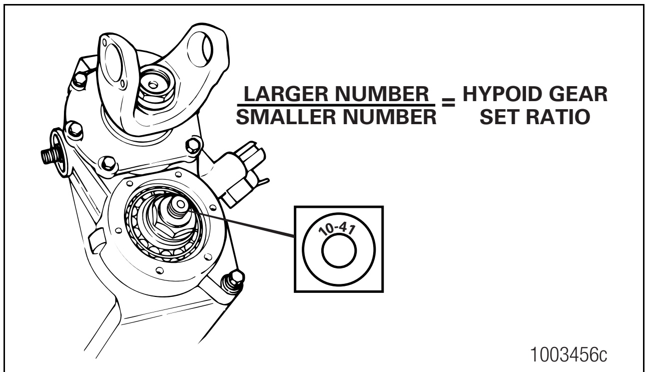


Figure 4.19

To Identify the Gear Teeth Number on the Rear Axle Drive Pinion

1. Remove the inter-axle driveshaft. Refer to the vehicle manufacturer's procedures.
2. Identify and record the gear set teeth numbers stamped on the end of the rear axle drive pinion. Figure 4.20.
3. Calculate the hypoid gear set ratio by dividing the larger number by the smaller number. Figure 4.20.

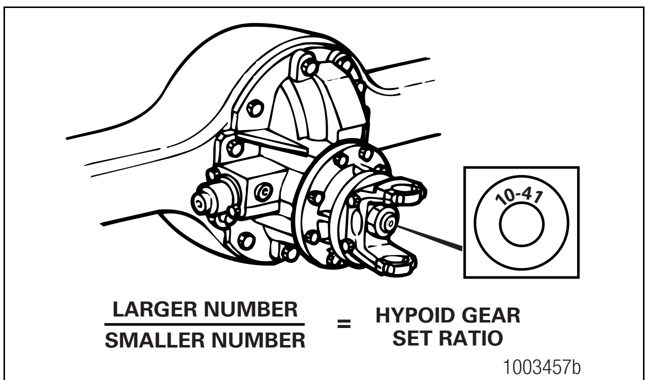


Figure 4.20

Compare Both Hypoid Gear Set Ratios

1. Both ratios must be within one percent of each other. To calculate the percentage difference between the axle ratios, refer to the equation in Table E.
   - **If the axle ratios shown on the identification tags are not within one percent of each other:** Refer to the vehicle manufacturer for further information.

2. Install the inter-axle driveshaft. Refer to the vehicle manufacturer's procedures.
3. Install the pinion cover. Refer to the vehicle manufacturer's procedures.
4. Remove the safety stands and lower the vehicle.

Verify the Actual Hypoid Gear Set Ratios

You can check the actual hypoid gear set ratios when you remove the differential carriers from the axle housings for service or repair. Refer to the following procedure to calculate the actual gear set ratios.

1. Count the number of ring gear teeth. Figure 4.21.
2. Count the number of pinion gear teeth. Figure 4.21.
3. Divide the number of ring gear teeth by the number of pinion gear teeth to determine the actual hypoid gear set ratio for each axle. Figure 4.21.

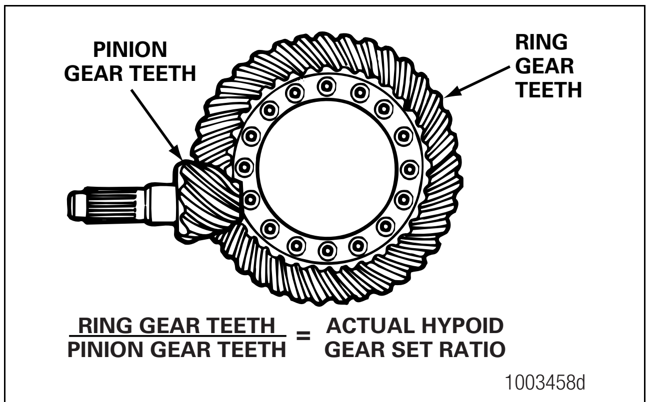


Figure 4.21

4. Calculate the percentage difference between the hypoid gear set ratios using the equation in Table E. All ratios must match within one percent.
   - **If the actual hypoid gear set ratios are not within one percent of each other:** Refer to the vehicle manufacturer for further information.

Inspection

Yoke

All current Meritor axles feature helical splines at the yoke interface. This feature provides a tight fit between the yoke and input shaft, output shaft and pinion shaft. For the axle to operate correctly, the input shaft, output shaft and pinion shaft must fit tightly to the corresponding yoke.

Check for Yoke Wear

⚠ WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Use a jack to raise the vehicle so that the wheels to be serviced are off the ground. Support the vehicle with safety stands.
3. Remove the driveline.
4. Remove the input, output or pinion shaft nut.
5. Attempt to remove the yoke by hand.
   - **If you can remove the yoke by hand:** The yoke is worn. Replace the yoke.
6. Use a correct yoke puller tool to remove the yoke.

Check for a Tight-Fit Condition

NOTE: You can check for a tight-fit condition when you install any serviceable yoke.

1. Attempt to install the yoke by hand.
   - **If the yoke bottoms out against the adjacent bearing:** Replace the yoke.
2. Use a correct yoke installation tool to install the yoke.
3. As you install the yoke, you should detect resistance between the yoke and shaft.
   - **If you do not detect resistance between the yoke and shaft:** Replace the yoke.
4. Install and tighten the input, output or pinion shaft nut to the correct torque. Refer to Section 8.
5. Install the driveline.
6. Remove the safety stands.
7. Lower the vehicle.

Tire Matching for Tandem and Tridem Axles

⚠ CAUTION

Unmatched tires on both tandem drive units and tridem drive units will cause tire wear and scuffing and possible damage to the drive units. Meritor recommends that the tires be matched to within 0.125-inch (3.18 mm) of the same rolling radius, 0.75-inch (19.05 mm) of the same rolling circumference.

Tandem Axles

The four largest tires should never be installed on one driving axle or the four smallest tires on the other driving axle. Such tire mounting will cause an inter-axle fight, unusually high axle lubricant temperatures that result in premature lubricant breakdown and possible costly axle service.

In addition to matching individual tire rolling radii or rolling circumference, Meritor recommends matching, as nearly as possible, the total tire circumference of one driving axle to the total tire circumference of the other driving axle. This will usually result in satisfactory tandem axle lubricant temperatures that lengthen drive unit service with higher tire mileage.

Park the vehicle on a level surface. The vehicle must carry a correctly distributed rated capacity load. All the tires must be the same size. Measure new tires to verify that they will be correctly matched.

1. Inflate all tires to the same pressure.
2. Carefully measure the rolling circumference of each tire with a steel tape.
3. Mark the size on each tire with chalk and arrange the tires in order of size, largest to smallest.
4. Mount the two largest tires on one side of one axle and mount the two smallest on the opposite side of the same axle.
5. Mount the four other tires on the other axle in the same manner.

6. Test run the vehicle to gather accurate rear axle lubricant temperature readings on the two axle lubricant temperature gauges.
7. Vary tire air pressure within the tire manufacturer's recommended range so the lubricant temperature of both axles is within 30°F (–1°C) of each other and not in excess of 200°F (93°C). This will usually result in uniform tire loading and good tire life.

Tridem Axles

When three driving axles are used together in a tridem series, unmatched tires will compound the problems described in the preceding paragraphs. Meritor recommends matching, as nearly as possible, the total tire circumference of each of the three driving axles.

To match tires on tridem units, follow the same procedure used for tandem units.

Arrange the tires in order of size.

- The two largest and two smallest go on one axle.
- The next two largest and smallest go on the second axle.
- The remaining four tires go on the third axle.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

Installation

Installing the Drive Pinion and Adjusting Pinion Depth and Preload

There are two procedures for adjusting pinion depth. The procedure in this manual is to install the pinion, bearings and calculated shim pack into the case WITHOUT the helical gear and two spacers. After you check the tooth contact patterns to determine the correct pinion position, you must disassemble the carrier to install the helical gear and two spacers.

An optional procedure is to install the pinion, bearings and calculated shim pack into the case WITH the helical gear and two spacers. After you check the tooth contact patterns to determine the correct pinion position, you only need to disassemble the carrier if an adjustment is necessary. Both procedures are acceptable.

Adjustment

Shim Pack Thickness for a New Drive Pinion

NOTE: Use this procedure if you'll install a new drive pinion and ring gear set or if you have to adjust the depth of the drive pinion. If the pinion depth shims are misplaced during carrier repair, use 0.030-inch (0.76 mm) for 145 Series axles and 0.050-inch (1.27 mm) for 160 Series axles for the initial pinion position. Figure 5.1.

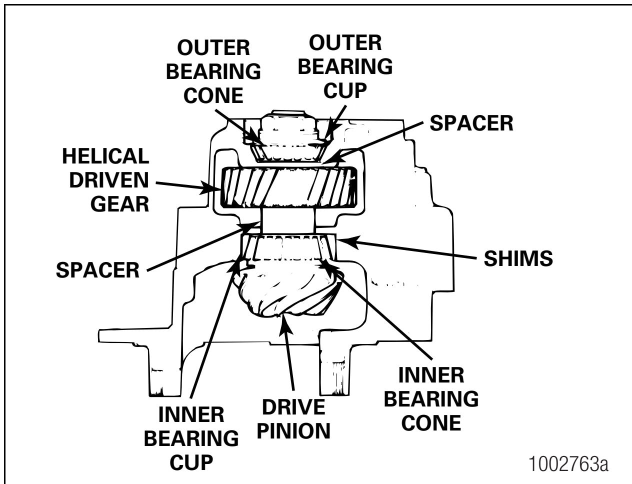


Figure 5.1

1. Use a micrometer to measure the thickness of the shim pack that was removed from the differential carrier. Record the measurement. Figure 5.2.

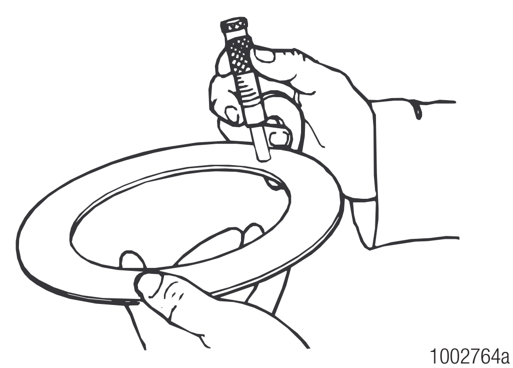


Figure 5.2

2. Find the pinion cone (PC) variation number on the drive pinion you'll replace. Record the number. Figure 5.3. The pinion cone number can be one of the following values.
   - PC +3, PC –3, +3 or –3 = 0.003-inch
   - PC +.03, PC 0.03 mm, +0.03 mm or –0.03 = 0.03 mm

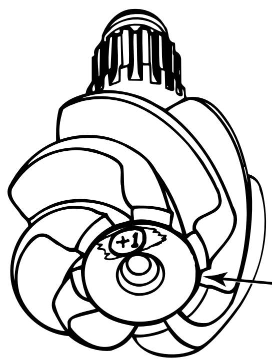


Figure 5.3

3. If you can't find the PC number or it's unreadable, install a new shim pack of the same thickness that you measured in Step 1.

NOTE: The following calculation is the opposite for a rear carrier, tandem or single.

4. If the old pinion cone number of a forward tandem carrier is a plus (+), ADD the cone number to the old shim pack thickness that was measured in Step 1.
5. If the old pinion cone number of a forward tandem carrier is a minus (–), SUBTRACT the cone number from the old shim pack thickness that was measured in Step 1.
6. Find the pinion cone variation number on the new drive pinion that will be installed. Record the number.
7. If the new pinion cone number of a forward tandem carrier is a plus (+), SUBTRACT the number from the standard shim pack thickness that was calculated in Step 4 or Step 5. Use new shims to make a shim pack to the determined thickness. Refer to Table F.
8. If the new pinion cone number of a forward tandem carrier is a minus (–), ADD the number to the standard shim pack thickness that was calculated in Step 4 or Step 5. Use new shims to make a shim pack to the determined thickness. Refer to Table F.

Table F

Examples	Inches	mm
1. Old Shim Pack Thickness	0.030	0.760
Old PC Number, PC +2	+ 0.002	+ 0.050
Standard Shim Pack Thickness	= 0.032	= 0.810
New PC Number, PC +5	– 0.005	– 0.120
New Shim Pack Thickness	= 0.027	= 0.690
2. Old Shim Pack Thickness	0.030	0.760
Old PC Number, PC –2	– 0.002	– 0.050
Standard Shim Pack Thickness	= 0.028	= 0.710
New PC Number, PC +5	– 0.005	– 0.120
New Shim Pack Thickness	= 0.023	= 0.590
3. Old Shim Pack Thickness	0.030	0.760
Old PC Number, PC +2	+ 0.002	+ 0.050
Standard Shim Pack Thickness	= 0.032	= 0.810
New PC Number, PC –5	+ 0.005	+ 0.120
New Shim Pack Thickness	= 0.037	= 0.930
4. Old Shim Pack Thickness	0.030	0.760
Old PC Number, PC –2	– 0.002	– 0.050
Standard Shim Pack Thickness	= 0.028	= 0.710
New PC Number, PC –5	+ 0.005	+ 0.120
New Shim Pack Thickness	= 0.033	= 0.830

Assembly

Drive Pinion Assembly

The depth of the drive pinion and ring gear contact is controlled by the thickness of the shim pack. Figure 5.4.

- **To increase the thickness of the drive pinion contact:** Increase the thickness of the shim pack.
- **To decrease the depth of the drive pinion pattern:** Decrease the thickness of the shim pack.

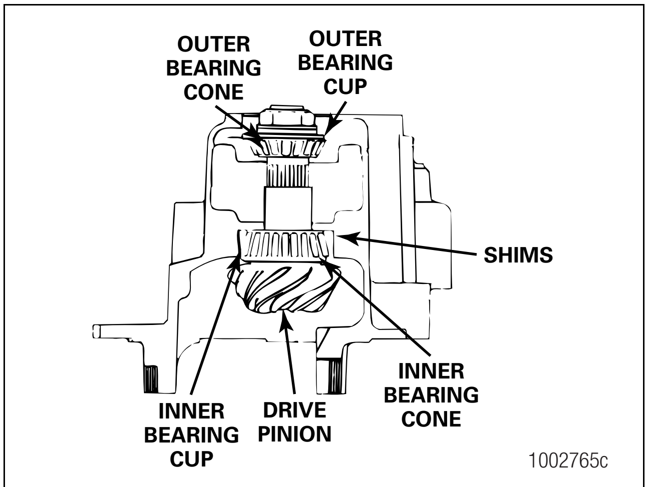


Figure 5.4

The preload of the bearings on the drive pinion is controlled by a spacer between the outer bearing cone and the helical driven gear.

Adjust the preload by changing the size of the spacer.

- **To decrease the preload:** Use a thicker spacer.
- **To increase the preload:** Use a thinner spacer.

If the depth of the drive pinion is changed, the thickness of the spacer must also be changed the same amount. Refer to the following examples.

- **If a 0.003-inch (0.076 mm) shim is ADDED to the shim pack to INCREASE the depth of the drive pinion:** A 0.003-inch (0.076 mm) larger spacer must be installed to keep the preload on the bearings.
- **If a 0.003-inch (0.076-mm) shim is REMOVED from the shim pack to DECREASE the depth of the drive pinion:** A 0.003-inch (0.076 mm) smaller spacer must be installed to keep the preload on the bearings.

NOTE: The helical driven gear and the spacers are installed when the bearing preload on the drive pinion is inspected and adjusted.

1. If you are installing a new ring gear and drive pinion, the correct thickness of the shim pack between the pinion inner bearing cup and the carrier must be determined. Refer to the procedure in this section before temporarily assembling and installing the drive pinion assembly according to this procedure.

   If you are installing the original ring gear and drive pinion, temporarily install the drive pinion assembly.

2. If removed, use a press and a sleeve to install the inner bearing cone onto the drive pinion. Place the sleeve onto the inner race of the bearing. Apply pressure until the bottom of the cone touches the shoulder on the pinion. Figure 5.5.

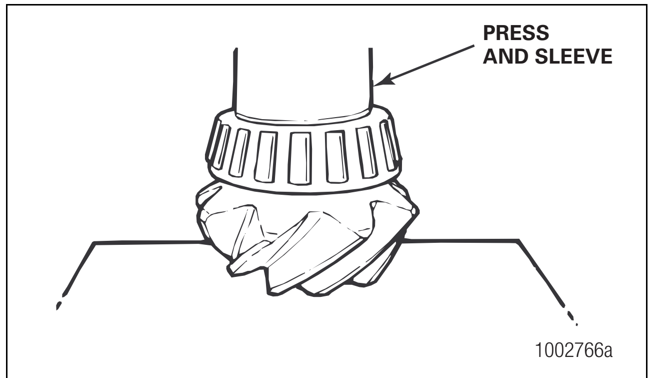


Figure 5.5

3. Apply axle lubricant to the bearing cups and cones.
4. If removed, install the shim pack and the inner bearing cup of the drive pinion.
   A. Place the carrier into a press so that the legs of the carrier are toward the TOP of the press.
   B. Install the correct amount of shims into the bore for the inner bearing cup of the drive pinion. Figure 5.6.
   C. Place the cup into the bore. Figure 5.6.
   D. Place supports under the differential carrier so that the carrier is level.
   E. Place a sleeve or a bearing driver tool onto the cup and press the cup into the bore until the bottom of the cup touches the shims. If a press is not available, use a sleeve, a brass drift or a bearing driver tool and a hammer to install the cup. Figure 5.7.

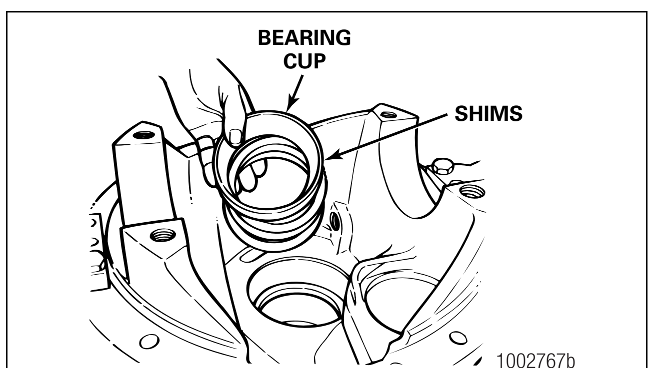


Figure 5.6

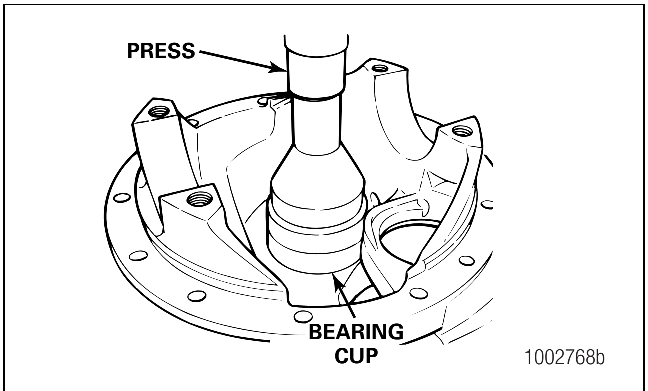


Figure 5.7

5. If removed, install the outer bearing cup for the drive pinion.
   A. Place the carrier into a press so that the legs of the carrier are toward the BOTTOM of the press. Place supports under the carrier so that the carrier is level.
   B. Place the outer bearing cup for the drive pinion into the bore of the carrier.
   C. Use a sleeve or a bearing driver tool and a press to install the cup. Press the cup into the carrier until the bottom of the cup touches the bottom of the bore. If a press is not available, use a sleeve, a brass drift or a bearing driver tool and a hammer to install the cup. Figure 5.8.

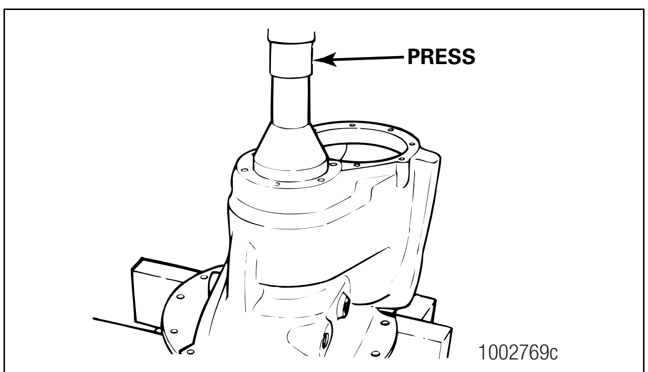


Figure 5.8

Installation

Drive Pinion Assembly

1. Place the drive pinion into the carrier so that the pinion is through the inner and the outer bearing cups.
2. Place the carrier into a press so that the legs of the carrier are toward the BOTTOM of the press. Place supports under the carrier so that the carrier is level. Place a support under the head of the drive pinion so that the inner bearing cone on the pinion shaft touches the inner bearing cup in the carrier.
3. Place the outer bearing cone onto the pinion shaft.
4. Use a press and a sleeve to install the bearing cone onto the pinion. Apply no more than two tons (1814 kg) of force to verify that the bearing cone is correctly installed. Figure 5.9.

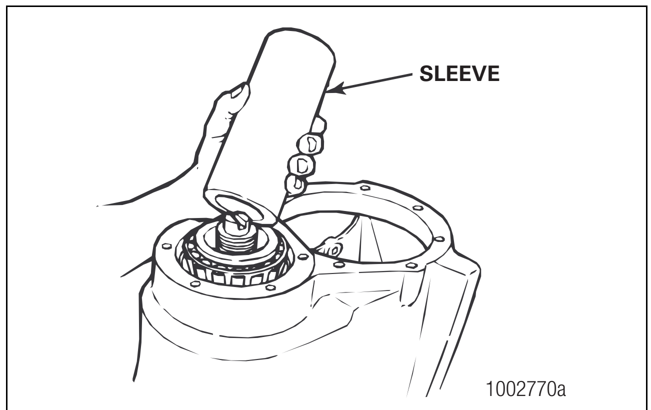


Figure 5.9

Adjustment

Drive Pinion Bearing Preload

NOTE: If the depth of the drive pinion was changed, then the amount of the change must be added or subtracted to the thickness of the spacer between the outer bearing cup and the helical driven gear.

After you obtain the correct gear tooth contact pattern and the correct shim pack thickness, you must adjust the bearing preload on the drive pinion. The preload is controlled by the thickness of the spacer between the helical driven gear and the outer bearing cone. Figure 5.10.

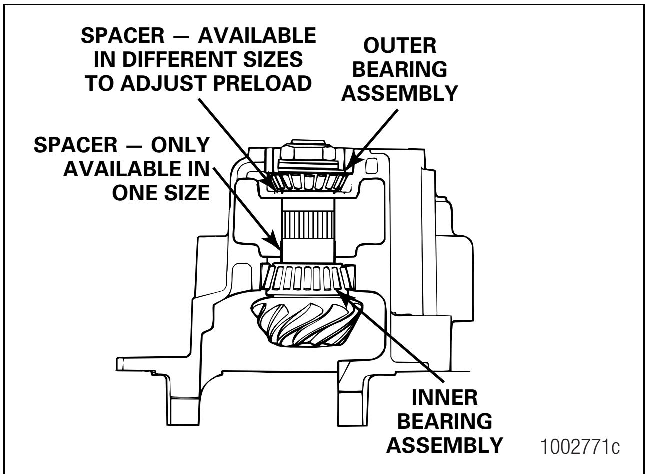


Figure 5.10

1. Place the carrier into a press so that the threaded end of the pinion is UP. Place supports under the flange of the carrier so that the carrier is level. Place a wood block under the head of the pinion. Figure 5.11.
2. Press the drive pinion out of the outer bearing cone. Remove the cone. Figure 5.11.

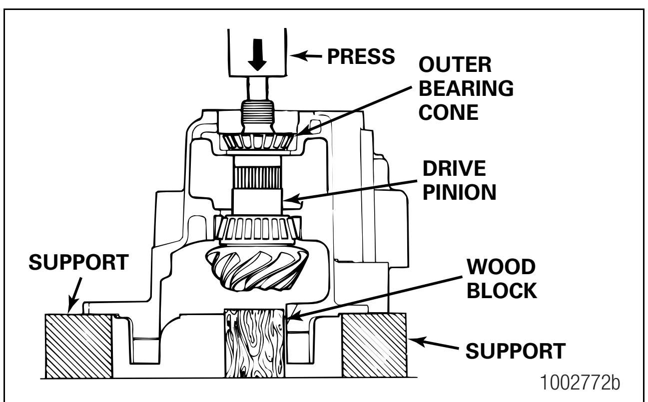


Figure 5.11

3. Turn the carrier over so that the legs of the carrier are UP. Place supports under the carrier so that the carrier is level.
4. Place the helical driven gear over the pinion bore in the carrier so that the splines inside the gear are toward the FRONT of the carrier. Place the large spacer on top of the helical driven gear so that the spacer is toward the inner bearing cup. Figure 5.12.

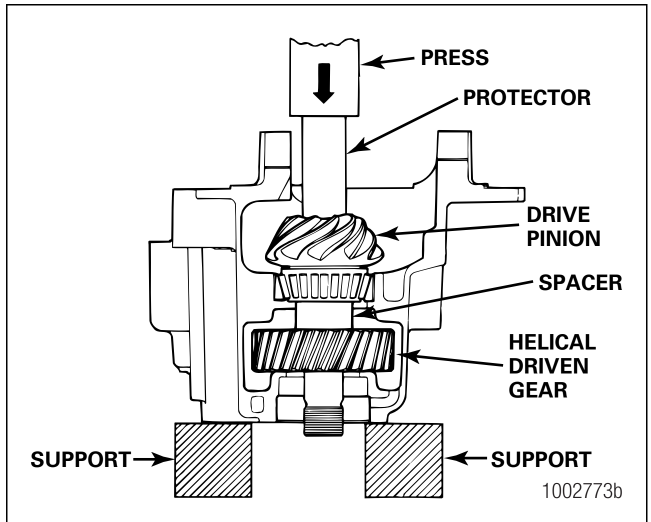


Figure 5.12

5. Install the drive pinion into the helical driven gear. Verify that the splines on the pinion engage the splines inside the gear. Figure 5.12.

⚠ CAUTION

Do not apply pressure after the inner bearing cone touches the inner bearing cup. If more pressure is applied, the cup, cone and drive pinion will be damaged.

6. Place a protector onto the head of the drive pinion. Use a press to install the pinion into the carrier so that the inner bearing cone touches the bearing cup. At this time, the helical driven gear will not be completely installed on the drive pinion. Figure 5.12.
7. Place the carrier into a press so that the threaded end of the pinion is toward the TOP of the press. Place supports under the flange of the carrier so that the carrier is level. Place a wood block under the head of the drive pinion so the inner pinion bearing cone touches the inner bearing cup. Figure 5.13.

⚠ CAUTION

Do not apply pressure after the helical driven gear touches the spacer in front of the inner bearing on the drive pinion. If pressure is applied after the parts touch each other, the gear will damage the spacer.

8. Use a press and a sleeve to completely install the helical driven gear onto the drive pinion. Use a sleeve on the hub of the gear that fits inside the pinion bore in the carrier. Press the gear onto the drive pinion until the gear touches the spacer. Figure 5.13.

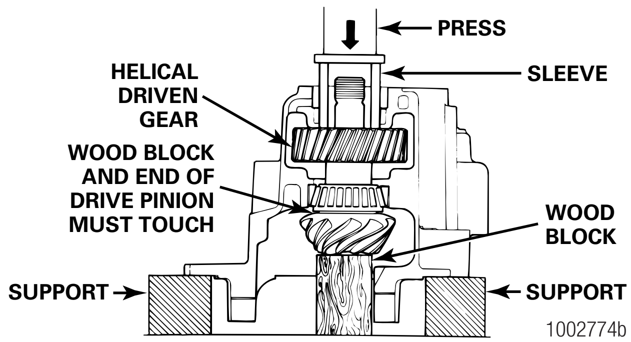


Figure 5.13

9. Cut two pieces of lead or solder approximately 0.5625-inch (14 mm) long and 0.625-inch (16 mm) wide. Use the two pieces of solder or lead as gauge blocks to determine the correct thickness of the spacer between the helical driven gear and the outer bearing.
10. Place the two pieces of lead or solder so that the pieces are opposite each other on top of the helical driven gear.
11. Place the outer bearing cone into the cup over the two pieces of lead or solder on top of the helical driven gear.
12. Remove the support from the flange of the carrier. Place a sleeve on top of the outer bearing cone. Use a press to apply two tons (1814 kg) of force to the outer bearing cone. The force of the press compresses the lead or solder pieces to the correct size. Do not apply more than two tons (1814 kg) of force. Figure 5.14.

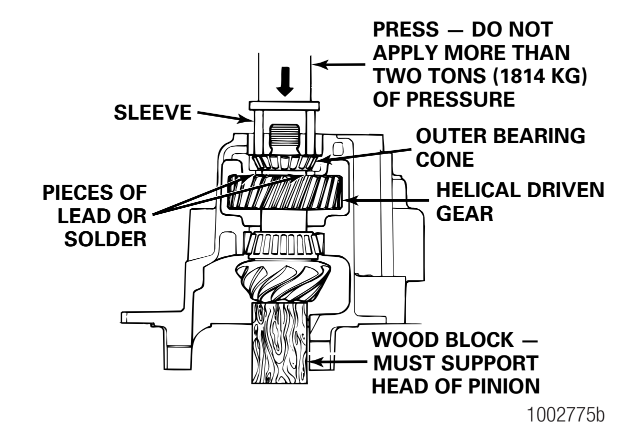


Figure 5.14

13. Release the pressure and remove the wood block from under the head of the drive pinion.
14. Use a press and a sleeve to press the shaft of the drive pinion out of the outer bearing cone. Do not press the shaft of the drive pinion out of the helical driven gear.
15. Remove the outer bearing cone and the two pieces of lead or solder from the outer bearing cone.
16. Use a micrometer to measure the thicknesses of the compressed pieces of lead or solder. Add the measurements of the two pieces and divide by two (2) to determine the average size of the pieces. Add 0.004-inch (0.100 mm) to the average size. Use this dimension to determine the size of the spacer to install between the helical driven gear and the outer bearing. Refer to Table G.

Table G

Example	Inch	(mm)
Thickness of piece number 1	0.504	(12.800)
Thickness of piece number 2	+0.506	(12.852)
Total thickness	1.010	(25.652)
Divide by two (2) to determine the average thickness	0.505	(12.826)
Add 0.004-inch (0.100 mm) to determine the thickness of the spacer	0.509	(12.926)

17. Place a wood block under the head of the drive pinion so that the inner bearing cone on the pinion touches the inner bearing cup in the carrier. Remove the supports from the carrier. Figure 5.15.

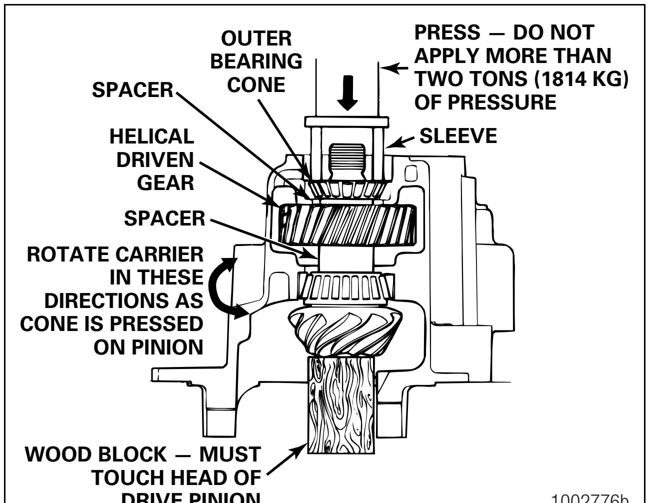


Figure 5.15

⚠ CAUTION

Do not apply pressure after the helical driven gear touches the spacer in front of the inner bearing on the drive pinion. If pressure is applied after the parts touch each other, the gear will damage the spacer.

NOTE: The inner bearing cone on the drive pinion must touch the inner bearing cup in the carrier when the helical driven gear is being installed.

18. Use a press and a sleeve to completely install the helical driven gear onto the drive pinion. Use a sleeve on the hub of the gear that fits inside the pinion bore in the carrier. Press the gear onto the drive pinion until the gear touches the spacer. Do not remove the wood block at this time. Figure 5.14.
19. Install the correct size spacer onto the shaft of the pinion in front of the helical driven gear.

NOTE: Verify that the wood block is still under the head of the drive pinion. The inner bearing cone on the pinion must touch the cup in the carrier.

20. Install the outer bearing cone onto the shaft of the drive pinion. Figure 5.15.
    A. Place the outer bearing cone onto the shaft of the drive pinion.
    B. Place a sleeve onto the top, inner race, of the outer bearing cone.
    C. Use a press to apply two tons (1814 kg) of force on the bearing cone to install the cone onto the shaft of the drive pinion. Rotate the carrier in both directions, so that the carrier pivots on the drive pinion, while the cone is being installed to verify that the bearing cone is correctly installed.
21. Release the pressure and remove the carrier from the press. Place the carrier in a repair stand.
22. Install the washer and the nut onto the drive pinion. Prevent the drive pinion assembly from rotating by using a fixture to hold the teeth of the helical driven gear or place wood blocks between the head of the pinion and the carrier wall. Tighten the nut to the specified torque. Refer to Section 8. Remove the holding fixture or the wood blocks.
23. Use an inch-pound torque wrench or a spring scale to inspect the preload of the bearings on the drive pinion.

Torque Wrench Method

1. Place an inch-pound (N•m) torque wrench and the correct socket onto the drive pinion nut. Figure 5.16.

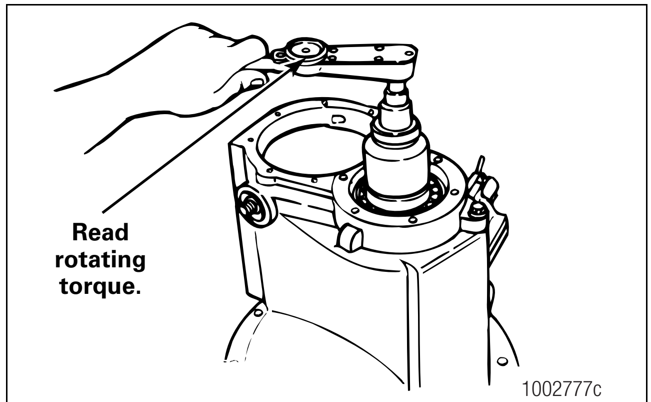


Figure 5.16

2. Use the torque wrench to rotate the drive pinion assembly. Inspect and record the torque level. Read while rotating the assembly. Record the dynamic or rotating torque not the breakaway torque.
3. The preload of the drive pinion bearings must be within the following limits.
    - For new pinion bearings: 5-45 lb-in (0.56-5.08 N•m) rotational torque
    - For used pinion bearings: 10-30 lb-in (1.13-3.39 N•m) rotational torque
    - **If the preload is not within the specified limits:** Remove and replace the spacer between the outer bearing cone and the helical driven gear. Refer to the procedure below.
        — **To decrease the preload:** Install a thicker spacer.
        — **To increase the preload:** Install a thinner spacer.

Spring Scale Method

1. Wind a cord around the washer under the nut of the drive pinion.
2. Attach a spring scale to the end of the cord.
3. Pull the spring scale and cord in a horizontal direction while looking at the reading on the spring scale. Figure 5.17.

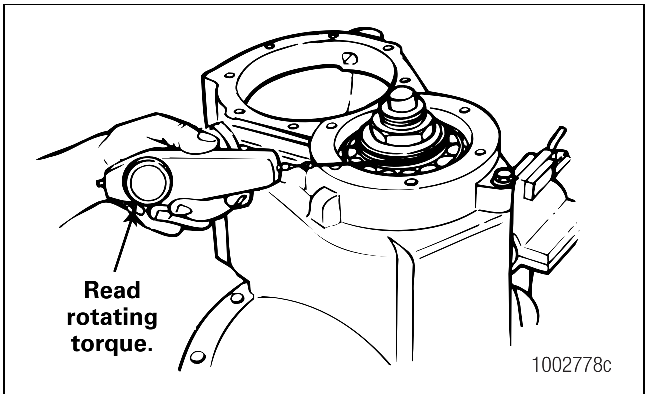


Figure 5.17

4. Measure the outer diameter of the washer under the drive pinion. Divide the outer diameter of the washer by two (2) to get the radius of the washer. Multiply the radius of the washer by the reading on the spring scale to get the preload on the pinion bearings.

Example

Outer diameter of the washer = 3.00-inches (76.20 mm)

Spring scale reading = 9 lbs (4 kg)

	Inch	(mm)
Outer diameter of the washer	3.00	(76.20)
Divide the outer diameter by two (2) to get the radius of the washer	1.50	(38.10)
Multiply the radius of the washer by the spring scale reading	13.50 lb-in	(1.49 N•m)

5. The preload of the drive pinion bearings must be within the following limits.
   - For new pinion bearings: 5-45 lb-in (0.56-5.08 N•m) rotational torque
   - For used pinion bearings: 10-30 lb-in (1.13-3.39 N•m) rotational torque
   - **If the preload is not within the specified limits:** Remove and replace the spacer between the outer bearing cone and the helical driven gear. Refer to the procedure below.

     — **To decrease the preload:** Install a thicker spacer.

     — **To increase the preload:** Install a thinner spacer.

Spacer Replacement

NOTE: Do not grind spacers by hand. The surfaces must be parallel within 0.0001-inch (0.0020 mm). You must use the correct spacers.

1. Prevent the drive pinion assembly from rotating by using a fixture to hold the teeth of the helical driven gear or place wood blocks between the head of the pinion and the carrier wall. Remove the nut and the washer from the shaft of the drive pinion. Figure 5.18.

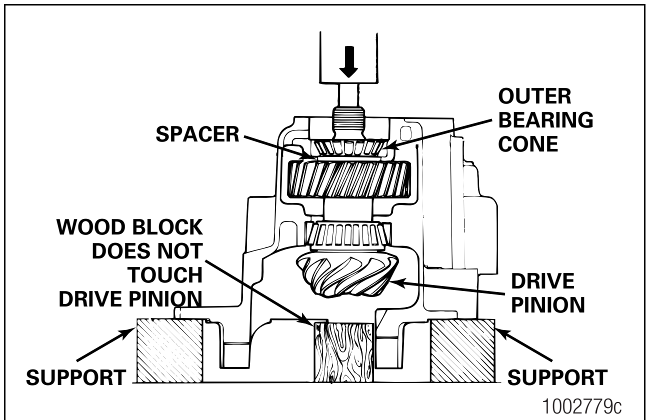


Figure 5.18

2. Place the carrier into a press so that the threaded end of the pinion is toward the TOP of the press. Place supports under the flange of the carrier so that the carrier is level. Place a wood block under the head of the pinion. Verify that the wood block does not touch the head of the drive pinion.
3. Press the drive pinion out of the bearing cone. Remove the outer bearing cone from the differential carrier.
4. Install the correct size spacer onto the shaft of the pinion over the helical driven gear.
5. Repeat Step 20 through Step 23 under Drive Pinion Bearing Preload in this section.
6. When the preload is within the specified range, install the main differential case and ring gear assembly into the carrier. Refer to procedure in this section.

Assembly

Main Differential and Ring Gear

⚠ CAUTION

Heat the ring gear before seating it onto the differential case. Do not press a cold ring gear on the flange case half. A cold ring gear will damage the case half because of the tight fit.

1. Expand the ring gear by heating the gear in a tank of water to 160-180°F (71-82°C) for 10 to 15 minutes.

⚠ WARNING

Wear safe clothing and gloves for protection from injury when working with the hot ring gear.

2. Use a lifting tool to safely lift the ring gear from the tank of water.
3. Install the ring gear onto the flange case half immediately after the gear is heated.
   - **If the ring gear does not fit easily on the case half:** Heat the gear again.
4. Align the ring gear and flange case half fastener holes. Rotate the ring gear as necessary.

NOTE: If rivets were used to hold the ring gear to the flange case half, replace them with bolts, nuts and washers. 140 Series carriers with rivets are serviced with bolt kits for reassembly.

5. Install the bolts, nuts and washers, if equipped, that hold the ring gear to the flange case half. Install the bolts from the front side of the gear. The bolt threads must be installed from the inside face of the ring gear and the nuts tightened from the back of the ring gear. Figure 5.19.

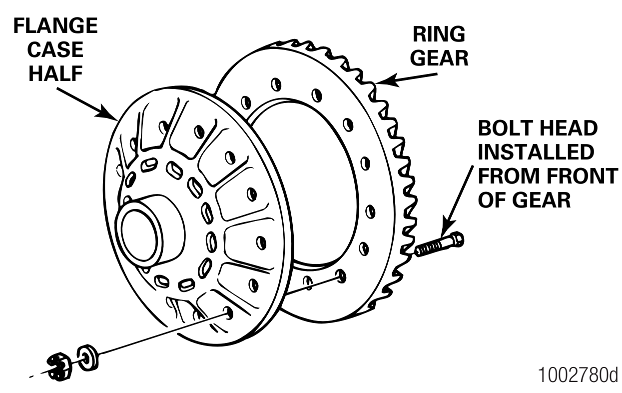


Figure 5.19

6. Tighten the bolts and nuts, if equipped, to the correct torque value. Refer to Section 8.
7. Inspect for gaps between the back surface of the ring gear and the case flange. Use a 0.003-inch (0.080 mm) feeler gauge to inspect at four points around the assembly. Figure 5.20.
   - **If the gaps exceed specification:** Inspect the flange case half and ring gear for the problem that causes the gap. Repair or replace parts as necessary. Reassemble the ring gear on the flange case half. Reinspect for gaps.

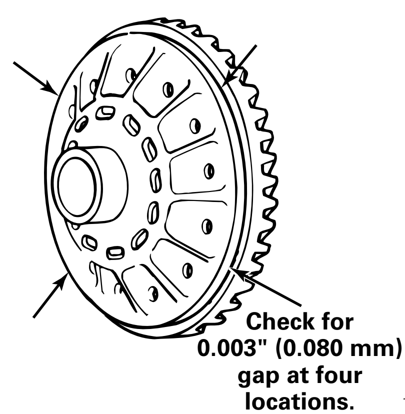


Figure 5.20

8. Use a press and the correct size sleeve to install the bearing cones onto both of the case halves. Figure 5.21.

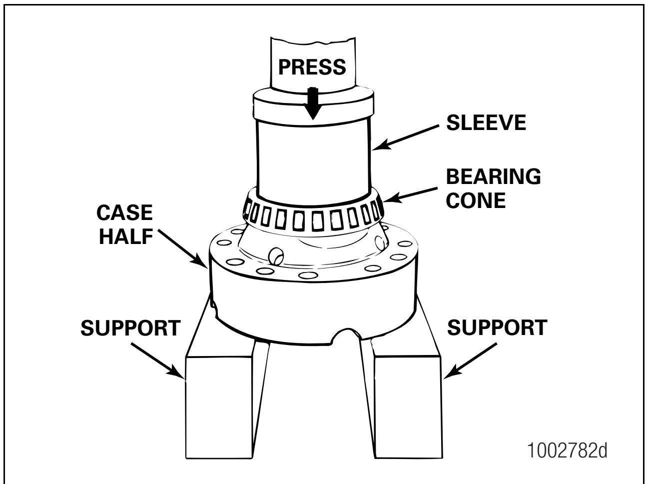


Figure 5.21

9. Apply axle lubricant on the inside surfaces of both case halves, spider or cross, thrust washers, side gears and differential pinions.
10. Place the flange case half onto a bench with the ring gear teeth toward the TOP.

⚠ CAUTION

The side gears in some carrier models have hubs of different lengths. Install the correct length side gear into the flange case half. Damage to components can result.

11. Install one thrust washer and side gear into the flange case half. Figure 5.22.

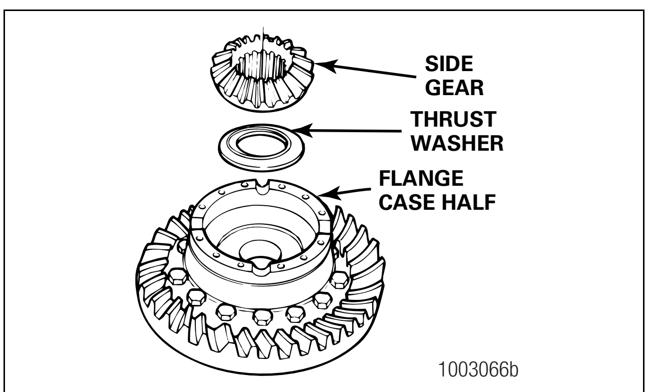


Figure 5.22

12. Install the spider or cross, differential pinions and thrust washers into the flange case half. Figure 5.23.

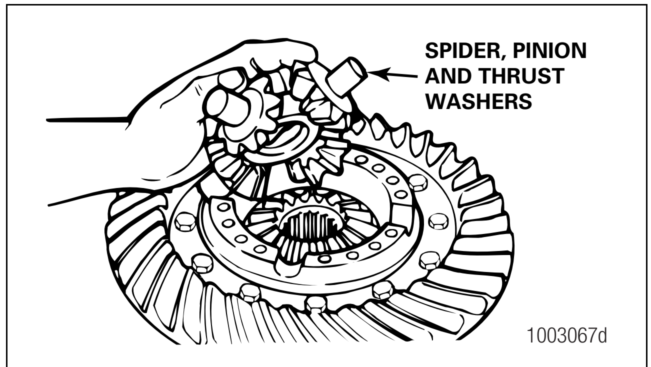


Figure 5.23

13. Install the second side gear and thrust washer over the spider and differential pinions. Figure 5.24.

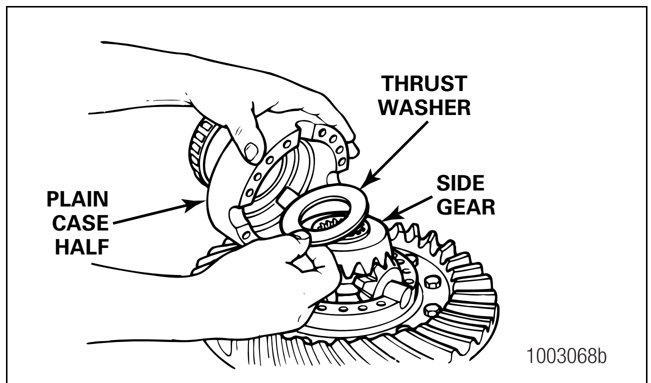


Figure 5.24

14. Place the plain half of the differential case over the flange half and gears. Rotate the plain half as needed to align the match marks. Figure 5.24 and Figure 5.25.

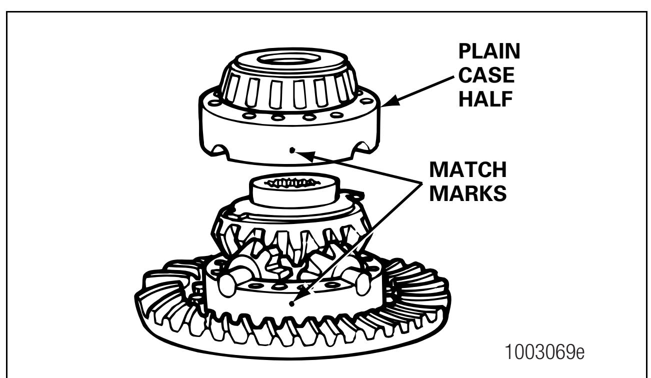


Figure 5.25

15. Install Dri-Loc® or equivalent fasteners into the case halves. Refer to Section 4.
    A. Install four capscrews and washers or bolts, nuts and washers into the case halves. The distance between the fasteners must be equal. Tighten the fasteners to the correct torque value in a crisscross pattern opposite each other. Refer to Section 8. Figure 5.26.
    B. Install the other fasteners into the case halves. Tighten the fasteners to the correct torque value. Refer to Section 8.

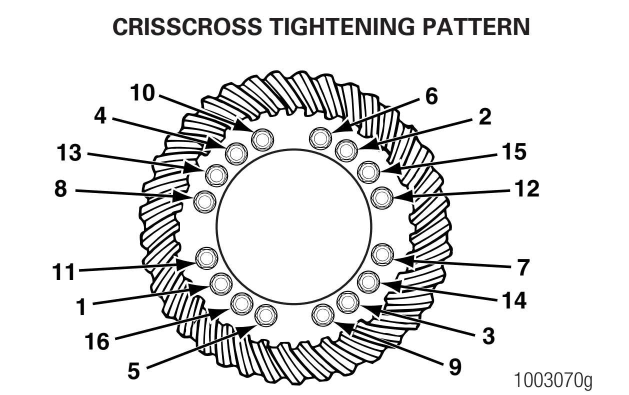


Figure 5.26

16. Check the rotating resistance of the differential gears. The differential assembly must rotate freely.

Check the Rotating Resistance of the Differential Assembly

1. Make an inspection tool using an axle shaft that matches the spline size of the differential side gear. Cut the shaft to approximately 12-inches (304.8 mm). Weld a nut onto the end of the shaft. Figure 5.27.

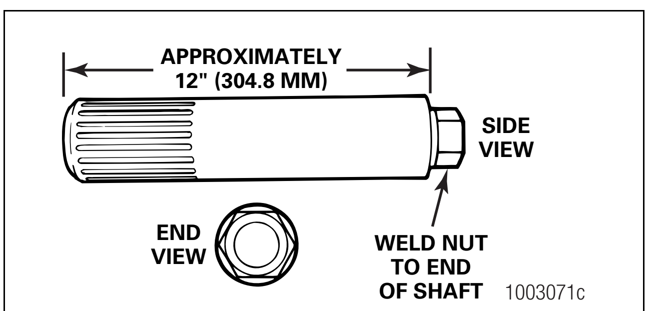


Figure 5.27

2. Place the differential and ring gear assembly into a vise. Install soft metal covers over the vise jaws to protect the ring gear. Figure 5.28.

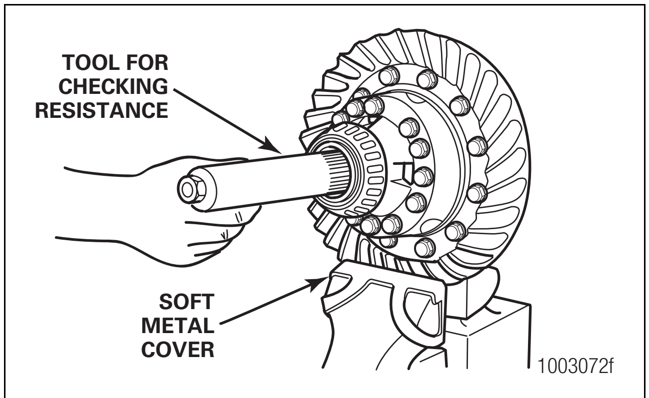


Figure 5.28

3. Install the tool into the differential until the splines of the tool are engaged with one side gear. Figure 5.28.
4. Place a torque wrench onto the nut of the tool and rotate the differential gears. As the differential gears rotate, read the value indicated on the torque wrench. Figure 5.29.
   - **If the torque value exceeds 50 lb-ft (67.8 N•m):** Disassemble the differential gears from the case halves. Inspect the case halves, spider, gears and thrust washers. Repair or replace parts. Assemble the parts and repeat Step 2 through Step 4.

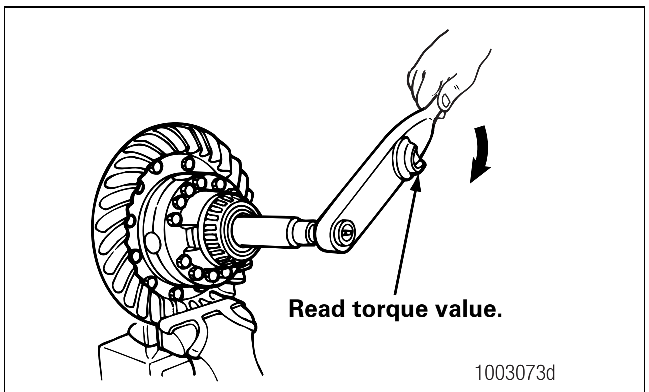


Figure 5.29

Installation

Main Differential Case and Ring Gear Assembly Into the Carrier

1. If the bearing cones on the main differential case were removed, install a new cone and cup in a fully-matched set from the same manufacturer. The bearing cones are not interchangeable. Use a press and sleeve to install the cones onto the case. Press only on the inner race of the bearing. Figure 5.30.

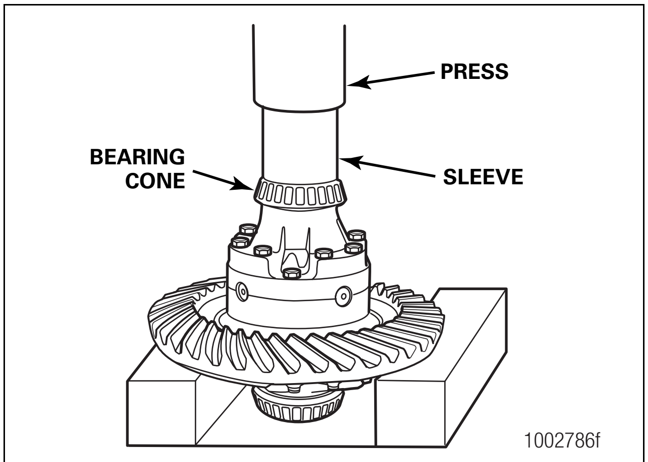


Figure 5.30

2. Clean and dry the bearing cups and bores of the carrier legs and bearing caps.
3. Apply axle lubricant to the bearing cups and cones.
4. Apply Meritor specification 2297-T-4180 adhesive evenly in the bearing bores of the carrier legs and bearing caps. Cover the surfaces completely. The adhesive must not contact the adjusting ring threads. Figure 5.31. Refer to Section 4.
5. Install the bearing cups over the bearing cones in the case halves. Figure 5.32.
6. Safely lift the differential and ring gear assembly and install it into the carrier. The bearing cups must be flat against the bores between the carrier legs. Figure 5.32.

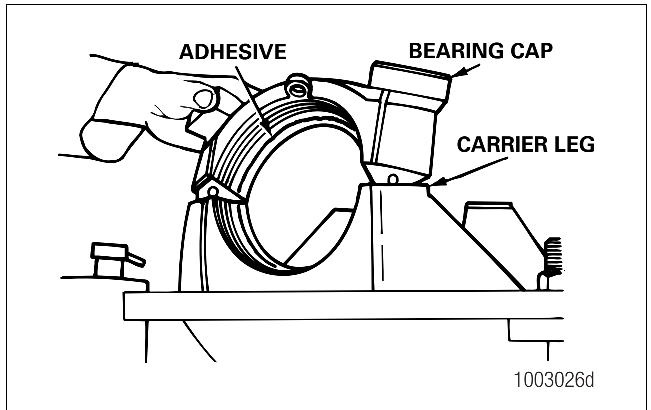


Figure 5.31

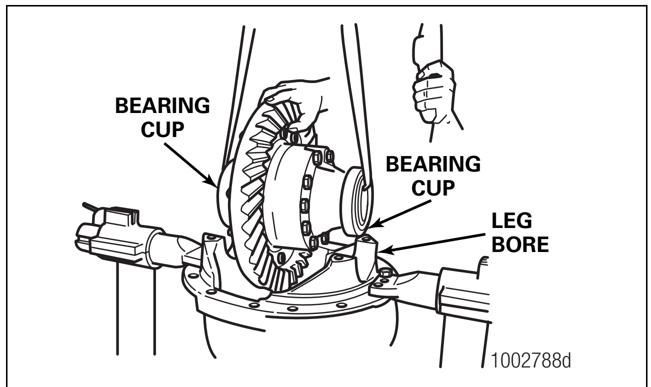


Figure 5.32

7. Install the bearing adjusting rings between the carrier legs. Hand-tighten the adjusting rings against the bearing cups. Figure 5.33.

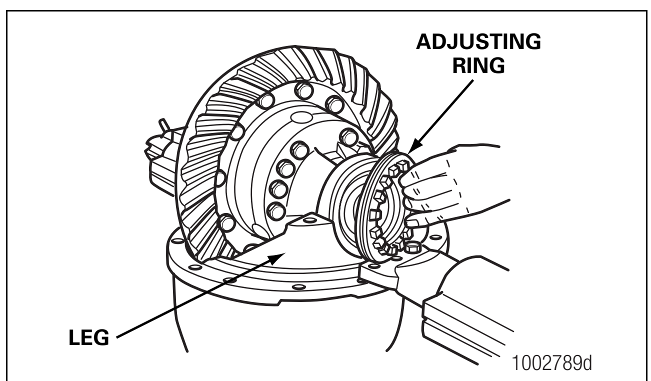


Figure 5.33

⚠ CAUTION

The bearing caps must be correctly installed or the adjusting rings will be damaged by cross-threading. Forcing the caps into position can damage the caps and the carrier housing.

8. Install the bearing caps over the bearings and adjusting rings in the correct location as marked before removal. Figure 5.34.

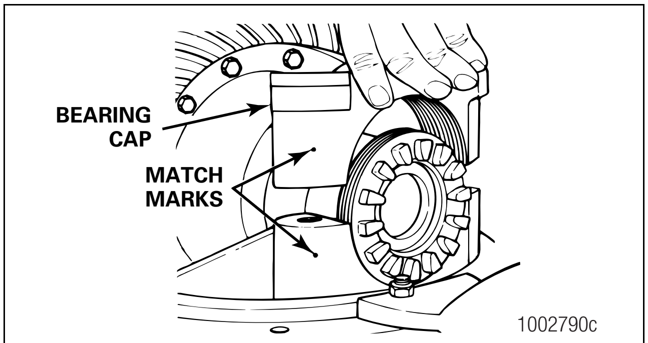


Figure 5.34

⚠ WARNING

Use a brass or synthetic mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off. Serious personal injury and damage to components can result.

⚠ CAUTION

If bearing caps are not installed correctly in the original carrier locations, the bores and threads in the caps will not match the carrier. Forcing the bearing caps into the incorrect position will result in damage to the carrier.

9. Use a light leather plastic or rubber mallet to seat each bearing cap. The caps must fit easily against the bearings, adjusting rings and carrier. Do not force the bearing caps into position.
   - **If the bearing caps do not correctly fit into position:** Check the alignment of the match marks between the caps and carrier. Remove the caps and repeat Step 7 through Step 9.
10. Install the capscrews and washers that secure the bearing caps to the carrier. Hand-tighten the capscrews four to six turns, then tighten the capscrews to the correct torque value. Refer to Section 8.

    Do not install the capscrews, cotter pins or roll pins, if equipped, that secure the bearing adjusting rings in position. Continue by adjusting the preload of the differential bearings, adjust the backlash of the hypoid gear and inspect the tooth contact patterns.

Adjustment

Differential Bearings Preload

Use either the dial indicator or the large micrometer method to inspect and adjust the main differential side bearings preload.

NOTE: The roll pins for the adjusting rings are installed after the tooth contact pattern is checked.

Dial Indicator Method

1. Attach a dial indicator onto the carrier mounting flange so that the plunger or the pointer is against the back surface of the ring gear. Figure 5.35.

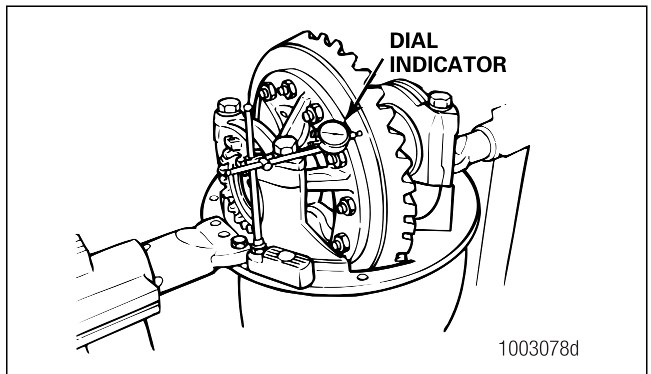


Figure 5.35

⚠ CAUTION

When you turn the adjusting rings, always use a tool that engages two or more opposite notches in the ring. A T-bar wrench can be used for this purpose. If the tool does not correctly fit into the notches, damage to the lugs will occur.

NOTE: On 160 Series axles, half of the bearing assembly extends out of the bearing cap and carrier.

2. Use a T-bar wrench to loosen the adjusting ring that is opposite the ring gear. A small amount of end play will show on the dial indicator. Figure 5.36.

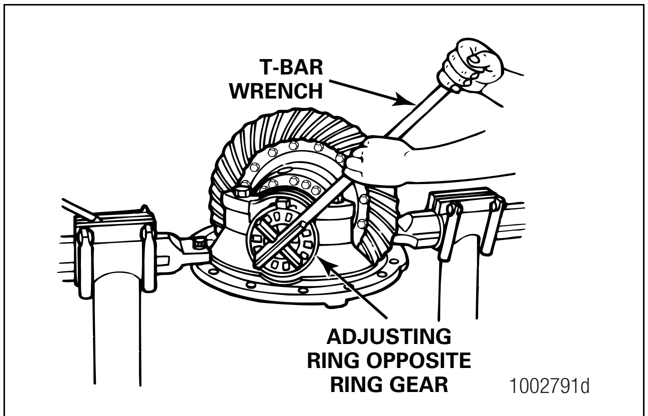


Figure 5.36

3. Use one of the following methods to move the differential and the ring gear carefully to the left and right while you read the dial indicator.
   A. Insert two pry bars between the bearing adjusting rings and the ends of the differential case. The pry bars must not touch the differential bearings. Figure 5.37.
   B. Insert two pry bars between the differential case or the ring gear and the carrier at locations other than described in Step A. The pry bars must not touch the differential bearings. Figure 5.38.

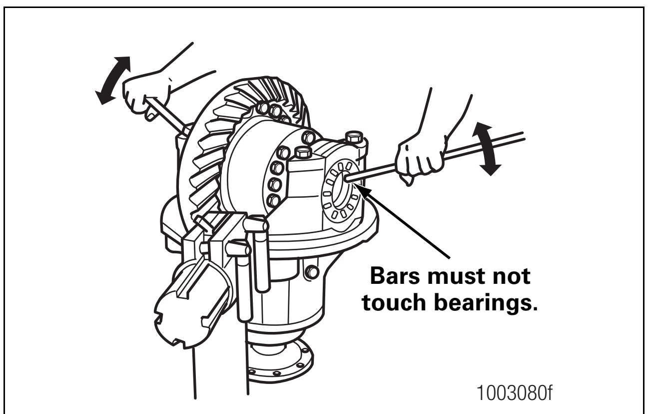


Figure 5.37

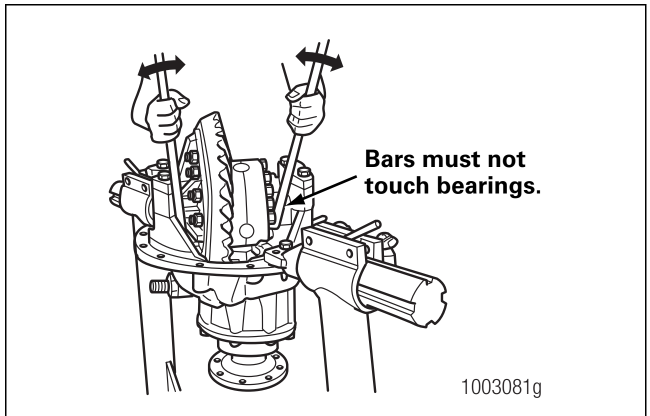


Figure 5.38

4. Tighten the bearing adjusting ring until the dial indicator reads ZERO end play. Move the differential and ring gear to the left and right as needed. If necessary, repeat Step A or Step B.
5. Tighten each bearing adjusting ring one notch from ZERO. The side bearings of the differential should have a preload of 15-35 lb-in (1.7-3.9 N•m). Figure 5.39.

   This procedure should expand the caps 0.008-0.010-inch (0.203-0.254 mm), and place the correct preload on the bearings when they are installed into the banjo housing.

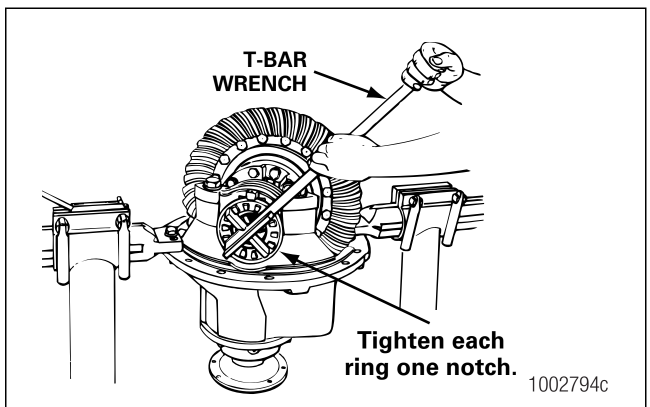


Figure 5.39

6. Proceed to check ring gear runout.

Large Micrometer Method

1. Hand-tighten the adjusting rings against the differential bearings.
2. Use a large micrometer to measure distance X and Y between the opposite surfaces of the bearing caps. Record the measurement. Figure 5.40 and Figure 5.41.

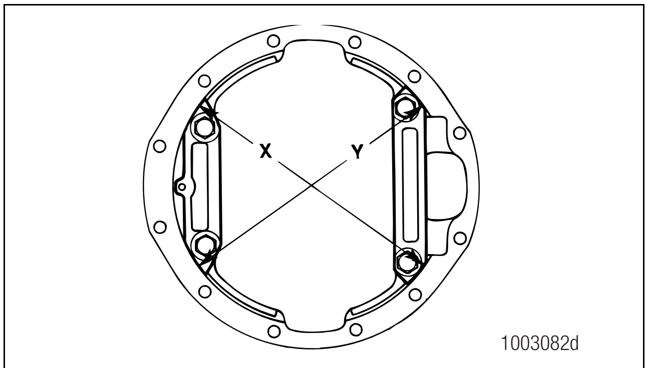


Figure 5.40

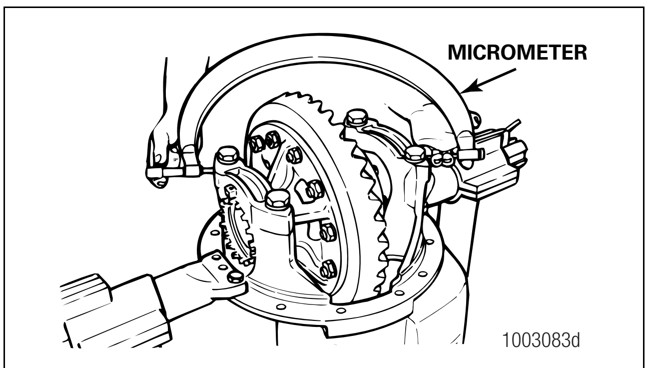


Figure 5.41

⚠ CAUTION

When turning the adjusting rings, always use a tool that engages two or more opposite notches in the ring. A T-bar wrench can be used for this purpose. If the tool does not correctly fit into the notches, damage to the lugs will occur.

3. Use a T-bar wrench to tighten each bearing adjusting ring one notch. Figure 5.36.
4. Measure distance X and Y again. Compare the measurements with the distances X and Y measured in Step 2. The difference between the two distances is the amount the bearing caps have expanded. Refer to Table H.

Table H: Example

Distances X and Y BEFORE tightening the adjusting rings	= 15.315-inches (389 mm)
Distances X and Y AFTER tightening the adjusting rings	= 15.324-inches (389.230 mm)
15.324-inches – 15.315-inches	= 0.009-inch difference
389.230 mm – 389.000 mm	= 0.230 mm difference

5. **If the difference is at or within the specification in Table I:** Continue by checking the runout.

   If the difference is less than the specification: Repeat as needed.

Table I: Expansion Between Bearing Caps

RS-140, RS-145 and RS-160 carrier models	0.002-0.009-inch (0.050-0.229 mm)
RS 120 and all other carrier models	0.006-0.013-inch (0.15-0.33 mm)

Ring Gear Runout

1. Attach a dial indicator onto the carrier mounting flange. Figure 5.42.

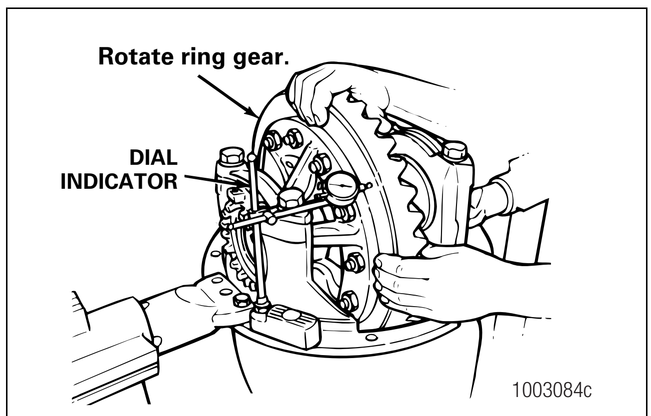


Figure 5.42

2. Adjust the dial indicator so that the plunger or pointer is against the back surface of the ring gear. Figure 5.42. Set the dial indicator to ZERO.

3. Rotate the differential and ring gear. Read the dial indicator. The ring gear runout must not exceed 0.008-inch (0.200 mm).
   - **If the ring gear runout is within the specification:** Proceed to Ring Gear Backlash.
   - **If the ring gear runout exceeds the specification:** Remove the differential and ring gear assembly from the carrier. Refer to Section 3.

   A. Inspect the differential parts, including the carrier, for wear and damage. Repair or replace parts as necessary.

   B. Install the main differential case and ring gear assembly into the carrier. Refer to the procedure in this section.

   C. Repeat the procedure for preload adjustment of the differential side bearings.

Ring Gear Backlash

Table J: Specifications

Ring Gear Pitch Diameter	Range of Backlash Setting	Backlash Setting for New Gear Sets
Less than 17-inches (431.8 mm)	0.008-0.018-inch (0.20-0.46 mm)	0.012-inch (0.30 mm)
Greater than 17-inches (431.8 mm)	0.010-0.020-inch (0.25-0.51 mm)	0.015-inch (0.38 mm)

Measure the outer diameter of the ring gear for the approximate pitch diameter. Figure 5.43.

- **If the old gear set is installed:** Adjust the backlash to the setting that was measured before the carrier was disassembled.
- **If a new gear set is installed:** Adjust the backlash to the correct specification for new gear sets.

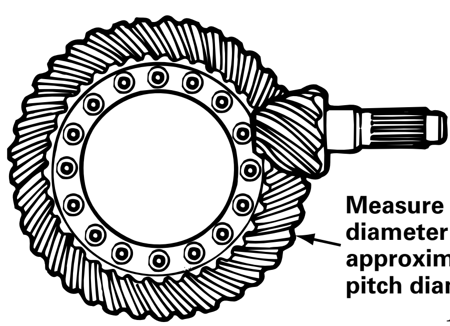


Figure 5.43

After checking the tooth contact patterns, the backlash can be adjusted within the specification limits, if needed. To change the location of the pattern, use the following procedures.

1. Attach a dial indicator onto the carrier mounting flange. Figure 5.44.

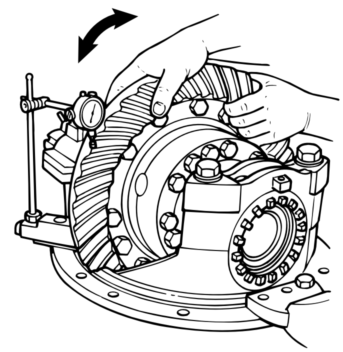


Figure 5.44

2. Adjust the dial indicator so that the plunger is against the tooth surface.
3. Adjust the dial indicator to ZERO. Hold the drive pinion in position.
4. After reading the dial indicator, rotate the differential and ring gear a small amount in both directions against the drive pinion teeth.
   - **If the backlash reading is within the specification:** Check the tooth contact patterns.
   - **If the backlash reading is not within the specification:** Adjust the backlash as needed.
5. Loosen one bearing adjusting ring one notch. Tighten the opposite ring by the same amount.
   - **To increase the backlash:** Move the ring gear away from the drive pinion. Figure 5.45.
   - **To decrease the backlash:** Move the ring gear toward the drive pinion. Figure 5.46.

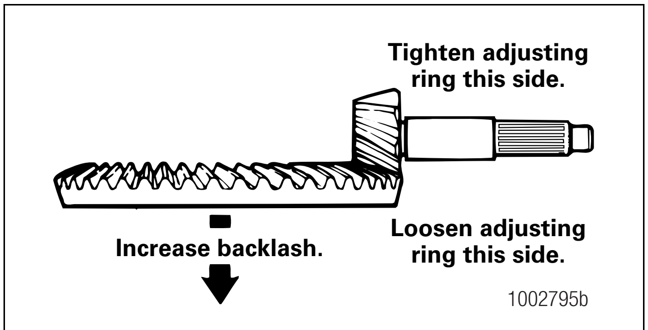


Figure 5.45

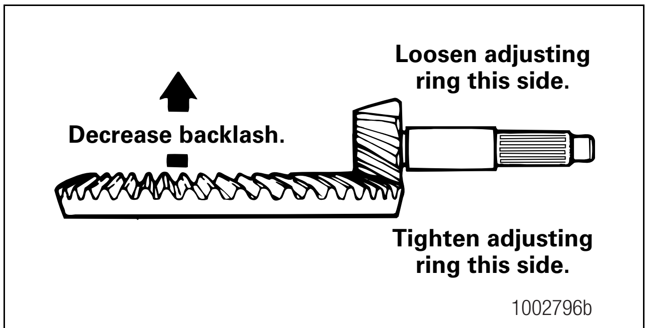


Figure 5.46

NOTE: When you adjust the backlash, only move the ring gear. Do not move the drive pinion.

6. Repeat Step 2 through Step 5 until the backlash is within specification. Record the setting for use when you adjust the pinion bearing preload.

Gear Set Tooth Contact Patterns, Backlash

Meritor carriers can have a conventional or a generoid hypoid gear set. The tooth contact patterns for each type of gear set are different. Check the part numbers to determine what type of gear set is in the carrier. Refer to Figure 5.47 for the location of part numbers. Refer to Section 4.

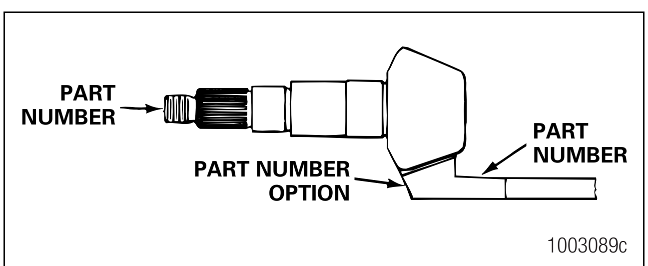


Figure 5.47

Examples

The following are part numbers for generoid gear sets.

- 36786-K or 36786-K2 for the ring gear
- 36787-K or 36787-K2 for the drive pinion

In the following procedures, movement of the contact pattern along the length of the tooth is indicated as toward the heel or toe of the ring gear. Figure 5.48.

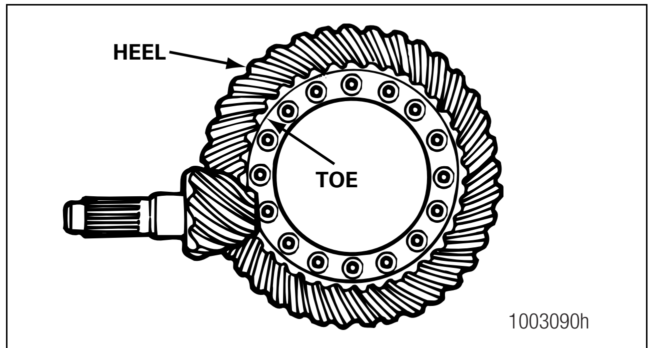


Figure 5.48

Always check the tooth contact patterns on the drive side of the gear teeth. Figure 5.49.

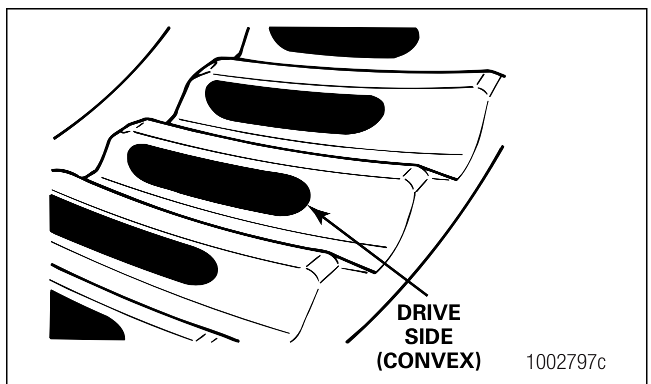


Figure 5.49

1. Adjust the backlash of a new gear set to either 0.012-inch (0.305 mm) or 0.015-inch (0.380 mm) depending on the size of the ring gear. Adjust the backlash of an old gear set to the setting that was measured before the carrier was disassembled. Refer to procedure in this section.
2. Apply a marking compound onto approximately 12 gear teeth of the ring gear. Rotate the ring gear so that the 12 gear teeth are next to the drive pinion. Figure 5.50.

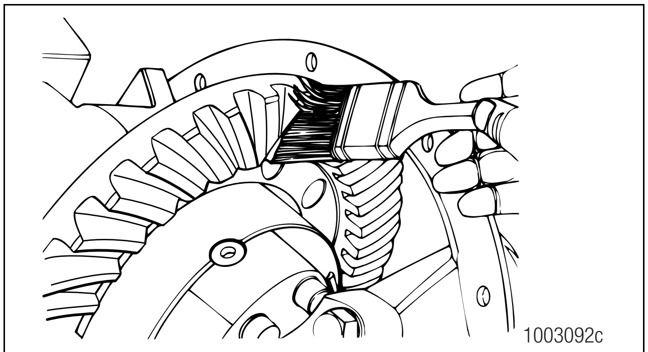


Figure 5.50

3. Rotate the ring gear forward and backward so that the 12 gear teeth go past the drive pinion six times to get the contact pattern. Repeat, if needed, to get a more clear pattern.
4. Look at the contact patterns on the ring gear teeth. Compare the patterns to Figure 5.51, Figure 5.52 and Figure 5.53.

   The location of a good hand-rolled contact pattern for a new gear set is toward the toe of the gear tooth and in the center between the top and bottom of the tooth.

   When the carrier is operated, a good pattern will extend approximately the full length of the gear tooth. The top of the pattern will be near the top of the gear tooth. Figure 5.54.

   The location of a good hand-rolled contact pattern for an old gear set must match the wear pattern in the ring gear. The new contact pattern will be smaller in area than the old wear pattern.

   A high contact pattern indicates that the drive pinion was not installed deep enough into the carrier. A low contact pattern indicates that the drive pinion was installed too deep in the carrier.

   - **If the contact pattern requires adjustment:** Continue by following Step 5 to move the contact patterns between the top and bottom of the gear teeth.
   - **If the contact patterns are in the center of the gear teeth:** Continue by following Step 6.

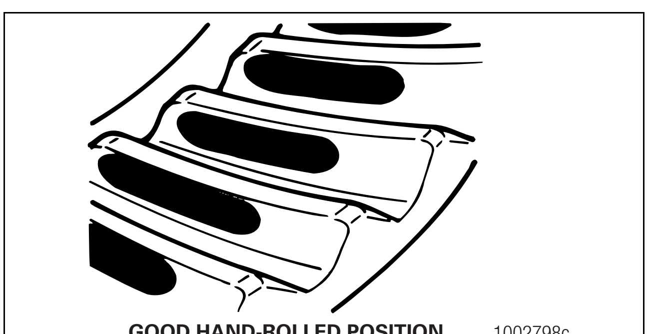


Figure 5.51

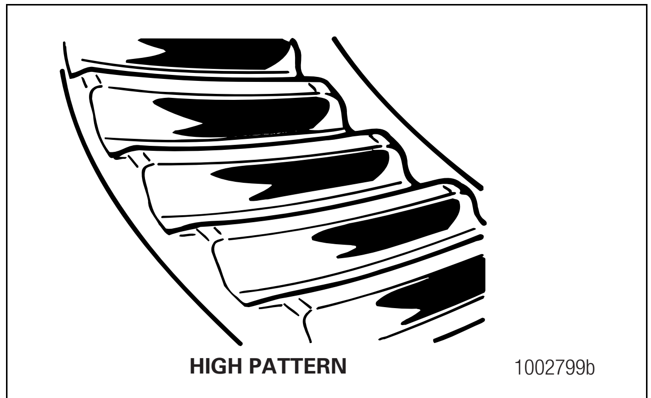


Figure 5.52

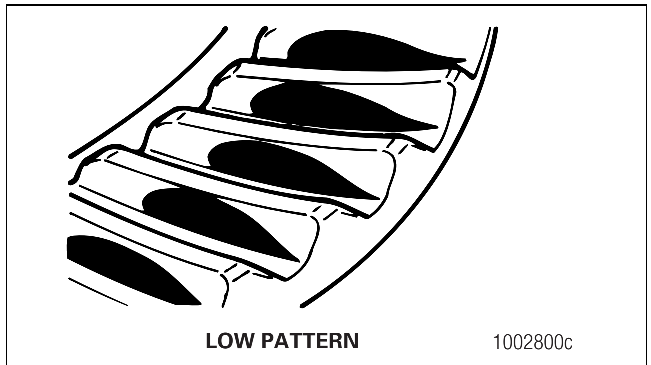


Figure 5.53

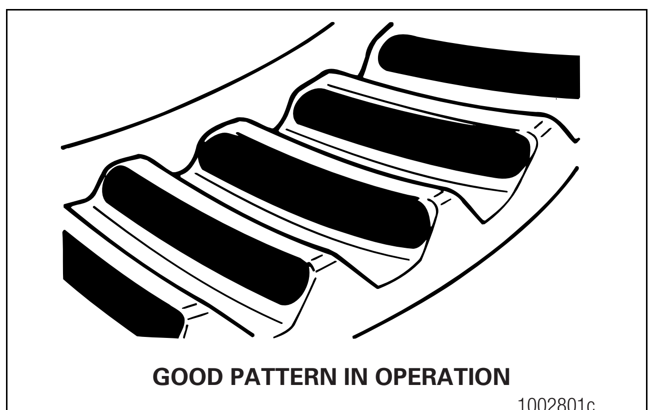


Figure 5.54

5. Change the thickness of the shim pack between the pinion inner bearing cup and the differential carrier to move the contact patterns between the top and the bottom of the gear teeth.

   A. Remove the drive pinion, inner bearing cup and shims from the carrier. Refer to Section 3.

      - **To correct a high-contact pattern:** Increase the thickness of the shim pack. When you increase the thickness of the shim pack, the drive pinion will move toward the ring gear. Figure 5.55.
      - **To correct a low contact pattern:** Decrease the thickness of the shim pack. When you decrease the thickness of the shim, the drive pinion will move away from the ring gear. Figure 5.56.

   B. Install the inner bearing cup, the shims and the drive pinion into the carrier. Refer to procedure in this section.

   C. Repeat Step 2 through Step 5 until the contact patterns are in the center between the top and bottom of the gear teeth.

Figure 5.55

Figure 5.56

6. Adjust the ring gear backlash within the specification range to move the contact patterns to the correct location along the length of the gear teeth. Refer to procedure in this section.

   A. Decrease the backlash to move the contact patterns toward the toe of the ring gear teeth. Figure 5.57.

   B. Increase the backlash to move the contact patterns toward the heel of the ring gear teeth. Figure 5.58.

   C. Repeat Step 2 through Step 4 and Step 6 until the contact patterns are at the correct location along the length of the gear teeth.

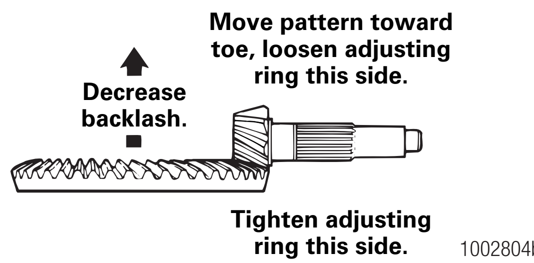


Figure 5.57

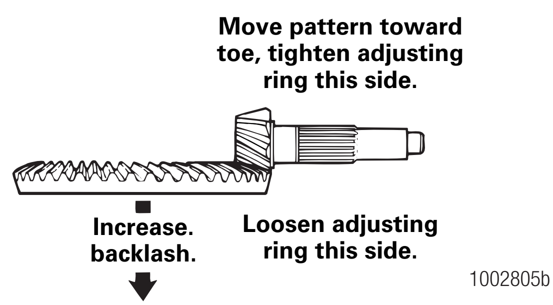


Figure 5.58

⚠ CAUTION

If the carrier has cotter pins or capscrews, lock the adjusting rings only with cotter pins or capscrews. If the carrier has roll pins, reuse the roll pins. Do not force a roll pin into a cotter pin hole. Damage to components can result.

7. Install the capscrews, cotter pins, roll pins or lock plates, if equipped, that hold the two bearing adjusting rings in position. Use the following procedures.
   A. Install capscrews between the lugs of the adjusting ring and through the boss of the bearing cap. New capscrews include a locking patch, which can only be used once. If you are installing used capscrews, apply Loctite® threadlocker to the capscrew threads before you install the capscrews. Figure 5.59.
   B. Install cotter pins between the lugs of the adjusting ring and through the boss of the bearing cap. Bend the two ends of the cotter pin around the boss. Figure 5.59.
   C. Use a drift and hammer to install the roll pin through the boss of the bearing cap until the roll pin is between the lugs of the adjusting ring. Figure 5.59.
   D. Install the lock plate onto the bearing cap so that the tab is between the lugs of the adjusting ring. Install the two capscrews and washers that hold the lock plate to the bearing cap. Tighten the capscrews to the correct torque value. Refer to Section 8. Figure 5.59.

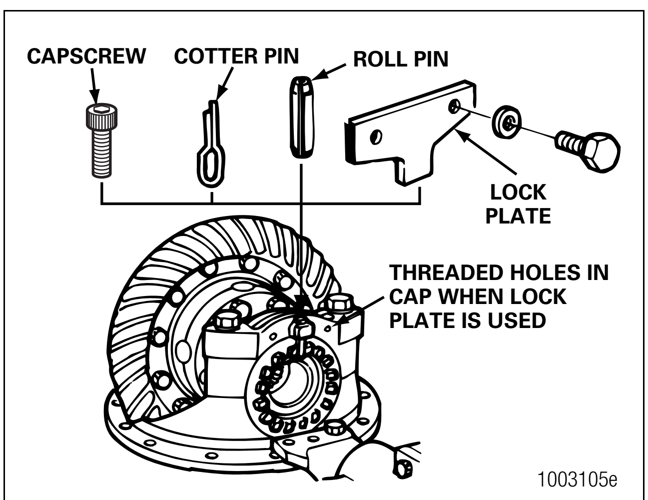


Figure 5.59

Installation

Thrust Screw (If Equipped)

1. Rotate the carrier in the repair stand until the back surface of the ring gear is toward the TOP.
2. Install the jam nut onto the thrust screw. Thread the jam nut to the middle of the thrust screw. Figure 5.60.

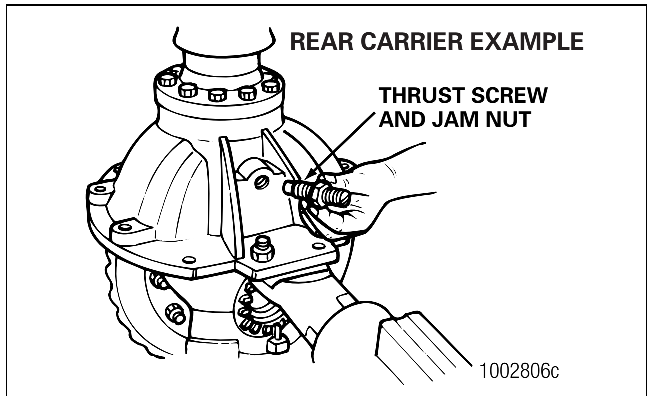


Figure 5.60

3. Install the thrust screw into the carrier. Use a feeler gauge to verify that the clearance between the thrust screw and the ring gear is 0.025-0.045-inch (0.65-1.14 mm).
4. Loosen the thrust screw one-half turn or 180 degrees. Figure 5.61.

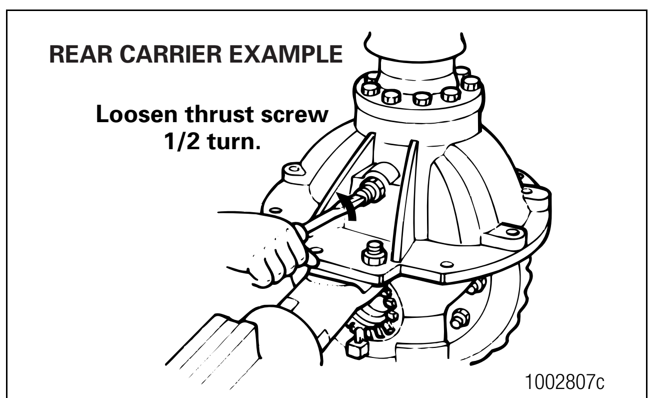


Figure 5.61

5. Tighten the jam nut, if equipped, to the correct torque value against the carrier. Refer to Section 8. Figure 5.62.

   To complete the assembly of axles equipped with driver-controlled main differential locks, refer to Section 6.

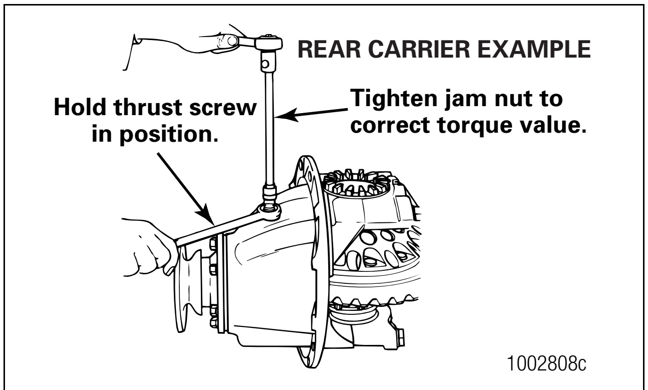


Figure 5.62

Air Shift Unit for the Inter-Axle Differential Lock

Air Applied and Spring Release Models, Standard

1. Inspect the shift shaft for damage. Use an emery cloth to remove any small damage. If necessary, replace the shift shaft. Figure 5.63.

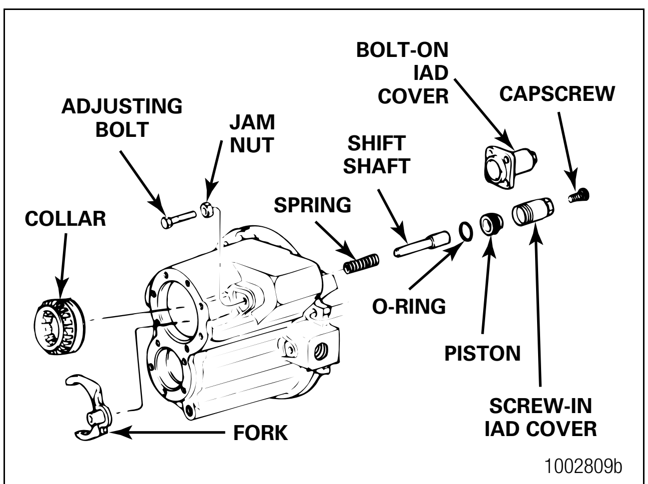


Figure 5.63

2. Place the spring and the shift fork into position in the carrier. The spring must touch the screw side of the carrier. The boss on the fork must be toward the adjusting bolt.

3. Install the shift shaft so the smaller part of the shaft goes through the fork and the spring.

4. If removed, install the O-ring onto the piston. Apply axle lubricant to the O-ring.

5. Install the piston onto the shift shaft.

⚠ WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

6. On flange-type cylinders, apply silicone gasket material onto the mounting surface of the cylinder.

   On threaded cylinders, apply a continuous 0.06-inch (1.5 mm) diameter bead of Loctite® flange sealant, Meritor part number 2297-D-7076, around the cylinder thread circumference.

7. Install the cylinder. On flange-type cylinders, install and tighten the capscrews 7-12 lb-ft (10-16 N•m).

NOTE: The adjusting screw is set to the specified distance after the input shaft assembly is installed.

8. Install the adjusting bolt and the jam nut.

Spring Applied and Air Release Models (Reverse Shift Systems)

1. Lubricate all the parts with axle lubricant. Figure 5.64.

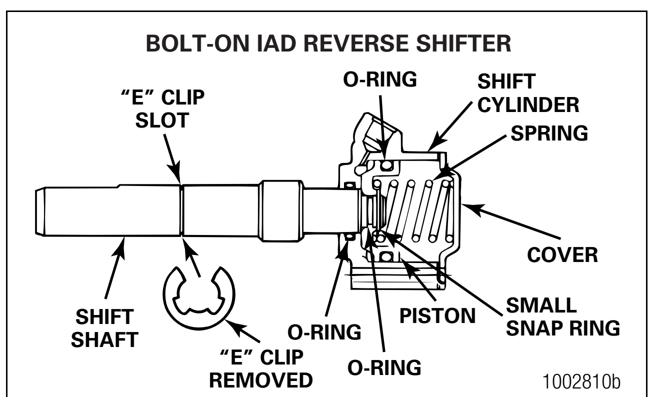


Figure 5.64

2. Inspect the shift shaft for damage. If necessary, replace the shift shaft.
3. If removed, install new O-rings into the groove in the shift shaft, into the groove in the shift cylinder and onto the piston.
4. Lubricate the bore of the shift cylinder with axle lubricant.
5. Install the piston into the shift cylinder.
6. Insert the shift shaft into the piston and shift cylinder assembly.
7. Install the small snap ring that fastens the piston onto the shift shaft.
8. Install the spring into the piston bore.
9. Install the gasket so that the tab on the gasket is under the right capscrew bore.
10. Place the shift cover onto the shift cylinder housing. Install two capscrews and washers to fasten the shift cover to the cylinder.
11. Install the assembly into the carrier so that the shift shaft is in the bore of the shift fork.
12. Install the "E" clip onto the shift shaft slot in front of the shift fork.
13. Install the capscrews and washers that fasten the assembly to the carrier. Tighten the capscrews to 7-12 lb-ft (10-16 N•m). T

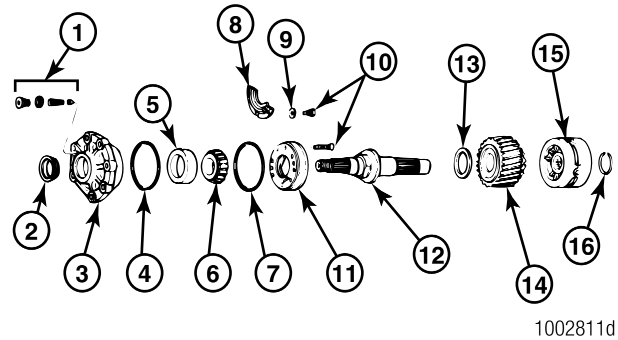
NOTE: The adjusting screw is set to the specified distance after the input shaft assembly is installed.

14. Install the adjusting bolt and jam nut.

Assembly

Input Shaft, Bearing Cage, Oil Pump and Inter-Axle Differential

1. Apply axle lubricant to the parts as they are being assembled. Figure 5.65.



1	PRESSURE RELIEF VALVE ASSEMBLY	10	CAPSCREWS
2	OIL SEAL	11	OIL PUMP — UNITS WITH OIL PUMP
3	BEARING CAGE	12	INPUT SHAFT
4	O-RING	13	THRUST WASHER
5	BEARING CUP	14	HELICAL DRIVE GEAR
6	BEARING CONE	15	INTER-AXLE DIFFERENTIAL
7	O-RING	16	SNAP RING
8	OIL BAFFLE — UNITS WITHOUT OIL PUMP		
9	WASHER		

Figure 5.65

2. If removed, install the bearing cup into the input bearing cage. Use a press and a sleeve to install the cup into the cage. The cup is correctly installed when the bottom of the cup is fully seated in the cage bore.
3. If removed, install a new oil seal into the input bearing cage.
   - **For unitized pinion seals:** Refer to the unitized pinion seal installation procedure in this section and then proceed to Step 4. Figure 5.66.
   - **For all other seals:** Refer to the following instructions.

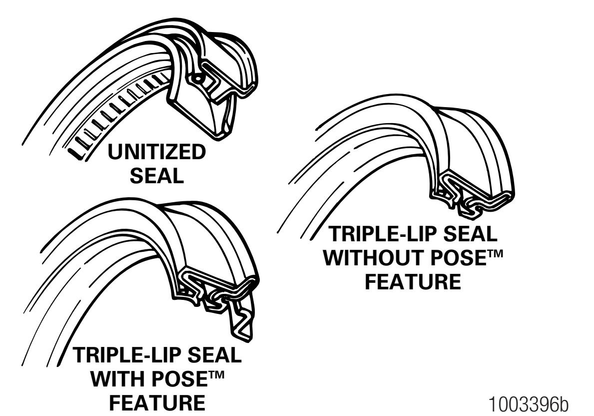


Figure 5.66

A. Apply axle lubricant to the inner bore of the bearing cage or the outer diameter of the new oil seal.

⚠ CAUTION

Hold the seal only on the outer diameter. Do not touch the lips in the inner diameter of the seal. If you touch the lips on the inner diameter of the seal, you will contaminate the lips and could cause a leak between the shaft and the seal.

B. Place the oil seal into the bearing cage so that the flange is parallel to the top of the cage.

C. Use a press and driver or flat metal plate to install the oil seal into the bearing cage. Figure 5.67.

⚠ CAUTION

Do not apply pressure after the seal flange touches the top of the cage or you will damage the cage.

D. Apply pressure until the metal flange of the seal is seated to the top of the cage.

E. After the seal is installed, a gap of 0.015-0.030-inch (0.381-0.762 mm) can exist between the flange and the cage. The gap is a normal condition because of the flexible coating on the flange of the seal. Use a feeler gauge to measure the gap between the complete flange-to-cage area.

- **If the gap varies more than 0.010-inch (0.254 mm) between the highest and lowest measurement:** Remove and reseat the seal. Figure 5.68.

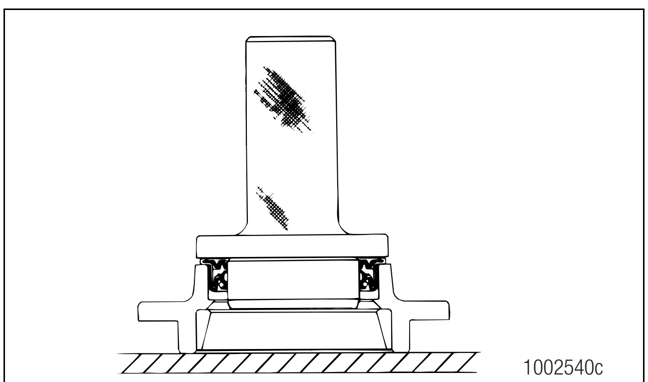


Figure 5.67

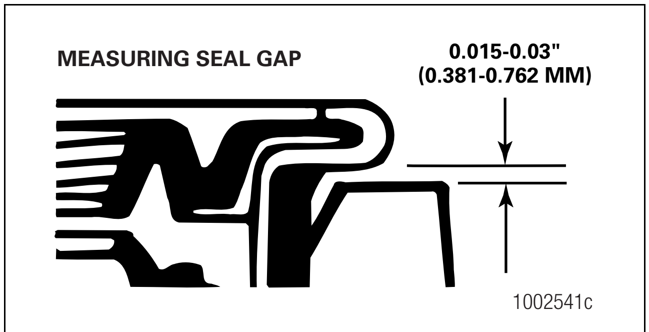


Figure 5.68

NOTE: If you replace either the bearing cup or cone, replace both parts in a fully-matched set from the same manufacturer.

4. On carriers that do not use an oil pump, install the input bearing cage.

   A. If removed, install the bearing cone onto the input shaft. Use a press and sleeve to install the cone onto the input shaft until it bottoms on the shoulder of the shaft. Figure 5.69.

   B. Install the O-ring onto the input bearing cage.

   C. Place the cage over the input shaft so that the cup in the cage is against the bearing cone.

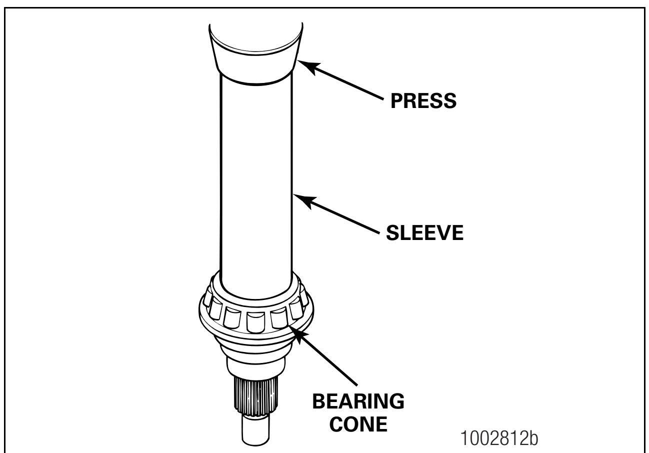


Figure 5.69

⚠ CAUTION

On early design forward carriers, verify that the drive flats in the bore of the pump are aligned with the flats on the input shaft. If the flats are not aligned, the pump will be damaged.

NOTE: If you replace either the bearing cup or cone, replace both parts in a fully-matched set from the same manufacturer.

5. On carriers that use an oil pump, install the input bearing cage and oil pump.

   A. Position the input shaft so that the threads are toward you.

   - **If dowel pins are used:** Install the oil pump onto the input shaft so that the dowel pin hole in the pump is toward the threads on the shaft.
   - **If a drive flat design pump is used:** Verify that the drive flats in the bore of the pump are aligned with the flats on the input shaft.
   - **If a spline design pump is used:** Verify that the splines in the pump are aligned with the splines on the shaft. Figure 5.70.

⚠ CAUTION

When the bearing cone and the oil pumps are installed on the input shaft, place supports under the input shaft. Do not place supports under the oil pump. The oil pump will be damaged if pressure is applied to the body of the pump.

   B. Place supports under the input shaft.

   C. Use a press and a sleeve to install the bearing cone onto the input shaft. The cone is correctly installed when the bottom of the cone touches the shoulder on the shaft. Figure 5.71.

   D. If removed, install the pressure relief valve assembly into the input bearing cage. Install the relief valve, spring and plug into the bore. Tighten the plug to 20-40 lb-ft (27-54 N•m). Figure 5.72.

   E. Install the input bearing cage over the input shaft on the oil pump.

   - **If dowel pins are used:** Verify that the dowel pins in the cage are aligned with the holes in the oil pump.

   F. Install the capscrews that fasten the oil pump to the input bearing cage. Tighten the capscrews to 22-23 lb-ft (30-31 N•m).

   G. Install the O-rings onto the oil pump and input bearing cage.

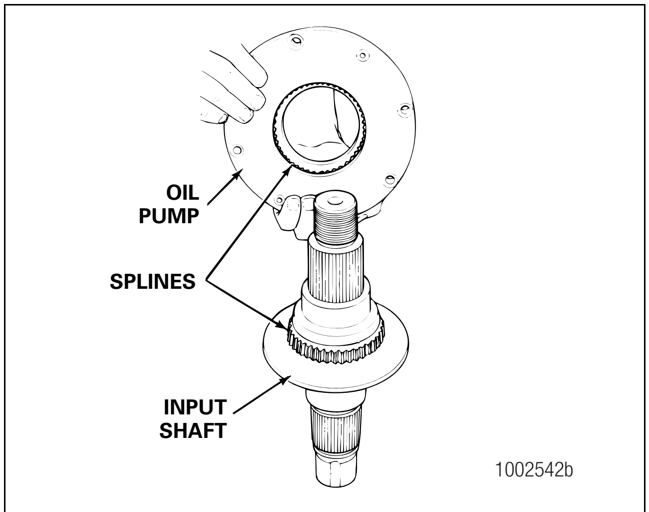


Figure 5.70

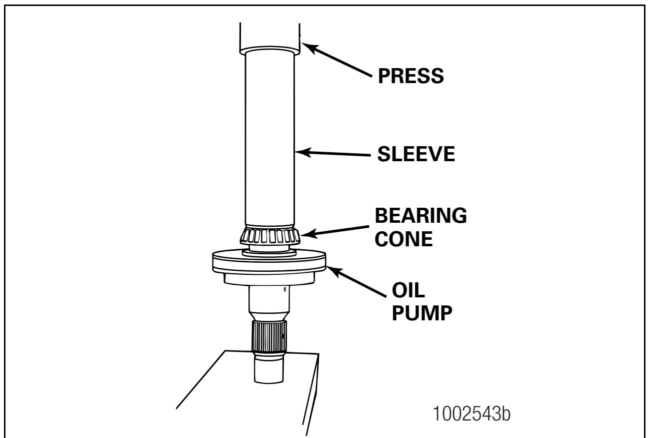


Figure 5.71

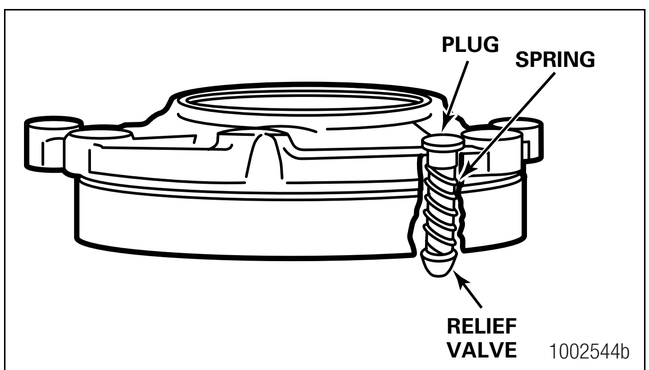


Figure 5.72

⚠ CAUTION

Do not use a Speedi-Sleeve with Meritor triple-lip oil seals. The edge of the sleeve will catch and roll the center dust lip and result in early seal leakage. Damage to components can result.

6. Inspect the yoke surface.
   - **If you installed a unitized pinion seal on the output bearing cage:** Refer to the clean and inspect the yoke after installing a unitized pinion seal procedure in this section and then proceed to Step 7. Figure 5.66.
   - **For all other seals:** Refer to the following instructions.

   A. Inspect the yoke for scratches, corrosion or a wear track from the previous oil seal. Replace the yoke if any of these conditions exist.

   B. Inspect the lead chamfer of the yoke for nicks and burrs which may damage the sealing tip during installation.

   C. Wipe clean the yoke sealing surface and face.
      - **If a yoke POSE™ seal is used:** Install the seal 1/2-inch (13 mm) onto the yoke hub. Refer to procedure in this section.

⚠ CAUTION

Use a press and a sleeve or yoke installation tool to install the yoke. Do not use a hammer or mallet. Using a hammer or mallet can damage the bearings, yoke or flange.

7. Use a press and sleeve or an installation tool to install the yoke or the flange onto the input shaft. If a press and sleeve are used, verify that the input shaft is well supported. Figure 5.73.

   If a yoke is removed after it has been partially or fully installed, the unitized pinion seal will be damaged. Remove and discard the original unitized pinion seal and replace it with a new one.

   If a yoke has been installed into the unitized pinion seal and then removed, the inner sleeve of the seal will be damaged. Install a new seal.

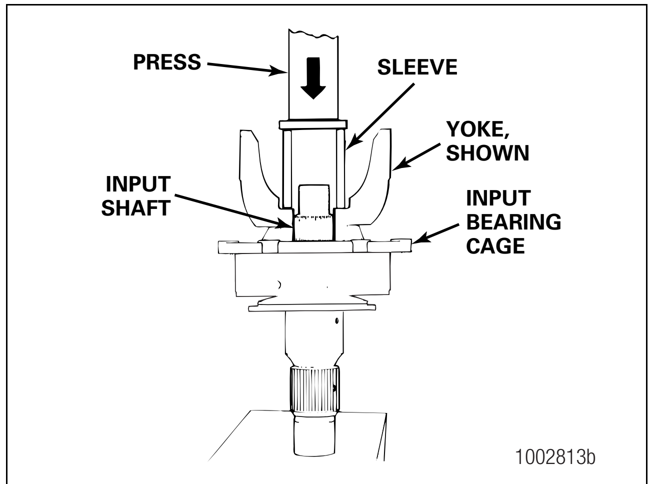


Figure 5.73

8. Install the nut that fastens the yoke or the flange to the input shaft. Hand-tighten the nut. Do not tighten the nut to the specified torque until the bearing cage and pump assembly is installed into the housing.

9. Place the thrust washer into the pilot bore on the end of the helical drive gear. The oil groove in the thrust washer must face the input shaft flange. Install the helical drive gear and the thrust washer onto the input shaft so that the thrust washer is toward the input bearing cage. Figure 5.74.

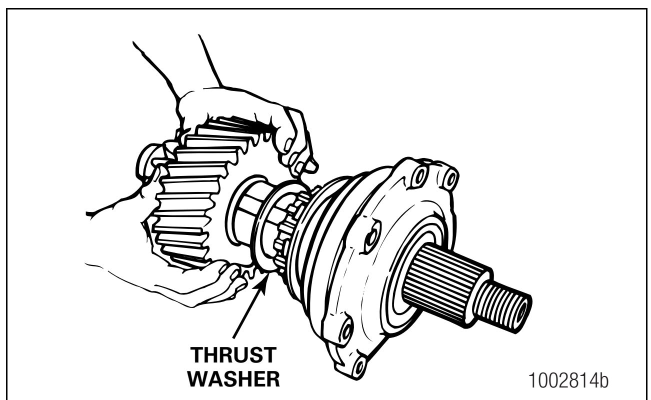


Figure 5.74

10. If disassembled, assemble the inter-axle differential.
    A. Apply axle lubricant to all of the inter-axle differential parts.
    B. Install the pinion gears and the thrust washers onto the spider.
    C. Place the spider and pinion assembly into one of the case halves of the inter-axle differential.
    D. Install the remaining case half over the case half with the spider assembly. Verify that the marks on each case half are aligned.
    E. Install four of the capscrews that fasten the case halves together. Install the capscrews so that the capscrews are the same distance away from each other. Equally tighten the capscrews to bring the case halves together.
    F. Install the rest of the capscrews. Tighten the capscrews to 45-55 lb-ft (60-75 N•m).
11. Install the inter-axle differential to the input shaft so that the teeth in the differential case are away from the helical drive gear. Install the snap ring that fastens the case to the shaft. Figure 5.75.

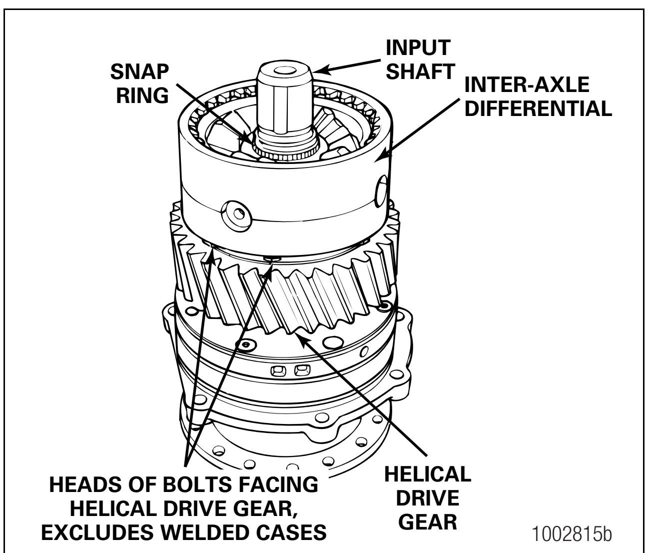


Figure 5.75

NOTE: If you replace either the bearing cup or the cone, replace both parts in a fully-matched set from the same manufacturer.

12. If removed, install the bearing cup for the rear side gear into the differential carrier. Use a press and a sleeve to install the cup into the carrier. If a press is not available, use a sleeve or a long, brass drift and a hammer to install the cup. The cup is correctly installed when the bottom of the cup is seated against the bottom of the bore. Figure 5.76.

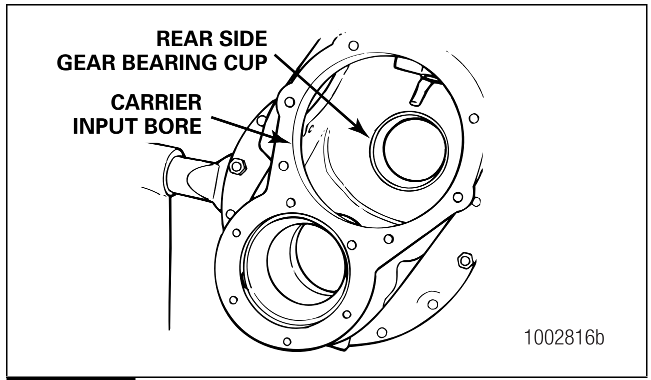


Figure 5.76

NOTE: If you replace either the bearing cup or the cone, replace both parts in a fully-matched set from the same manufacturer.

13. If removed, install the bearing cone onto the rear side gear. Use a press and sleeve to install the cone onto the gear. The cone is correctly installed when the bottom of the cone touches the shoulder on the side gear.
14. Install the oil screen and plug assembly into the suction line in front of the carrier. Tighten the screen and plug assembly to 48 lb-ft (65 N•m). Figure 5.77.

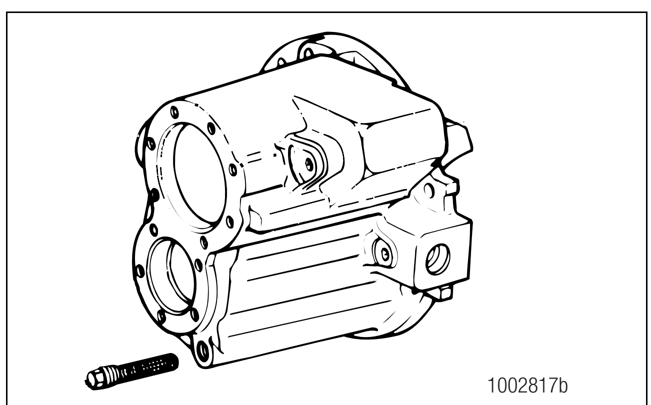


Figure 5.77

Installation

Input Shaft Assembly

NOTE: The shim pack under the input bearing cage is installed after the end play of the input bearing is inspected and adjusted.

1. Place the differential carrier into a repair stand so that the ring gear is facing DOWN.
2. If necessary, place the clutch collar into the differential carrier so that the teeth on the outside of the collar are toward the input yoke. Install the clutch collar onto the shift fork so the tabs of the fork fit into the slot of the clutch collar.
3. Install the rear side gear and bearing assembly through the clutch collar and into the differential carrier. Figure 5.78.

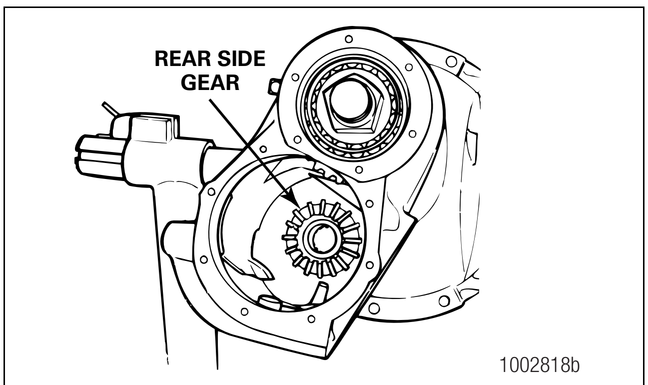


Figure 5.78

4. Verify that the painted alignment marks on the teeth of the helical gears are visible during the installation of the input shaft assembly. Figure 5.79.

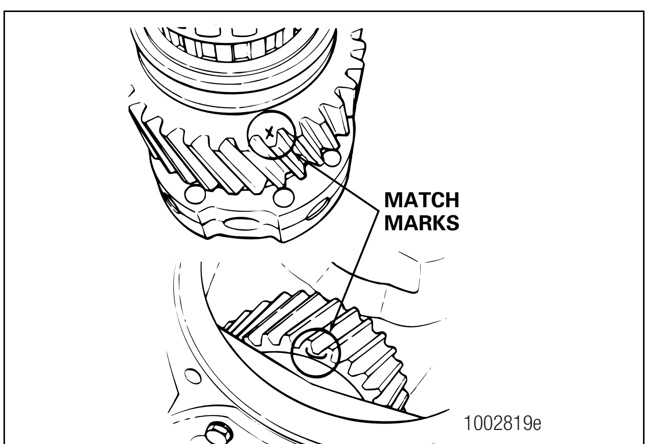


Figure 5.79

5. Install the input shaft assembly into the differential carrier.
   A. Connect a lifting device to the input yoke. Lift the input shaft assembly over the bore in the differential carrier.
   B. Lubricate the O-rings with axle oil.
   C. On 160 Series carriers, rotate the inter-axle differential case so that one of the notches on the case is aligned with the helical driven gear in the carrier. Figure 5.80.
   D. Lower the input shaft assembly into the differential carrier. Figure 5.81.

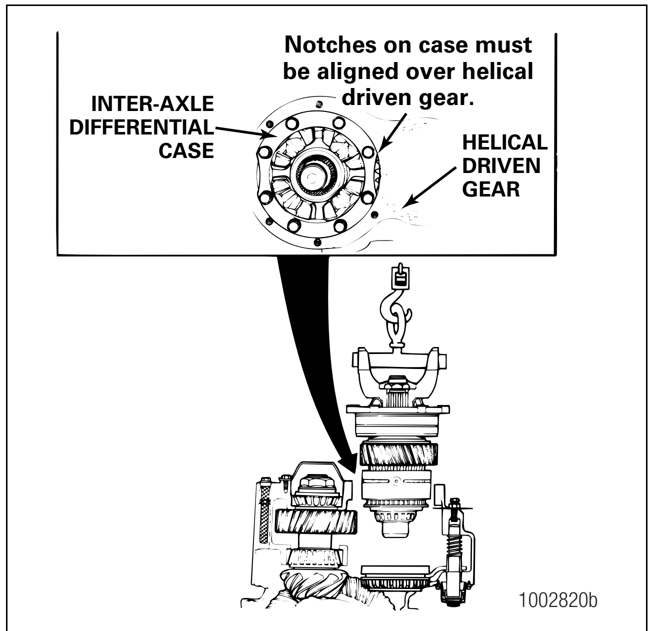


Figure 5.80

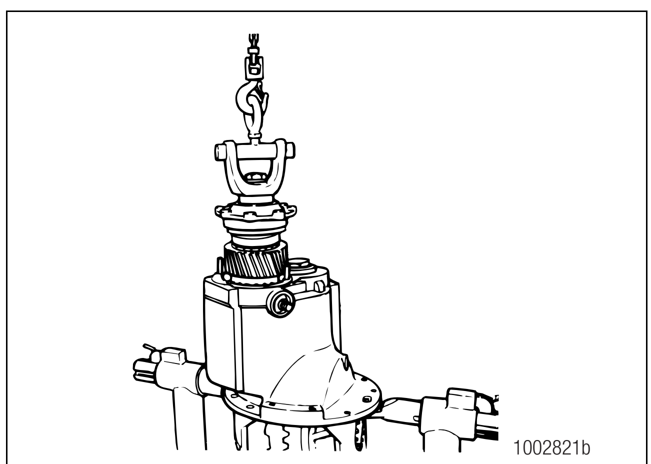


Figure 5.81

Inspection

Adjust the Input Bearing End Play

1. Install the capscrews, but not the washers, that fasten the input bearing cage to the carrier. Rotate the input shaft in each direction to verify that the bearings are correctly installed while you hand-tighten the capscrews. Do not tighten the capscrews.
2. Use a feeler gauge to measure the gap between the input bearing cage and the differential carrier. Inspect the gap at four equally-spaced places on the cage. Figure 5.82.

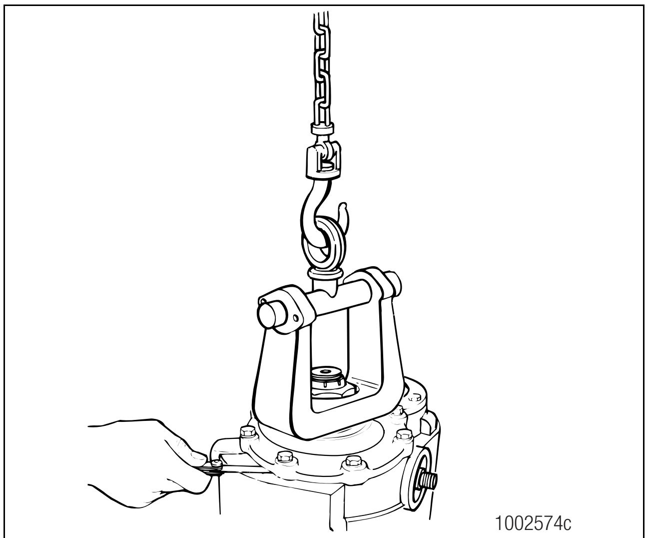


Figure 5.82

3. Add up the four measurements and determine the average gap between the cage and the carrier. Add 0.005-inch (0.130 mm) to the average gap measurement to determine the size of the shim pack between the cage and the carrier. Figure 5.83.

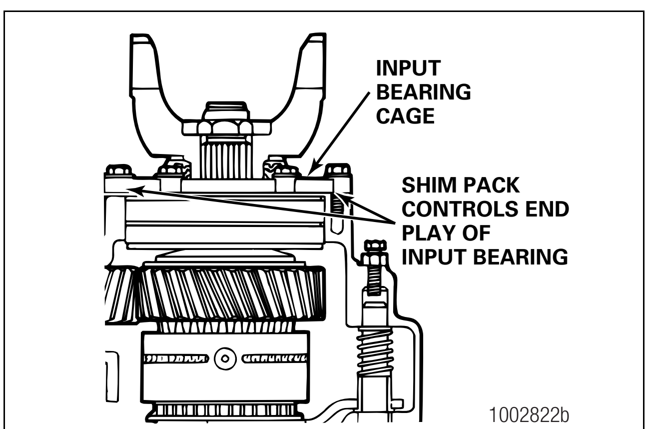


Figure 5.83

4. Build a shim pack. Use at least three shims when you build a shim pack. Always place the thickest shims in the middle of the shim pack.
5. Remove the capscrews that fasten the input bearing cage to the carrier.
6. Install the shim pack.
   A. Connect a lifting device to the input yoke. Lift the input shaft assembly until there is 0.25-0.50-inch (6-12 mm) between the cage and carrier mounting surface.
   B. Install the shim pack under the bearing cage. Verify that the hole pattern of the shim pack matches the hole pattern of the cage. Figure 5.84.
   C. Install the capscrews and washers that fasten the cage to the carrier. Verify that the capscrews are aligned with the holes in the shim pack. Tighten the capscrews so that the threads engage in the holes of the carrier.
   D. Lower the input shaft assembly so that the cage and the shim pack are installed against the carrier. Remove the lifting device from the yoke or flange.
   E. Tighten the capscrews to 75-95 lb-ft (100-127 N•m) while rotating the input shaft in each direction to verify that the bearings are correctly installed. T

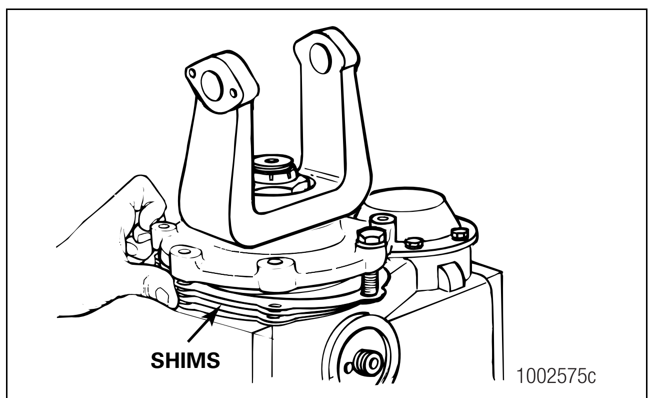


Figure 5.84

7. Apply Loctite® 277 threadlocker to the input shaft threads of all forward carriers prior to installation of the nut. Begin at the top of the threaded area and allow the Loctite® threadlocker to run down the length of the threaded area.
8. Place a holding tool onto the input yoke or flange and tighten the nut to the specified torque. Refer to Section 8.
9. Rotate the yoke at least one full turn after you tighten the yoke nut to the correct torque specification to ensure that the seal seats correctly.

10. Inspect the end play of the input shaft.
    A. Rotate the input shaft in each direction and push the yoke or flange toward the bearing cage. This ensures that the input shaft assembly is at the bottom of its travel.
    B. Use a dial indicator with a magnetic base or a C-clamp base to inspect the end play of the input bearing. Verify that the pointer of the dial indicator is against the top of the input shaft. Set the dial indicator to ZERO. Figure 5.85.
    C. Use a pry bar and a support to push the yoke or the flange away from the carrier. Read the dial indicator. The reading must be 0.002-0.008-inch (0.050-0.200 mm). Figure 5.86.
       - **If the end play of the input bearing is not 0.002-0.008-inch (0.050-0.200 mm):** Add or remove shims from the shim pack. Repeat Step 5 through Step 9.
11. Place the shield for the oil filter onto the bearing cage.

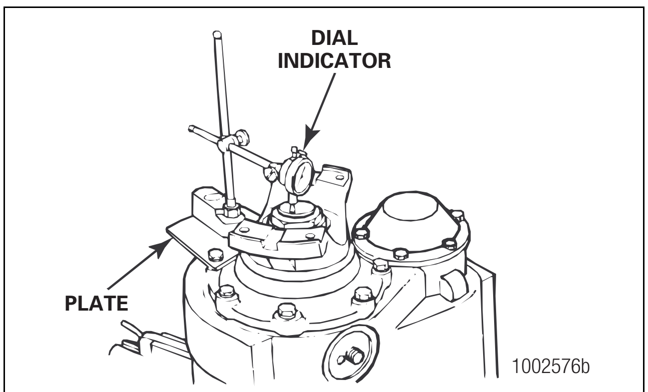


Figure 5.85

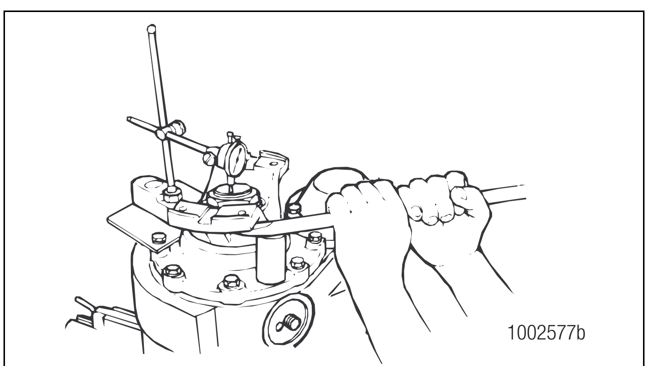


Figure 5.86

12. On RT-145 carriers that do not use an oil pump, use the following procedure.
    A. Remove the input shaft assembly from the carrier.

⚠ WARNING

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin. If Loctite® adhesive material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

    B. Spray Loctite® Primer N sealant on the cage and carrier faces around the perimeter of the lube trough hole at the two o'clock position. Figure 5.87. Allow the primer to dry three to five minutes.
    C. Carefully apply Loctite® 518 sealant to the cage and carrier faces around the lube trough hole. Avoid allowing any excess Loctite® sealant accumulation in the bearing cage bore. Figure 5.87.
    D. Use guide studs to install the input shaft and cage assembly with the appropriate shim pack. Tighten the capscrews to 95 lb-ft (128 N•m).
    E. Allow four hours for the Loctite® 518 sealant to cure before returning the vehicle to service.

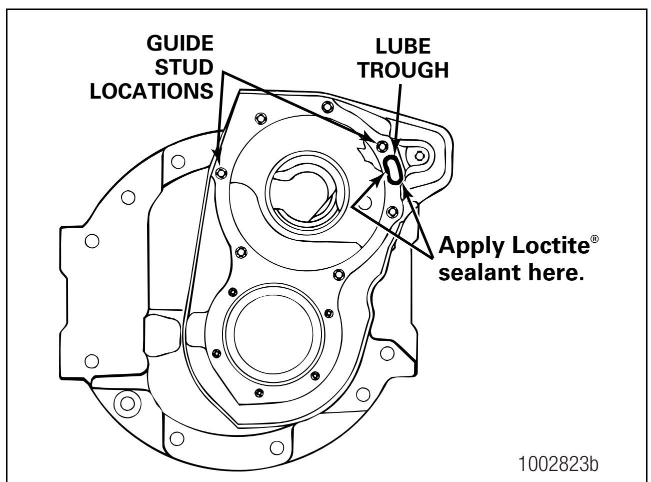


Figure 5.87

Installation

Driver-Controlled Main Differential Lock

Refer to Section 6 for installation procedures.

Output Bearings and Thru-Shaft

1. Apply axle lubricant to bearing cups and cones. Figure 5.88.

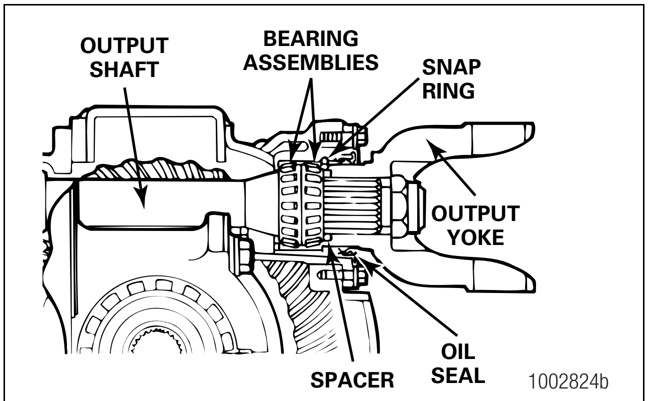


Figure 5.88

NOTE: If you replace either the bearing cup or the cone, replace both parts in a fully-matched set from the same manufacturer.

2. If the bearing cones were removed from the thru-shaft, install new bearing cones. Place both cones back-to-back onto the thru-shaft. Use a press and sleeve to install both cones. Apply pressure until the inner cone seats onto the shoulder of the thru-shaft. Figure 5.89.

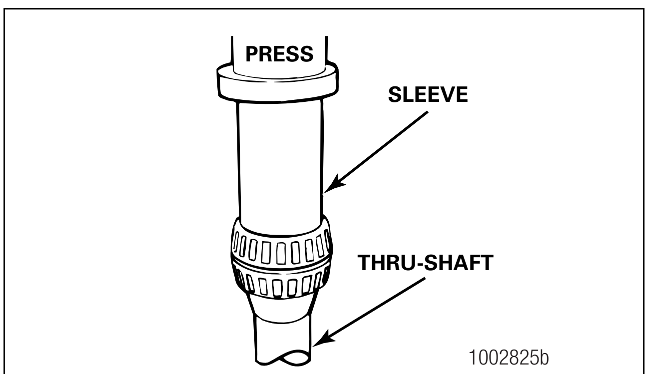


Figure 5.89

3. Use a press and sleeve to install the inner bearing cup into the cage. Place the thru-shaft and bearing assembly into the cage.

4. Use a press and sleeve to install the outer bearing cup into the cage over the thru-shaft. Figure 5.90.

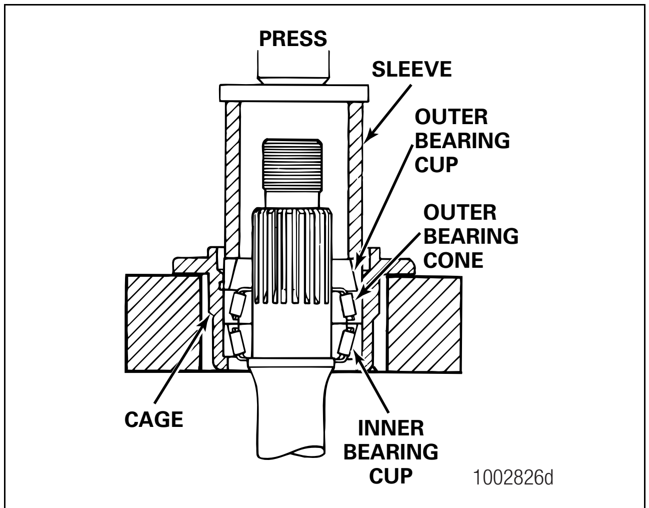


Figure 5.90

5. Install the snap ring that fastens the outer cup in the cage. The snap ring controls the end play of the output bearing. Figure 5.91.

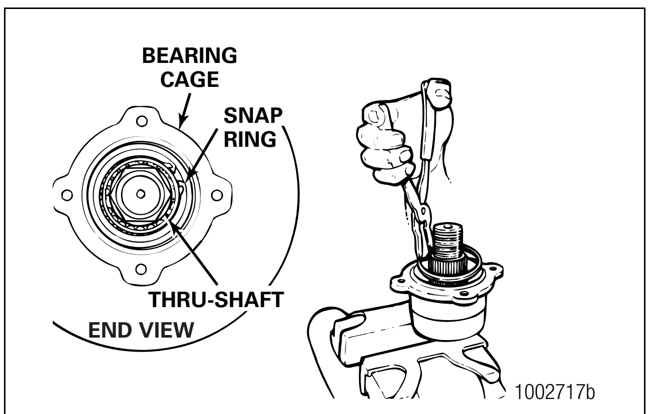


Figure 5.91

6. Install the snap ring or the yoke-to-cone spacer onto the thru-shaft until the snap ring touches the outer cone.

7. Inspect and adjust the end play of the thru-shaft bearing.

Inspection

Adjust the Output Bearing End Play

The output bearing end play is controlled by the size of the snap ring that holds the bearings in the output cage. The snap rings are available in increments of 0.003-inch (0.076 mm). Install the snap ring which results in an end play of 0.001-0.004-inch (0.025-0.102 mm).

1. Place the thru-shaft and the bearing cage assembly into a vise with soft metal covers on the jaws of the vise.
2. Use an installation tool to install the yoke or flange onto the thru-shaft. Do not use the nut to draw the yoke onto the shaft. Do not install the oil seal at this time.
3. Install the nut that fastens the yoke or flange to the thru-shaft. Place a holding tool on the yoke or flange and tighten the nut to the specified torque. Refer to Section 8.
4. Push the yoke or flange toward the cage and rotate the shaft in each direction to verify that the bearings are correctly installed.
5. Install a dial indicator so that the base of the indicator is on the mounting flange of the cage. The pointer of the indicator must touch the yoke or flange end of the thru-shaft. Set the dial indicator to ZERO. Figure 5.92.

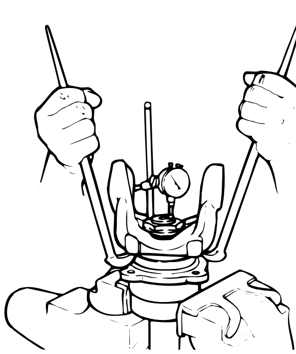


Figure 5.92

6. Place pry bars under the yoke or flange and push the yoke or flange away from the cage. Record the reading on the dial indicator. The reading must be 0.001-0.004-inch (0.025-0.102 mm). The reading is the measurement of the end play on the output bearing.
   - **If the end play reading is not 0.001-0.004-inch (0.025-0.102 mm):** Remove and replace the snap ring that fastens the bearings in the cage. Install a thinner snap ring to increase the end play. Install a thicker snap ring to decrease the end play. Figure 5.93.
7. Remove the nut that fastens the yoke or flange to the thru-shaft. Use the correct puller tool to remove the yoke.

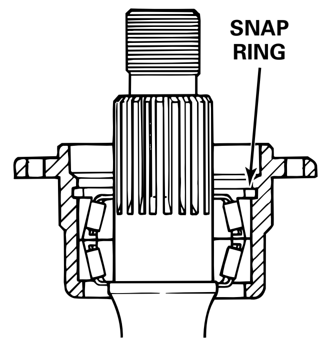


Figure 5.93

Installation

Unitized Pinion Seal

1. Remove the old seal. Do not damage the bearing cage seal surface area. Do not touch or allow dirt or grease to contaminate the sealing surface areas or the adjacent bearings.
2. Inspect the bearing cage seal area for damage that could cause lubricant leaks after you install the seal. Use emery paper or an equivalent product to remove scratches, nicks or burrs only.

⚠ CAUTION

Inspect the axle breather for contaminants, such as dirt, lubrication or debris, which can cause pressure to build inside the axle. Damage to the seal and premature seal lip wear can result. Remove the axle breather. Use a safe cleaning solvent to clean the inside and outside of the breather.

3. Inspect the axle breather for contaminants, such as dirt, lubrication or debris.
   - **If you find contaminants in the axle breather:** Remove the axle breather. Use a safe cleaning solvent to clean the inside and outside of the breather.
4. Remove the replacement unitized seal from the package. Figure 5.94.

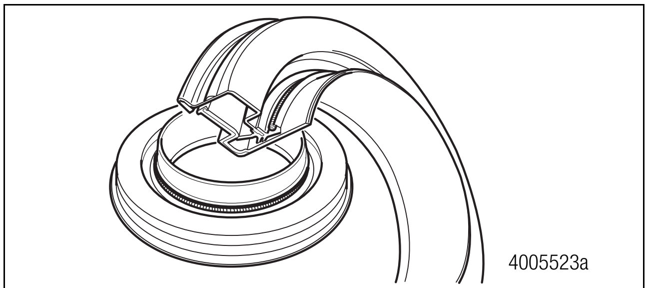


Figure 5.94

⚠ CAUTION

If a yoke is removed after it has been partially or fully installed, the unitized pinion seal will be damaged. Remove and discard the original unitized pinion seal and replace it with a new one.

If a yoke has been installed into the unitized pinion seal and then removed, the inner sleeve of the seal will be damaged. Install a new seal.

5. Select the correct seal driver from Table K. Each seal driver is designed to correctly install a specific diameter seal. To determine the yoke seal diameter, measure the yoke journal. To obtain the Meritor seal driver KIT 4454, refer to the Service Notes page on the front inside cover of this manual.

Table K: Unitized Pinion Seals and Seal Drivers*

Single Models	Tandem Models	Axle Model and Position	Seal Service Part Number	Previous Seal Part Number	Seal Drivers	Sleeve Drivers
MX-21-160 MX-23-160R RF-16-145	RT-34-144 /P RT-34-145 /P MT-40-143	14X/16X/18X/38X Forward-Rear Unit Input (FUI)	A1-1205X2728	A-1205R2592	2728T1	2728T2
RF-21-160 RF-22-166	RT-40-145 /A /P RT-40-149 /A /P	14X/16X Forward-Rear Unit Output (FUO)	A1-1205Y2729	A-1205P2590	2729T1	2729T2
RF-23-185 RS-17-145	RT-44-145 /P RT-40-160 /A /P	14X Rear-Rear Unit Input (RUI)	A1-1205Z2730	A-1205N2588	2730T1	Not Required — Sleeve is unitized
RS-19-145 RS-21-145 RS-21-160 RS-23-160 /A RS-23-161 /A RS-25-160 /A RS-23-186 RS-26-185 RS-30-185	RT-40-169 /A /P RT-46-160 /A /P RT-46-169 /A /P RT-46-164EH /P RT-46-16HEH /P RT-50-160 /P RT-52-185* RT-58-185*	16X/18X Rear-Rear Unit Input (RUI)	A1-1205A2731	A-1205Q2591	2731T1	Not Required — Sleeve is unitized

* Forward and rear input only.

Forward input and output seals must be serviced with the seal and sleeve. The service part number provides both when required.

6. Position the driver and seal. Figure 5.95.
   - **If you use the R4422401 driver tool to install a forward tandem axle seal:** The driver tool outer spokes or fins must fit between the bearing cage bolts. Ensure that the bolts on the bottom of the bearing cage are not in the path of the driver spokes.
   - **If the driver spokes contact the bearing cage bolts:** The driver will incorrectly install the seal into the bearing cage seat and can also result in damage to the driver. The reference mark on the driver tool must be in the 12 o'clock or the 6 o'clock positions when you install the new seal.

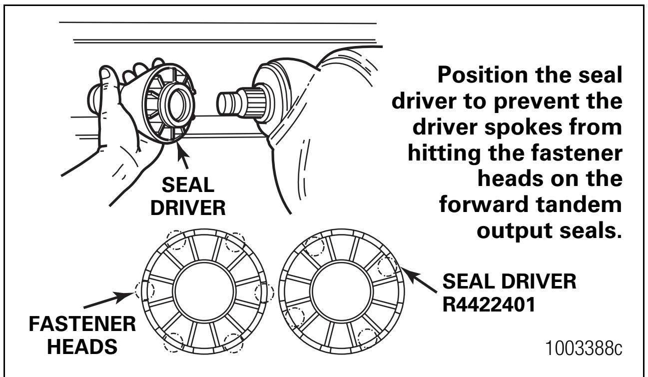


Figure 5.95

⚠ CAUTION

Use a rubber mallet to install the seal. Do not use a steel, brass or plastic hammer. Using a steel, brass or plastic hammer can damage the seal and driver tool.

7. Use a rubber mallet to drive the seal into or against the bearing cage. The seal must fully seat into or against the bearing cage. Figure 5.96.
8. Visually inspect the seal to verify that it is seated correctly.

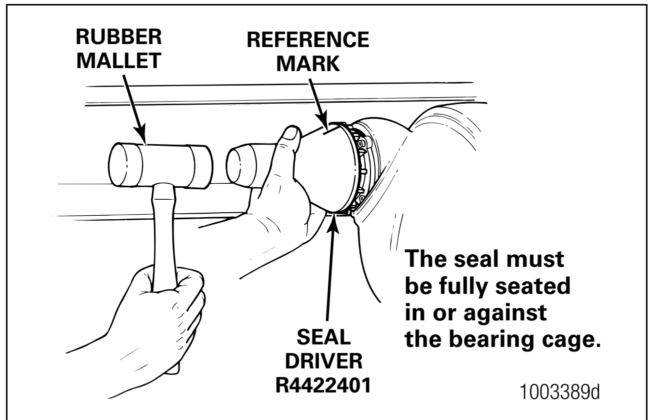


Figure 5.96

Installing a Multiple-Lip Seal (MLS)

140, 160 and 180 Series Single Drive Axles
140, 160, 180 and 380 Series Tandem Drive Axles

Meritor multiple-lip seals feature a separable sleeve installed onto the yokes at the tandem forward-rear input and forward-rear output positions. No sleeve is used on the rear-rear input.

Installation of the new seals requires a set of four seal drivers and two sleeve drivers. Refer to Table L for part numbers.

Table L: Multiple-Lip Seal (MLS) Seal Drivers and Sleeves Part Numbers

Axle Model and Position	Seal Service Part Number	Previous Seal Part Number	Seal Drivers	Sleeve Drivers
140, 160, 180 and 380 Forward-Rear Unit Input (FUI)	A1-1205X2728	A-1205R2592	2728T1	2728T2
140 and 160 Forward-Rear Unit Output (FUO)	A1-1205Y2729	A-1205P2590	2729T1	2729T2
140 Rear-Rear Unit Input (RUI)	A1-1205Z2730	A-1205N2588	2730T1	Not Required — Sleeve is unitized
160 and 180 Rear-Rear Unit Input (RUI)	A1-1205A2731	A-1205Q2591	2731T1	Not Required — Sleeve is unitized

Special Tools for Installing Multiple-Lip Seals (MLS)

Forward input and output seals must be serviced with the seal and sleeve. The service part number provides both when required. Check your application carefully before installing the multiple-lip seal.

There are six new installation drivers required for replacement of the multiple-lip axle yoke seals. Figure 5.97. To obtain these sleeves, seals and drivers, call ArvinMeritor's Commercial Vehicle Aftermarket at 888-725-9355.

- A sleeve driver and seal driver for the forward-rear input
- A sleeve driver and seal driver for the forward-rear output
- Two model specific seal drivers for the rear-rear input

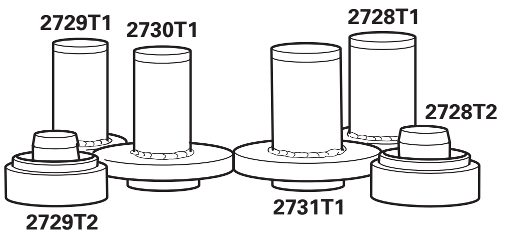


Figure 5.97

WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

1. Clean the ground and polished surface of the yoke journal using a clean shop towel and a safe cleaning solvent. Do not use abrasive cleaners, towels or scrubbers to clean the yoke or flange surface. Do not use gasoline.
2. Inspect the yoke seal area for damage that could cause lubricant leaks after you install the seal. Use emery paper or an equivalent product to remove scratches, nicks or burrs only.
3. Install the deflector, if equipped, onto the yoke. You must install the deflector before you install the sleeve into the yoke. Figure 5.98.

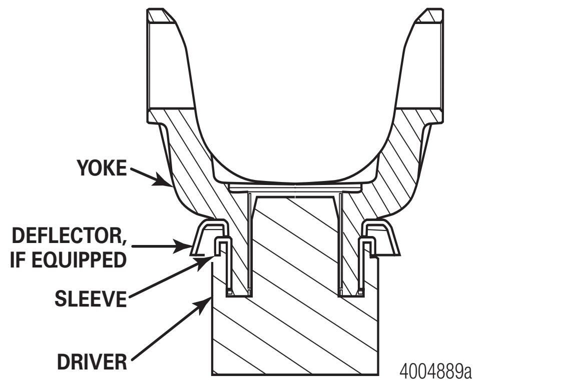


Figure 5.98

WARNING

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

Do not hit steel parts with a steel hammer. Pieces of a part can break off. Serious personal injury and damage to components can result.

4. Apply a light coat of axle oil to the yoke seal journal. Position the sleeve into the forward-rear axle output yoke sleeve driver. Do not touch the greased areas of the sleeve. The sleeve must be kept clean prior to assembly into the seal. Use an arbor press and the appropriate driver to install the sleeve into the yoke. Verify that the sleeve is fully-seated in the yoke to prevent damage to components. Figure 5.99.

   The yoke must be fully pressed into the sleeve driver until the end of the yoke bottoms out in the sleeve driver. This will correctly position the sleeve on the yoke. When correctly seated, the forward-rear output sleeve is positioned 0.200-inch ± 0.030-inch (5 mm ± 0.75 mm) from the end of the yoke. Figure 5.100.

   - **If you do not have a press:** Position the yoke on a five-inch (127 mm) spacer on a workbench. Use a dead-blow hammer and the appropriate driver to install the sleeve into the yoke. Figure 5.101.

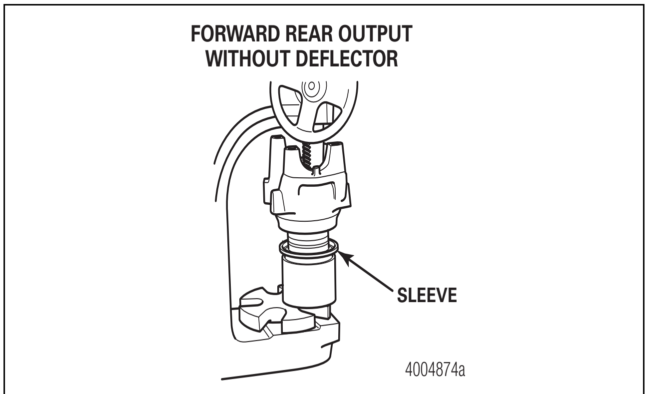


Figure 5.99

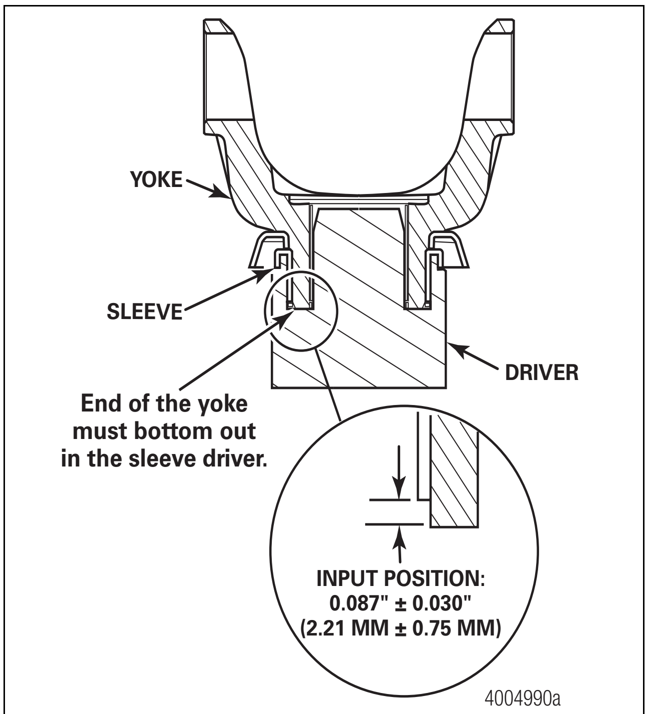


Figure 5.100

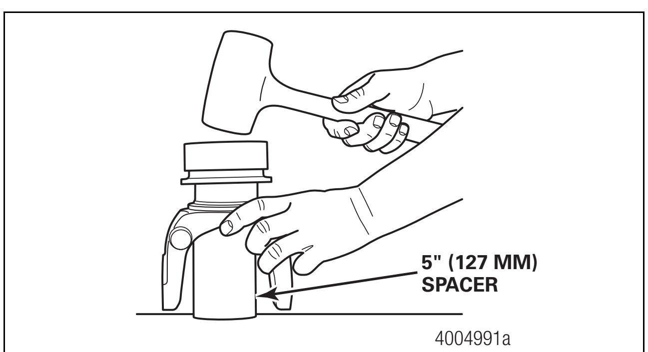


Figure 5.101

5. Apply a light coat of axle oil to the yoke seal journal. Position the sleeve into the forward-rear axle input yoke sleeve driver. Do not touch the greased areas of the sleeve. The sleeve must be kept clean prior to assembly into the seal. Use an arbor press and the appropriate driver to install the sleeve into the yoke. Verify that the sleeve is fully-seated in the yoke. Figure 5.102.

   The yoke must be fully pressed into the sleeve driver until the end of the yoke bottoms out in the sleeve driver. This will correctly position the sleeve on the yoke. When correctly seated, the forward-rear input sleeve is positioned 0.030-inch ± 0.030-inch (0.75 mm ± 0.75 mm) from the end of the yoke. Figure 5.100.

   - **If you do not have a press:** Position the yoke on a five-inch (127 mm) spacer on a workbench. Use a dead-blow hammer and the appropriate driver to install the sleeve into the yoke. Figure 5.101.

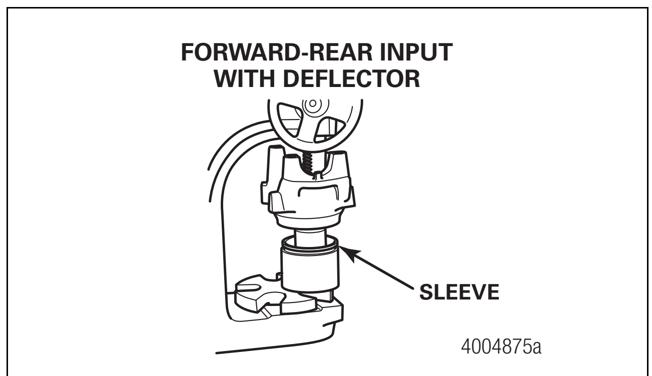


Figure 5.102

⚠ CAUTION

Hold the sleeve and seal only on the outer diameter. Do not touch the greased inner diameter of the seal and the greased area of the sleeve. This can contaminate the seal and cause a leak between the shaft and the seal. Damage to components can result.

6. Install the forward-rear axle input seal. Hold the sleeve and seal only on the outer diameter. Position the seal into the seal driver and align it with the forward-rear axle input bearing cage. Do not touch the lips in the inner diameter of the seal. Use a dead-blow hammer and the appropriate driver to install the seal into the bearing cage. Figure 5.103.

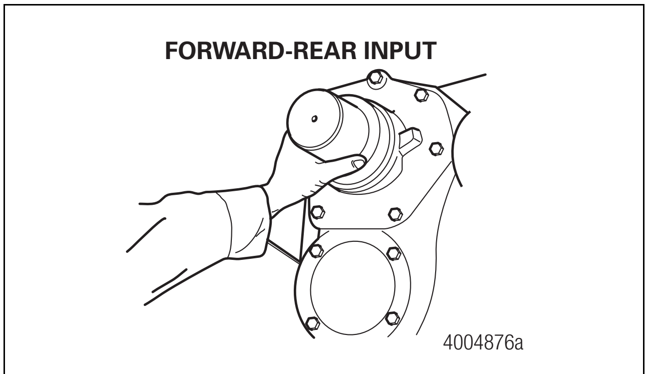


Figure 5.103

⚠ CAUTION

On axles that have the bolt-on deflector on the forward-rear output shaft bearing cage, the deflector must be removed and discarded. The new forward output sleeve will not assemble correctly to the new output seal with the bolt-on deflector in place. Remove the deflector from the output shaft bearing cage and reassemble the output cage hex-head capscrews and washers according to the appropriate maintenance manual instructions. Damage to components can result.

7. Install the forward-rear axle output seal. Hold the sleeve and seal only on the outer diameter. Position the seal onto the seal driver and align it with the forward-rear axle output shaft. Do not touch the lips in the inner diameter of the seal. Use a dead-blow hammer and the appropriate driver to install the seal onto the output shaft. Figure 5.104.

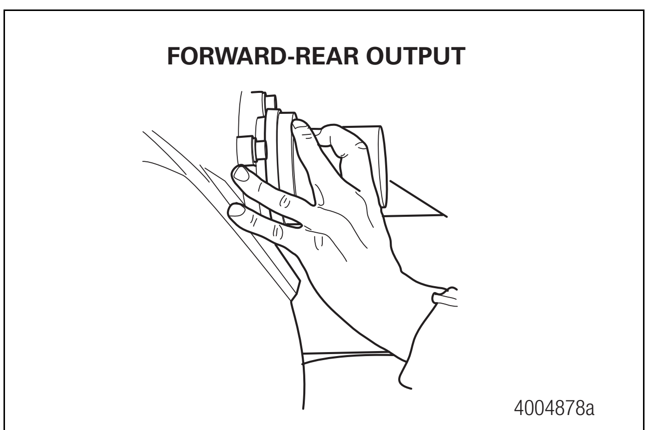


Figure 5.104

8. Install the rear-rear axle input seal. Hold the seal only on the outer diameter. Position the seal into the seal driver and align it with the rear-rear axle input bearing cage. Use a dead-blow hammer and the appropriate driver to install the seal into the bearing cage. Figure 5.105.

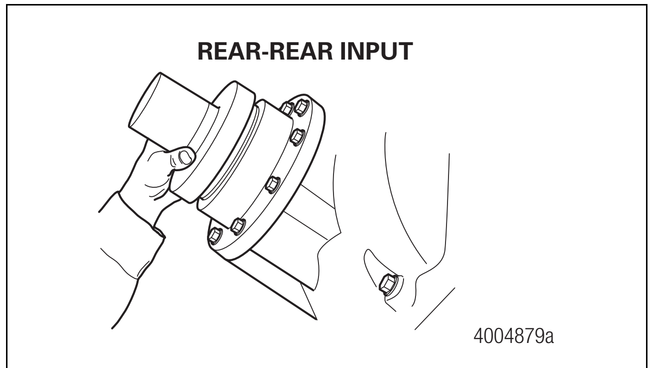


Figure 5.105

9. Use a feeler gauge to check the seal gap at all three axle positions. The seal is correctly installed if the gap is less than 0.005-inch (0.127 mm) around the circumference of the seal flange. Figure 5.106.
   - **If the gap is more than 0.005-inch (0.127 mm):** Use a dead-blow hammer and the appropriate driver to completely install the seal.

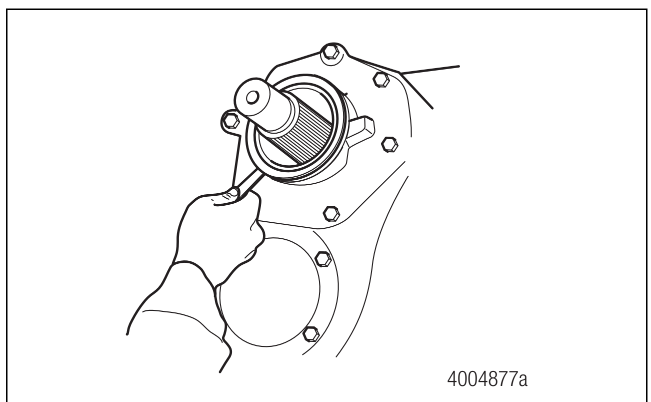


Figure 5.106

Clean and Inspect the Yoke After Installing a Unitized Pinion Seal

⚠ WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

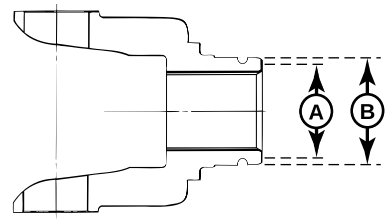
- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

1. Use a clean shop towel and a safe cleaning solvent to clean the ground and polished surface of the yoke journal. Do not use gasoline, abrasive cleaners, towels or scrubbers to clean the yoke. Do not attempt to polish the yoke.

NOTE: The unitized seal features a rubber inner sleeve that is designed to seal and rotate with the yoke. This feature allows you to reuse a yoke with minor grooves.

2. Inspect the yoke seal surface for grooves.
   - **If you find grooves on the yoke:** Use calipers to measure the groove diameters. If any groove diameter measures less than the dimensions shown in Figure 5.107, replace the yoke.

UNITIZED PINION SEAL (UPS)



Yoke Seal Diameter	Minimum Yoke Diameter at Groove (Inches)
3.000/3.005"	2.990"
3.250/3.255"	3.240"

1003390e

A MINIMUM GROOVE DEPTH — DIAMETER
B YOKE SEAL DIAMETER

Figure 5.107

⚠ CAUTION

Do not install a POSE™ seal after you install a unitized pinion seal. The use of a POSE™ seal will prevent correct seating of the unitized pinion seal on the yoke and can result in lubricant leakage at the seal. POSE™ seal installation is recommended only for triple-lip and other previous design seals.

Do not use thin metal wear sleeves to refresh the yoke surface. Wear sleeves pressed onto the yoke can prevent correct seating of the pinion seal, damage the pinion seal assembly and can cause the seal to leak.

3. Before you install the yoke, lightly lubricate or coat the yoke seal journal with axle oil.
4. Align the yoke splines with the shaft splines. Slide the yoke over the shaft spline.

Tight Fit Yokes and POSE™ Seal

1. Apply axle lubricant to the hub of the yoke or flange. Figure 5.108.

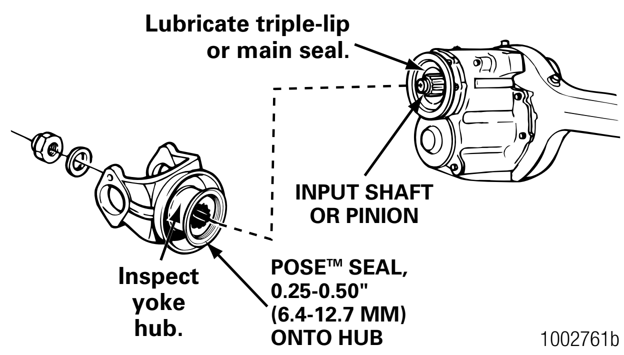


Figure 5.108

2. Verify that the lips of the POSE™ seal and the outer retainer of the triple-lip seal or main seal are clean and free from dirt and particles that may cause lubricant leakage between the seals.
3. Install the POSE™ seal onto the hub of the yoke or flange by hand. The lips of the seal must face toward the end of the hub, opposite shoulder. Slide the POSE™ seal onto the hub until the lips are 0.25-0.50-inch (6.4-12.7 mm) from the end of the hub. Do not install the POSE™ seal against the shoulder. Figure 5.109.

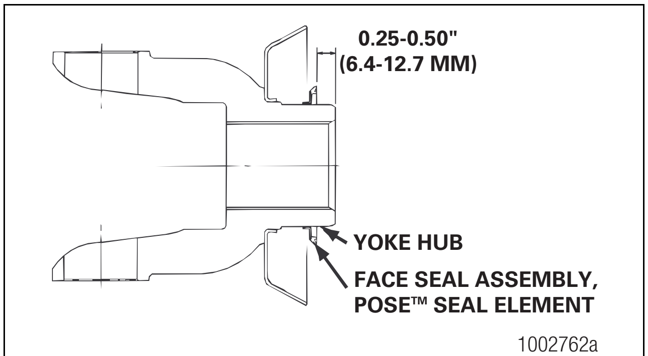


Figure 5.109

4. Before you install the yoke or flange onto the shaft, apply axle lubricant to the hub.

NOTE: The POSE™ seal will position itself correctly as the yoke or flange is pressed on the shaft.

5. Install the yoke or flange using the correct procedure. The yoke must be completely seated before you tighten the pinion nut to the input shaft.

Output Yoke or Flange and Oil Seal for the Output Bearing Cage

⚠ CAUTION

Hold the seal only on the outer diameter. Do not touch the lips in the inner diameter of the seal. If you touch the lips on the inner diameter of the seal, you will contaminate the lips and cause a leak between the shaft and the seal.

Do not apply pressure after the flange of the seal touches the top of the cage or you will damage the seal.

1. Prepare the seal for installation.
   A. Apply axle lubricant to the inner bore of the output bearing cage or the outer diameter of the new oil seal.
   B. Place the oil seal into the cage so that the flange is parallel to the top of the cage.
   C. Use a press and sleeve, or a mallet and sleeve, to install the seal into the cage. The seal is correctly installed when the metal flange of the seal seats on the top of the cage. Figure 5.110.

NOTE: The gap cannot be measured in the RT-40-145. The seal seats below the lip.

   D. After the seal is installed, a gap of 0.015-0.030-inch (0.381-0.762 mm) can exist between the flange and the cage. The gap is a normal condition because of the flexible coating on the flange of the seal. Use a feeler gauge to measure the gap around the complete flange-to-cage area.
      - **If the gap varies more than 0.010-inch (0.254 mm) between the highest and lowest measurement:** Remove and reseat the seal. Figure 5.111.

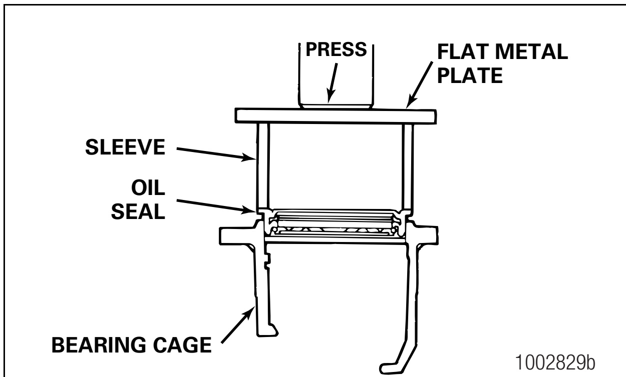


Figure 5.110

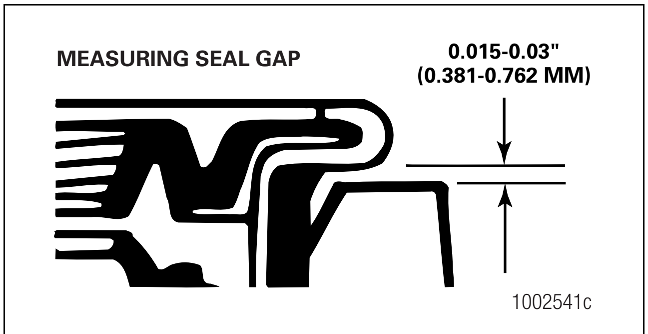


Figure 5.111

⚠ CAUTION

Do not use a Speedi-Sleeve with Meritor triple-lip oil seals. The edge of the sleeve will catch and roll the center dust lip and result in early seal leakage.

2. Inspect the yoke surface.
   - **If you installed a unitized pinion seal on the output bearing cage:** Refer to the clean and inspect the yoke after installing a unitized pinion seal procedure in this section and then proceed to Step 3.
   - **For all other seals:** Refer to the instructions below.

   A. Inspect the yoke surface for scratches, corrosion or a wear track from the previous oil seal. Replace the yoke if any of these conditions exist.

   B. Inspect the lead chamfer of the yoke for nicks and burrs which may damage the sealing lip during installation. Use an emery cloth to repair nicks and burrs.

   C. Wipe clean the yoke sealing surface and face.

   D. Clean the splines in the yoke or flange and on the thru-shaft.

   E. Apply axle lubricant to the splines in the yoke or flange and the thru-shaft.
   - **If a POSE™ seal is used:** Refer to the tight fit yokes and POSE™ seal installation procedure in this section.

⚠ CAUTION

Use a press and a sleeve or yoke installation tool to install the yoke. Do not use a hammer or mallet. Using a hammer or mallet can damage the bearings, yoke or flange.

If a yoke is removed after it has been partially or fully installed, the unitized pinion seal will be damaged. Remove and discard the original unitized pinion seal and replace it with a new one.

If a yoke has been installed into the unitized pinion seal and then removed, the inner sleeve of the seal will be damaged. Install a new seal.

3. Use a press and sleeve or an installation tool to install the yoke or flange onto the thru-shaft. Verify that the splines inside the yoke or flange are aligned with the splines on the thru-shaft. If a press and sleeve are used, verify that the thru-shaft is supported.
4. Apply a single bead of Loctite® 277 adhesive (part number 1199Y3795) or Loctite® 270 adhesive (part number 2297M5213) at the top of the thru-shaft threads from inboard to outboard. The bead should be 0.120-inch wide.
5. Install the nut that fastens the output yoke or flange to the thru-shaft. Place a holding tool on the yoke or flange and tighten the nut to the specified torque. Refer to Section 8.
6. Rotate the yoke at least one full turn after the yoke nut is tightened to the correct torque specification. This ensures correct seating of the seal.

Differential Carrier into the Axle Housing

⚠ WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

1. Use a cleaning solvent and rags to clean the inside of the axle housing and the carrier mounting surface. Refer to Section 4.
2. Inspect the axle housing for damage. Repair or replace the axle housing. Refer to Section 4.
3. Check for loose studs, if equipped, in the mounting surface of the housing where the carrier fastens. Remove and clean the studs that are loose.
4. Install the studs into the axle housing. Refer to procedure in this section. Tighten the studs to 150-230 lb-ft (203-312 N•m).

⚠ WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

⚠ CAUTION

Apply silicone gasket material in a continuous 0.25-inch (6 mm) bead. If you use more than this amount, gasket material can break off and plug lubrication passages. Damage to components can result.

5. Apply a 0.25-inch (6 mm) continuous bead of silicone gasket material to the mounting surface of the housing where the carrier fastens. Figure 5.112.

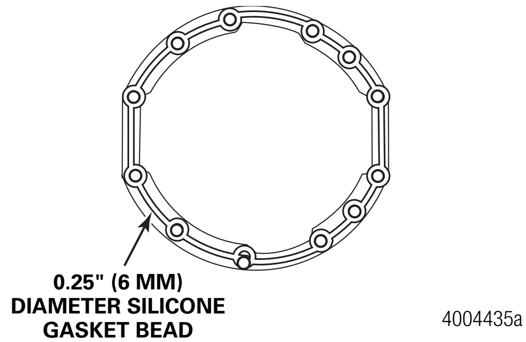


Figure 5.112

6. On an axle with a driver-controlled main differential lock, shift the lock into and hold the lock in the locked or engaged position. The locked position provides enough clearance between the shift collar and the axle housing for carrier installation. Refer to Section 6.
7. Use a hydraulic roller jack or a lifting tool to install the carrier into the axle housing. Figure 5.113.

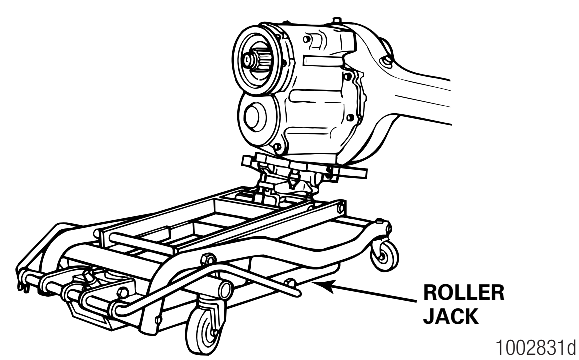


Figure 5.113

⚠ WARNING

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin. If Loctite® adhesive material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

8. Spray the capscrew threads with Loctite® sealant. Allow the primer to dry for three to five minutes.

⚠ CAUTION

Do not use a hammer or mallet to install the carrier. A hammer or mallet will damage the mounting flange of the carrier and cause oil leaks.

NOTE: Nord-Lock® washers are reusable, but replace them if they are leaking.

9. Install the nuts and washers or the capscrews and washers into the four corner locations around the carrier and the axle housing. Hand-tighten the fasteners. Do not tighten to the specified torque.
   - **For fasteners with Nord-Lock® washers:** Install the washers with the radial teeth side facing the carrier. Figure 5.114.
10. Carefully push the carrier into position. Alternately tighten the four fasteners two or three turns. Figure 5.115.

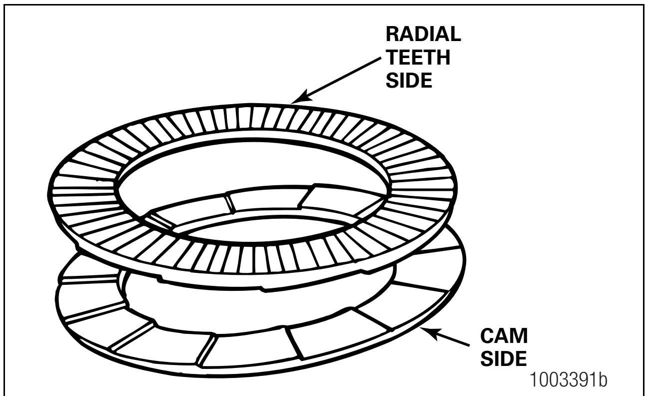


Figure 5.114

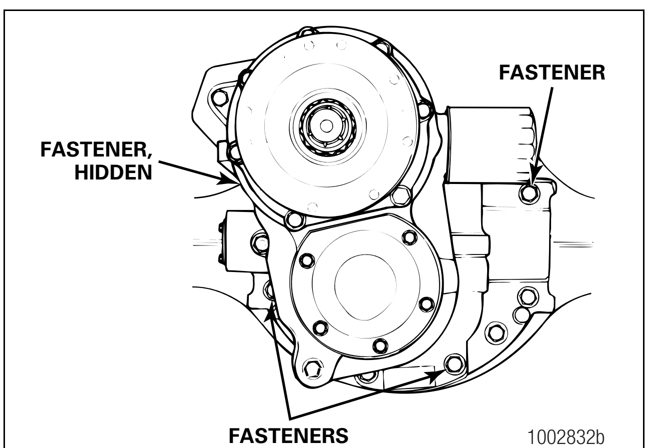


Figure 5.115

11. Repeat Step 10 until the four fasteners are tightened to the correct torque value.
    - **For fasteners with standard flat washers:** Tighten the fasteners to 150-230 lb-ft (204-312 N•m).
    - **For fasteners with Nord-Lock® washers:** Tighten the fasteners to 210 lb-ft (287 N•m).
12. Install the remaining fasteners and the washers that hold the carrier in the axle housing. Tighten the fasteners to the correct torque value. Refer to Section 8.
13. Install the washers and tighten the capscrews that fasten the output bearing cage to the axle housing. Tighten the capscrews to 35-50 lb-ft (48-67 N•m).
14. Adjust the shift fork for the inter-axle differential lock. The movement of the shift fork is controlled by the adjusting screw for the air-shift cylinder.
    A. Loosen the jam nut on the adjusting screw. Loosen the adjusting screw so that the screw does not touch the shift shaft. Figure 5.116.
    B. Apply and hold 60 psi (413 kPa) of air pressure to the shift cylinder so that the shift collar engages the splines in the inter-axle differential case.
    C. Verify that the adjusting screw does not touch the shift shaft when the shift collar engages the inter-axle differential case.
    D. Tighten the adjusting screw until the tip of the screw touches the end of the shift shaft. Release the air pressure.
    E. When the screw touches the shaft, tighten the adjusting screw an additional one turn. Apply air pressure, then tighten the jam nut. Figure 5.117.
    F. Disengage the inter-axle differential lock by holding the input yoke or flange and rotating the output yoke or flange. The output yoke or flange should rotate with less than 50 lb-ft (67 N•m) of torque applied.
    G. Apply and hold 60 psi (413 kPa) of air pressure to the shift cylinder to verify that the shift collar engages the splines in the inter-axle differential case. When the input yoke or flange is rotated, the output yoke or flange must rotate. Release the air pressure.
    H. Apply a rust prevention oil such as Meritor part number 1199-U-1113 or equivalent to the inlet of the air cylinder.

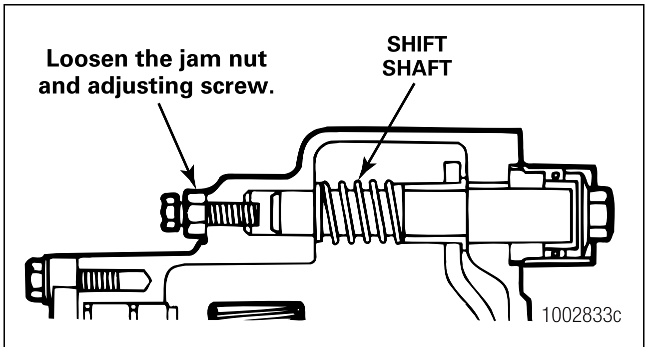


Figure 5.116

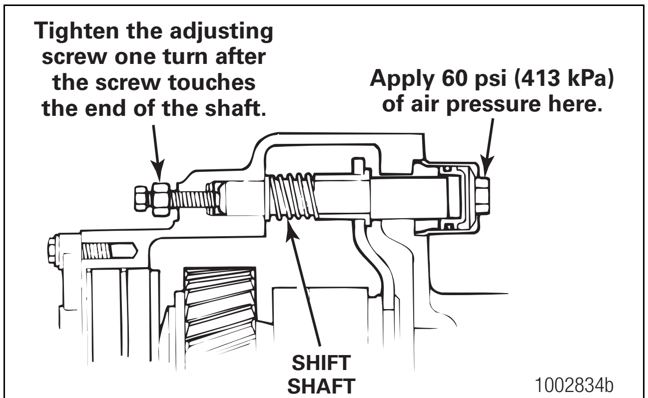


Figure 5.117

15. Connect the vehicle driveshafts to the input and the thru yokes or flanges.
16. Connect the air lines to the inter-axle differential air cylinder and, if used, the main differential lock cylinder.
17. On axles with a main differential lock, connect the electrical connector of the sensor unit. Verify that the main differential lock is disengaged.
18. If removed, install the oil filter adapter onto the differential carrier. Use Meritor specification 2297-T-4180 adhesive or equivalent. Refer to Section 4. Tighten the adapter to 40-60 lb-ft (55-80 N•m). Figure 5.118.

CAUTION

If the oil filter is tightened more than 3/4 of a turn after it contacts the carrier, the oil filter will be damaged and leak fluid. Damage to components can result.

19. Apply axle lubricant to the gasket of the new oil filter. Install the oil filter onto the adapter. When the gasket on the filter contacts the carrier, tighten the oil filter an additional 3/4 of a turn. If necessary, use an oil filter wrench to tighten the filter. Figure 5.118.

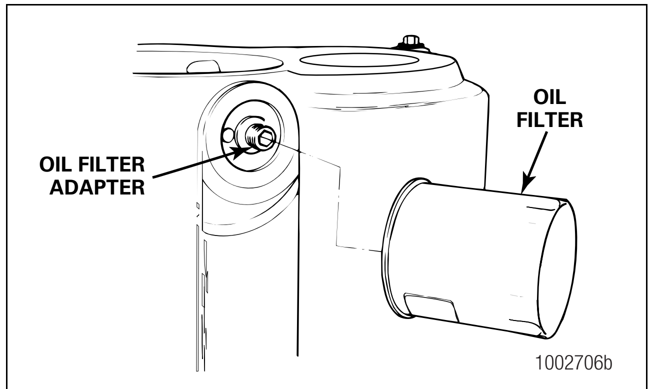


Figure 5.118

Axle Shaft

WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin. If Loctite® adhesive material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Tapered Dowel, Hardened Washer and Hardened Nut

1. Clean the mating surfaces of the axle shaft and wheel hub.
2. If silicone gasket material is used, apply a 0.125-inch (3 mm) diameter bead of the gasket material around the mating surface of the hub and around the edge of each fastener hole.

3. Install the gaskets and axle shafts into the axle housing and carrier. The gasket and flange of the axle shafts must fit flat against the wheel hub. Figure 5.119.
4. If the wheel hubs have tapered hole studs, install solid tapered dowels onto each stud and onto the flange of the axle shaft. Figure 5.119.

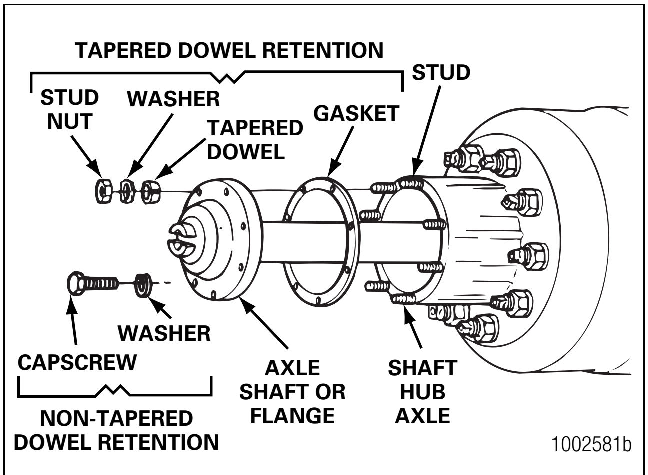


Figure 5.119

5. If the wheel hubs have straight hole studs, install the nuts and washers onto the studs. Figure 5.119. Tighten the nuts to the correct torque value. Refer to Section 8.
6. Position the gasket between the thru-shaft bearing cage and the axle housing.
7. Install the thru-shaft and bearing cage assembly into the axle housing. Rotate the thru-shaft to align the splines of the thru-shaft with the splines of the rear side gear.
8. Clean the cage-to-housing capscrews. Remove RTV residue from the thru-drilled tapped holes.
9. Apply a 0.25-inch (6 mm) length bead of Loctite® 518 sealant in the thru-drilled tapped holes located at the two, five and eight o'clock positions. Figure 5.120.
10. Install the gasket and axle shaft into the housing. The gasket and flange of the axle shaft must fit flat against the wheel hub. Figure 5.119.

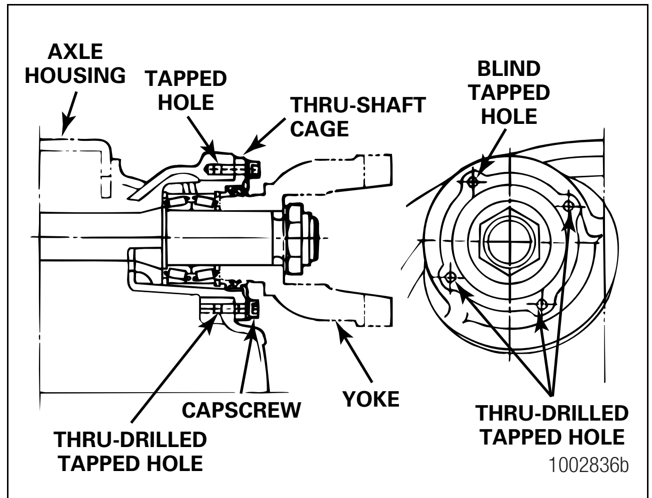


Figure 5.120

11. Install solid tapered dowels over each stud and into the flange of the axle shaft. Use a punch or a drift and hammer, if necessary.
12. Install the Grade 8 nuts and hardened washers onto the stud. Lock washers are an acceptable alternative. Tighten the stud nuts to the torque specified in Table M.

Table M: Shaft-to-Hub Torque Fastener Chart — Tapered Dowel Applications

Fastener	Thread Size	Torque Value — Grade 8 Nuts lb-ft (N•m) Plain Nut	Locknut
Stud Nut or Axle Shaft	0.44-20	50-75 (68-102)	40-65 (54-88)
	0.50-20	75-115 (102-156)	65-100 (88-136)
	0.56-18	110-165 (150-224)	100-145 (136-197)
	0.62-18	150-230 (204-312)	130-190 (176-258)
Studs	All	Install the coarse thread end of the stud into the hub and tighten to the last thread.	

13. Fill the axle with the specified lubricant. Refer to procedure in this section.

Straight Holes, Nuts and Hardened Washers

1. Clean the mating surfaces of the axle shaft and wheel hub.
2. If silicone gasket material is used, apply a 0.125-inch (3 mm) diameter bead of the gasket material around the mating surface of the hub and around the edge of each fastener hole.

3. Install the gaskets and axle shafts into the axle housing and carrier. The gasket and flange of the axle shafts must fit flat against the wheel hub. Figure 5.119.
4. If the wheel hubs have tapered hole studs, install solid tapered dowels onto each stud and onto the flange of the axle shaft. Figure 5.119.
5. If the wheel hubs have straight hole studs, install the nuts and washers on the studs. Tighten the nuts to the correct torque value. Refer to Section 8.
6. Position the gasket between the thru-shaft bearing cage and the axle housing.
7. Install the thru-shaft and bearing cage assembly into the axle housing. Rotate the thru-shaft to align the splines of the thru-shaft with the splines of the rear side gear.
8. Clean the cage-to-housing capscrews. Remove RTV residue from the thru-drilled tapped holes.
9. Apply a 0.25-inch (6 mm) length bead of Loctite® 518 sealant in the thru-drilled tapped holes located at the two, five and eight o'clock positions. Figure 5.121.

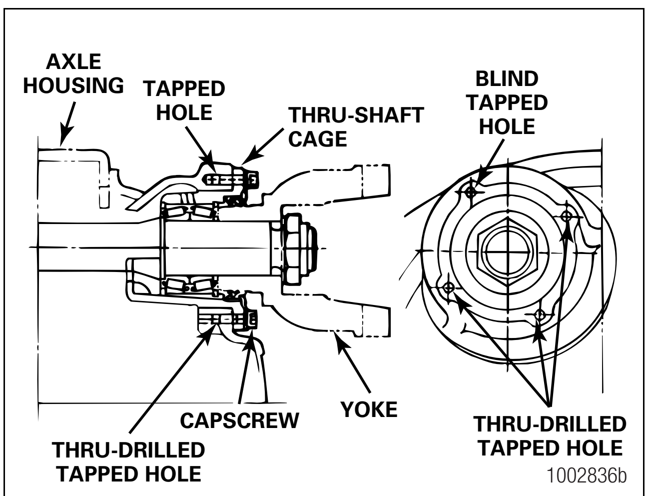


Figure 5.121

10. Install the gasket and axle shaft into the housing. The gasket and flange of the axle shaft must fit flat against the wheel hub. Figure 5.119.
11. Install the Grade 8 nuts and hardened washers on the stud. Lock washers are an acceptable alternative. Tighten the stud nuts to the torque specified in Table N.
12. Fill the axle with the specified lubricant. Refer to procedure in this section.

Table N: Shaft-to-Hub Torque Fastener Chart — Non-Tapered Dowel Applications

Fastener	Thread Size	Torque Value — Grade 8 Nuts lb-ft (N•m): Plain Nut	Torque Value — Grade 8 Nuts lb-ft (N•m): Locknut
Stud Nut or Axle Shaft	0.62-18	150-230 (203-312)	130-190 (176-258)
	0.75-16	310-400 (420-542)	270-350 (366-475)
Studs	All	Install the coarse thread end of the stud into the hub and tighten to the last thread.	

Fill the Axle with Lubricant

NOTE: For additional lubrication information, refer to Maintenance Manual 1, Preventive Maintenance and Lubrication. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

1. Park the vehicle on a level surface. When the angle of the drive pinion changes, the lubricant capacity of the axle will change.
2. Remove the fill plug from the side of the bowl cover of the axle housing. Figure 5.122.

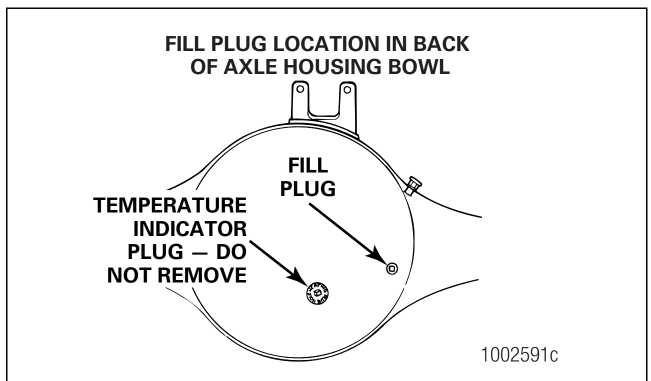


Figure 5.122

3. Fill the axle with lubricant until the lubricant level is to the bottom of the fill plug hole. Refer to Section 7.
4. Install the fill plug. Tighten the fill plug to 35 lb-ft (47 N•m). When correctly installed, one complete thread of the fill plug is visible between the housing and plug head.
5. Road test the vehicle in an unloaded condition for one to two miles (1.6-3.2 km) at speeds not more than 25 mph (40 kmh). Recheck the lubricant levels and all the fasteners.
6. If used, inspect the operation of the driver-controlled main differential lock. Refer to Section 6.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Description

Some Meritor drive axle models have a driver-controlled main differential lock (DCDL). This differential lock is operated by a carrier-mounted, air-actuated shift unit. When activated, the shift unit moves a sliding collar which is installed on the splines of the axle shaft. When engaged, the collar locks the axle shaft to a second set of splines on the differential case. Both driven wheels are then simultaneously engaged. Figure 6.1.

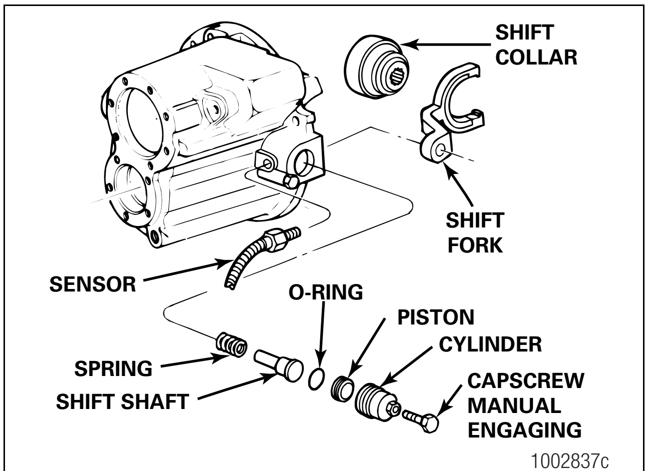


Figure 6.1

Meritor carrier models with driver-controlled differential lock equipment are manufactured in metric dimensions and sizes. When these carriers are serviced, it is important to use the correct metric size tools on the fasteners. Refer to Section 8.

Removal

Differential Carrier from the Axle Housing

Before the differential carrier can be removed or installed, the differential lock must be shifted into and held in the locked or engaged position. The locked position gives enough clearance between the shift collar and the axle housing to permit the removal or installation of the carrier.

The Axle Shafts Were Removed for Towing with the Differential in the Unlocked or Disengaged Position

Install the left-hand axle shaft into the housing before continuing. Perform the following steps for reinstalling the axle shafts into the axle housing.

1. Remove the protective covers, if used, from the wheel-end hubs.
2. If the drive axles are equipped with a main differential lock, shift the differential to the unlocked or disengaged position. Install the axle shafts with two sets of splines and new gaskets in the correct location as follows. Figure 5.119.
   A. Push the axle shaft and gasket into the hub and housing until the shaft stops against the differential lock collar.
   B. Push down and in on the axle shaft flange and rotate the shaft until the splines of the shaft and the shift collar are engaged.
   C. Push the axle shaft further into the housing until the shaft stops against the differential side gear.
   D. Push down on the axle shaft flange and rotate the shaft until the splines of the shaft and the side gear are engaged.
   E. Push the axle shaft completely into the housing until the axle shaft flange and gasket are flush against the wheel hub.

Engagement or Lockout of the DCDL

⚠ WARNING

During DCDL disassembly or carrier removal, when the DCDL is in the locked or engaged position and one of the vehicle's wheels is raised from the floor, do not start the engine and engage the transmission. The vehicle can move and cause serious personal injury. Damage to components can result.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Manual Method

Use the following manual engaging method to shift the DCDL into the locked position.

If an auxiliary air supply is not available or if the differential carrier is to be stored for later use, use this manual engaging method for the DCDL. Figure 6.2 and Figure 6.3.

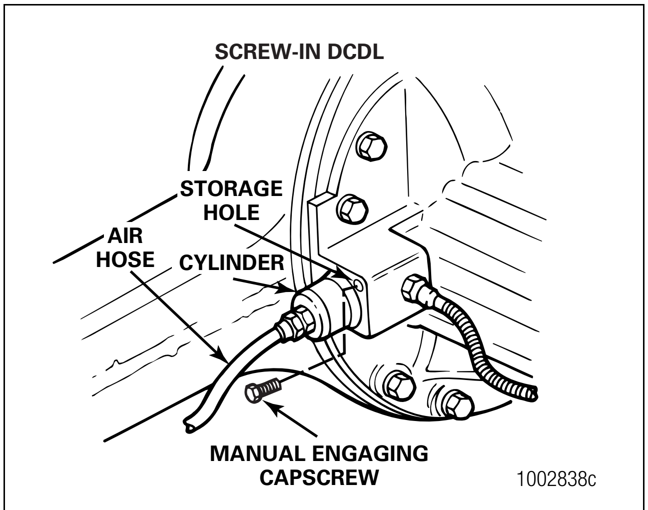


Figure 6.2

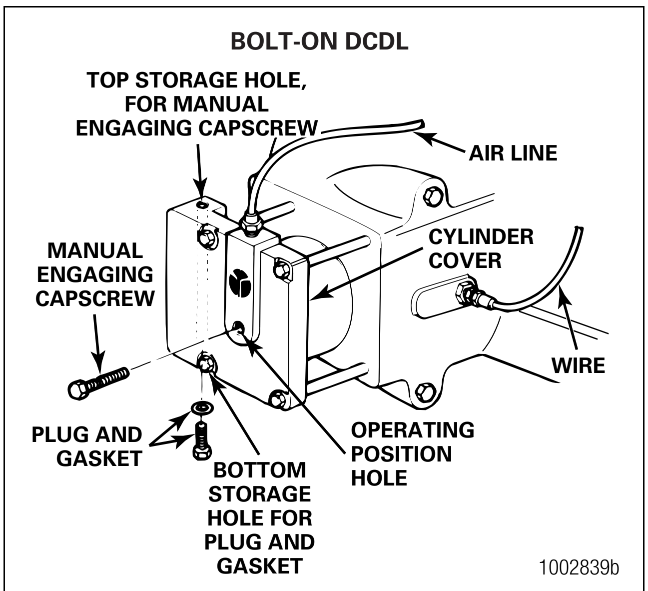


Figure 6.3

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Remove the drain plug from the bottom of the housing and drain the lubricant.
3. Use a jack to raise the left-hand wheel of the drive axle.
4. Place a jackstand under the left-hand spring seat to hold the vehicle in the raised position.
5. Disconnect the driveline from the input yoke.
6. Disconnect the vehicle air line from the inter-axle differential and main differential lock actuator assemblies.
7. For a bolt-on style differential lock cylinder, remove the plug and gasket from the hole in the center of the screw-in DCDL cylinder or bolt-on DCDL cover.
8. Remove the manual engaging capscrew from the top storage hole in the cylinder cover or the shift tower of the carriers with the threaded type shift assembly. Figure 6.2 and Figure 6.3.

NOTE: For a bolt-on DCDL shift assembly, the storage hole for the plug and gasket is the opposite end of the storage hole for the manual engaging capscrew. Figure 6.3.

9. Install the plug and gasket into the bottom storage hole in the cylinder cover or in the shift tower.
10. Install the manual engaging capscrew into the threaded hole in the center of the cylinder cover or cylinder.

⚠ CAUTION

There will be a small amount of spring resistance felt when you turn in the manual engaging capscrew. If a high resistance is felt before reaching the locked or engaged position, stop turning the capscrew, or the cover, fork and capscrew threads will be damaged.

11. Turn the manual adjusting capscrew to the right until the head is approximately 0.25-inch (6 mm) from the cylinder cover. Do not turn the capscrew beyond its normal stop.

    A high resistance on the capscrew indicates that the splines of the shift collar and the differential case half are not aligned or engaged. To align the splines, use the following procedure.

    A. Rotate the left-hand wheel to align the splines of the shift collar and case half while you turn in the manual engaging capscrews.

    B. When the normal amount of spring resistance is again felt on the capscrew, the splines are engaged. Continue to turn in the manual engaging capscrew until the head is approximately 0.25-inch (6 mm) from the cylinder cover. The capscrew is now in the service position and the main differential lock is completely engaged.

12. Remove the carrier from the axle housing. Refer to Section 3.
13. Release the differential lock by removing the manual engaging capscrew and seal from the cylinder cover or cylinder.

Auxiliary Air Supply Method

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Use a jack to raise the left-hand wheel of the drive axle. Place a safety stand under the left-hand axle housing leg to support the vehicle in the raised position.
3. Remove the drain plug from the bottom of the housing and drain the lubricant.
4. Disconnect the driveline from the input yoke.
5. Disconnect the vehicle air line from the inter-axle differential and main differential lock actuator assemblies.
6. Install a suitable air line coupling into the main differential actuator assembly.
7. Install the air line into the coupling.

⚠ CAUTION

When you use an auxiliary air supply to engage the DCDL, you must supply air to the DCDL until you remove the carrier. Do not disconnect the air line or reduce air pressure to the DCDL before you remove the carrier from the housing. Damage to components can result.

8. Supply 120 psi (827 kPa) regulated air pressure through the air line.
9. Verify that the DCDL is engaged.
10. Remove the carrier from the axle housing. Refer to Section 3.
11. Shut-off the air supply to the DCDL.
12. Disconnect the air line from the main differential actuator assembly coupling.

Differential and Gear Assembly and Main Differential Lock

Screw-In DCDL Shift Assembly

The current design shift fork does not employ roll pins. Nubs on the inner face of the fork hold the shift collar in place. Figure 6.4.

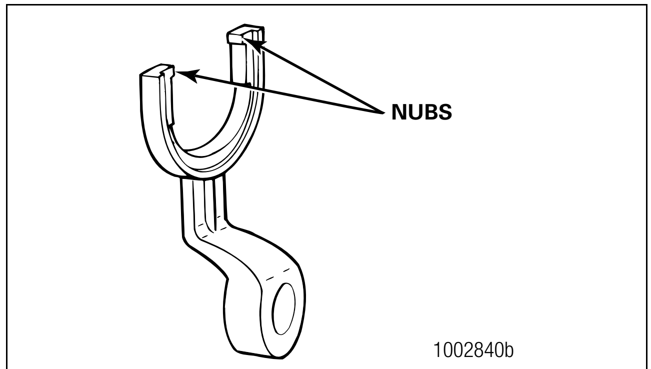


Figure 6.4

1. Verify that the differential lock is released and the engaging capscrew and seal are removed from the shift cylinder.
2. Tap the shift collar with a rubber mallet to loosen and remove the collar from the shift fork. Figure 6.5.

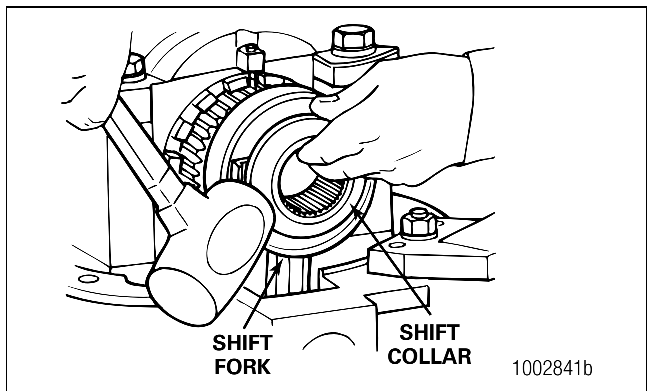


Figure 6.5

3. Remove the differential lock sensor switch, if used, and jam nut from the carrier. Figure 6.6.

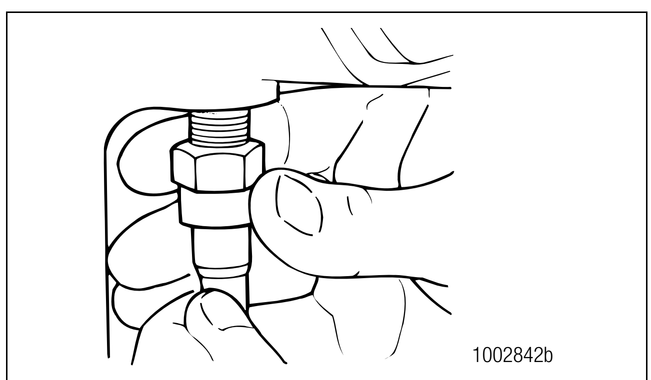


Figure 6.6

4. Remove the shift cylinder and piston assembly from the carrier by turning it to the left. Figure 6.7.

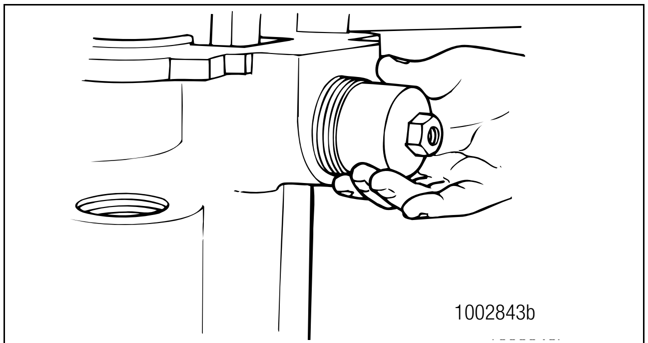


Figure 6.7

5. Place the shift cylinder and piston assembly in a vise that has brass covers over the jaws. Remove the piston and O-ring from inside the cylinder. Use a narrow drift through the hole in the top of the cylinder to push out the piston. It may be necessary to use a mallet to tap out the piston. Figure 6.8.

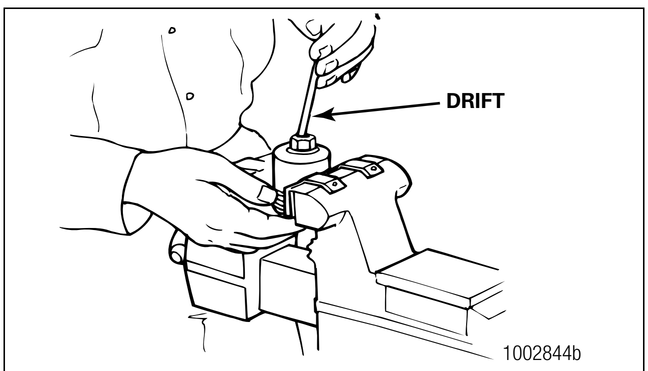


Figure 6.8

6. Carefully remove the O-ring from the piston. Use a thin pointed tool to remove the O-ring. Do not damage the piston. Figure 6.9.

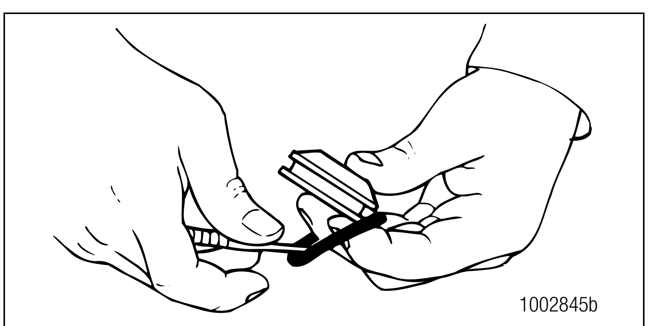


Figure 6.9

7. Inspect the O-ring for any damage such as cracks, cuts or breaks.
   - **If the O-ring is damaged:** Replace it with a new O-ring when you assemble the components.
8. Clean and inspect all shift assembly parts. Refer to Section 4.
9. Pull the shift shaft from the fork and out of the carrier. Figure 6.10.

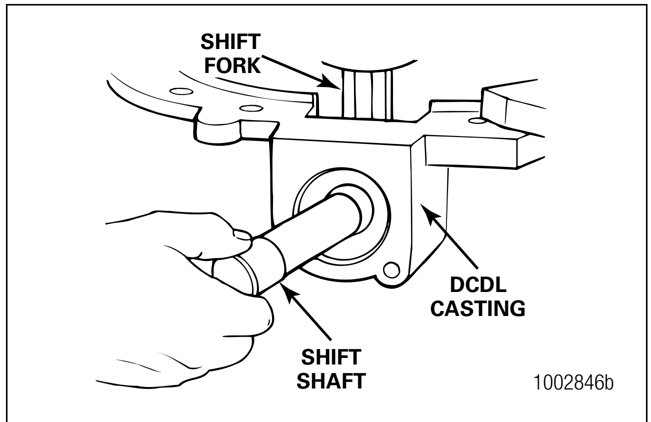


Figure 6.10

10. Remove the shift shaft spring and fork from the carrier. Figure 6.11.

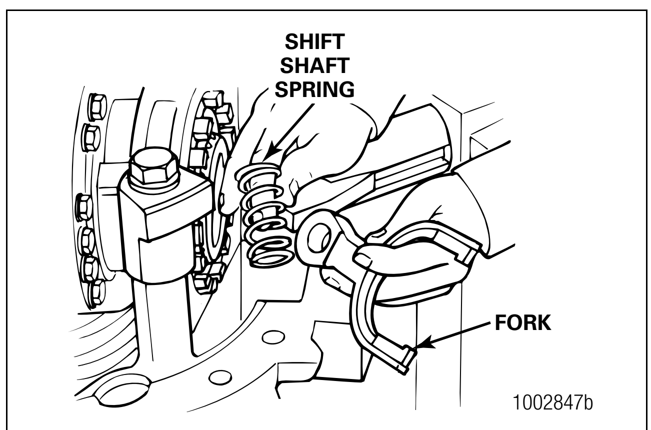


Figure 6.11

11. If roll pins are used, use a hammer and brass drift to remove the roll pins for the adjusting rings on the bearing caps. If capscrews or cotter pins are used, remove the capscrews or cotter pins.

12. Remove the bearing cap capscrews and washers, the bearing caps and adjusting rings. Match mark one bearing cap and one carrier leg so that these parts will be assembled in the correct positions.
13. Lift the differential and gear assembly from the carrier. Figure 6.12.

    Further disassembly of these carriers is the same as axles without the driver-controlled main differential lock. To continue disassembly, follow the procedures in Section 3.

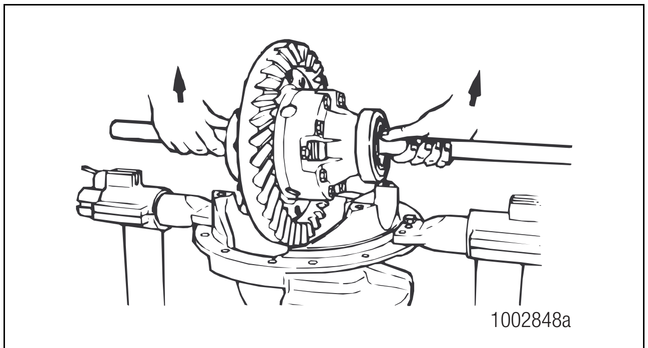


Figure 6.12

Bolt-On DCDL Shift Assembly

1. To remove the differential lock sliding shift collar, tap out the two retainer roll pins until they are level with the inner face of the shift fork. Figure 6.13.

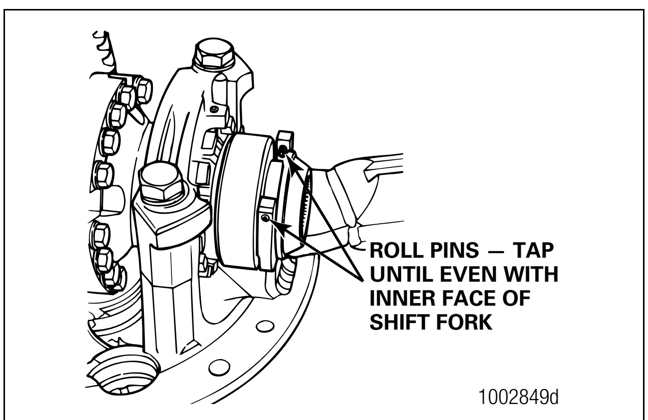


Figure 6.13

2. If required, remove the differential lock shift unit.
   A. Remove the sensor switch and jam nut.
   B. Remove the four capscrews and washers that hold the cylinder cover. Remove the cover. On the 160 Series, remove the copper gasket. Figure 6.14.
   C. Remove the shift cylinder and piston.
   D. Remove the shift shaft from the shift fork. It may be necessary to use heat to separate the shaft from the fork to loosen it.

NOTE: Some models use silastic seal instead of the flat washer in Step E. Also, a roll pin is installed in the shift shaft and is used as a stop for the shift shaft spring. It is not necessary to remove this roll pin during a normal disassembly.

   E. Remove the shift shaft spring and flat washer.
   F. Remove the shift fork and continue with Step 11 in the previous procedure.

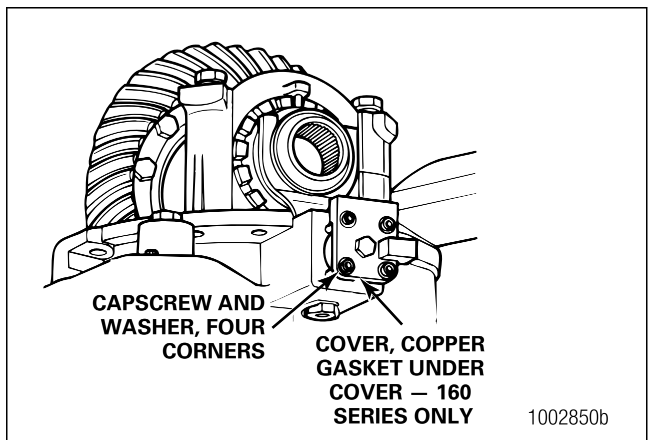


Figure 6.14

Installation

Differential Shift Assembly

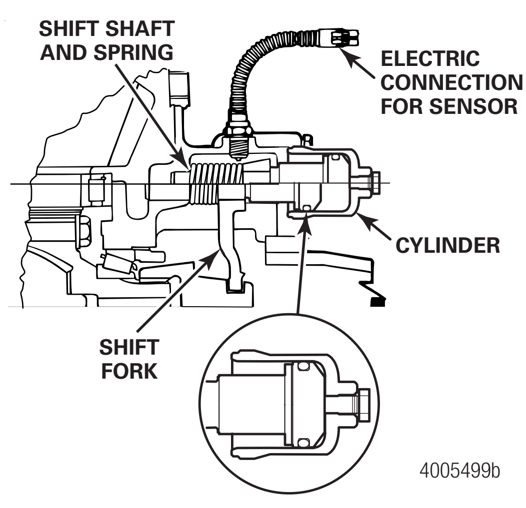
⚠ WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin. If Loctite® adhesive material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

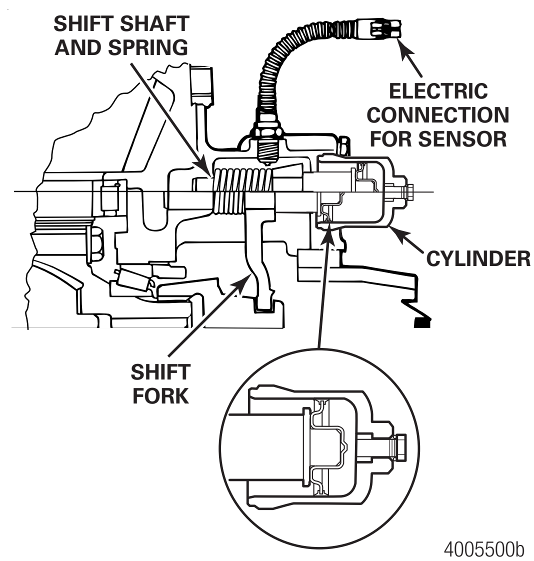
Screw-In DCDL Shift Assembly

Install the differential shift assembly after the differential carrier is assembled and the gear and bearing adjustments are made. The screw-in DCDL shift assembly is shown in Figure 6.15 and Figure 6.16.



SCREW-IN STYLE WITH O-RING

Figure 6.15



SCREW-IN STYLE WITH BONDED LIP SEAL PISTON

Figure 6.16

1. Install the shift fork into the shift of the carrier. The "L" shape of the fork and the bore for the shift shaft must face out toward the cylinder bore in the side of the carrier. Figure 6.17.

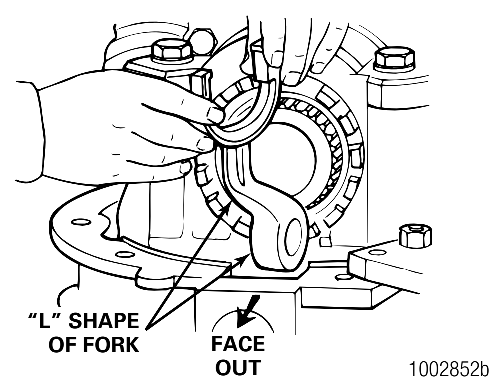


Figure 6.17

2. Compress the shift shaft spring as required and install it between the back of the fork and carrier wall inside the carrier. Figure 6.18.

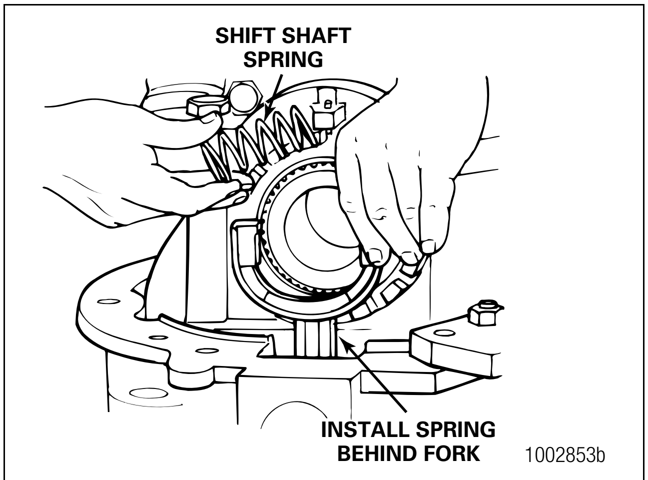


Figure 6.18

3. Align the spring and bore in the shift fork with the shift shaft bore in the carrier.
4. Install the shift shaft through the bore in the carrier, fork and spring until it is against the shift fork. Figure 6.19.

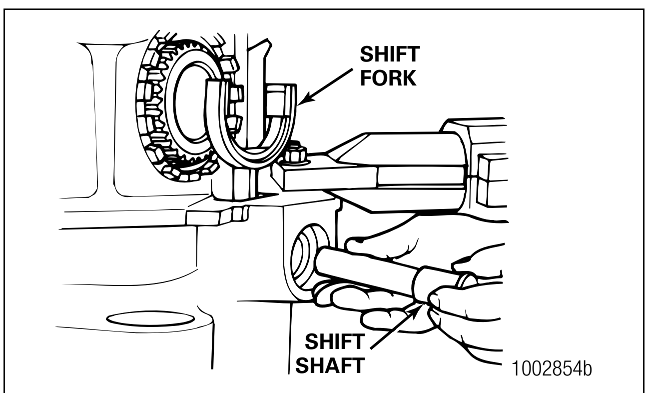


Figure 6.19

5. If required, lubricate a new O-ring with axle lubricant. Install the O-ring into the piston groove.
6. Install the piston and O-ring assembly into the shift cylinder, bevel end first. Push on the piston until it is against the bottom of the cylinder. Figure 6.20.

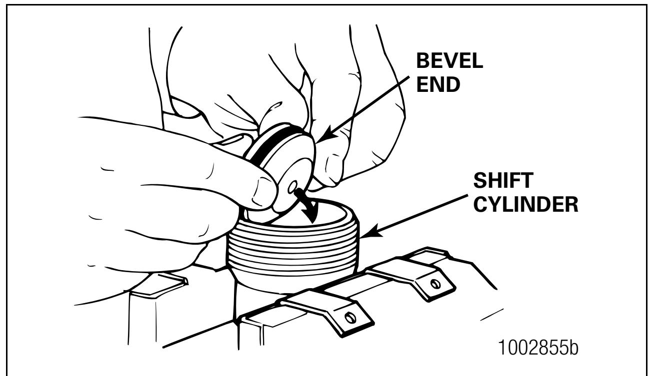


Figure 6.20

7. Apply a continuous 0.06-inch (1.5 mm) diameter bead of Loctite® flange sealant, Meritor part number 2297-D-7076, around the DCDL cylinder threads.
8. Turn the shift cylinder and piston assembly to the right until it bottoms in the carrier casting bore. Figure 6.21.

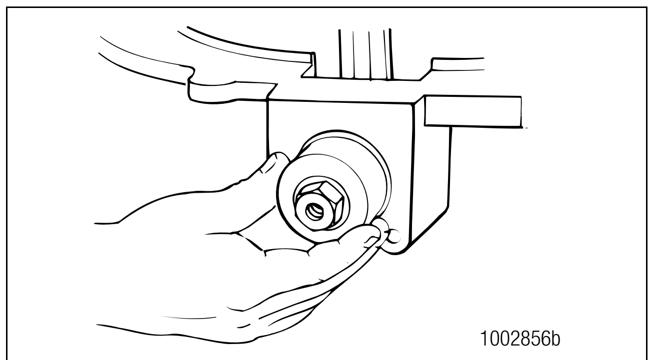


Figure 6.21

9. Position the shift collar over the fork. The large splines of the collar must face toward the main differential. Use a rubber mallet to tap the shift collar through the nubs of the shift fork. Figure 6.22.

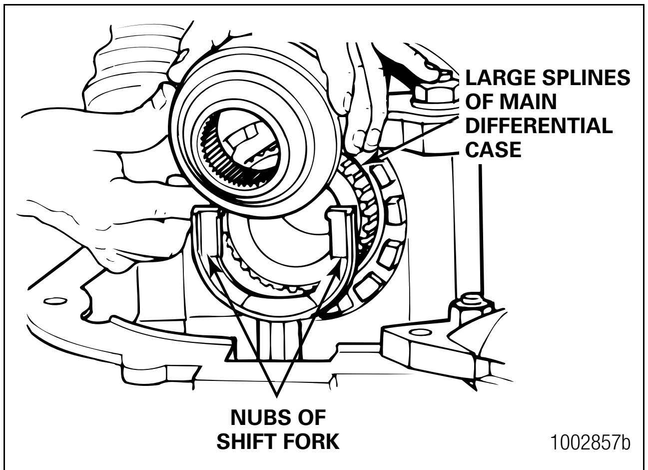


Figure 6.22

10. Engage the splines of the collar with the splines of the differential case. Insert the manual engaging capscrew through the top of the shift cylinder to move the shift collar toward the differential case. Rotate the collar as necessary to align the splines. Figure 6.23.

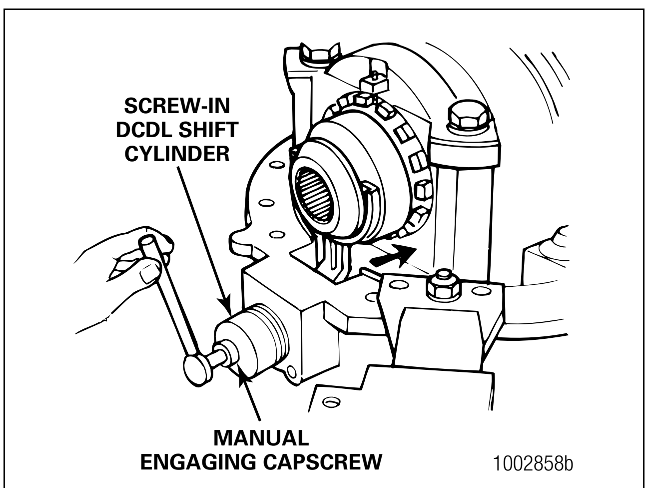


Figure 6.23

11. Turn the manual adjusting capscrew to the right until the head is approximately 0.25-inch (6 mm) from the cylinder cover. Do not turn the capscrew beyond its normal stop. The capscrew is now in the service position and the main differential lock is completely engaged.

NOTE: The differential must be in the locked position to install the axle shaft into the axle housing.

12. With the shift collar in the locked position, install the sensor switch into the threaded hole in the front of the carrier. Figure 6.24.

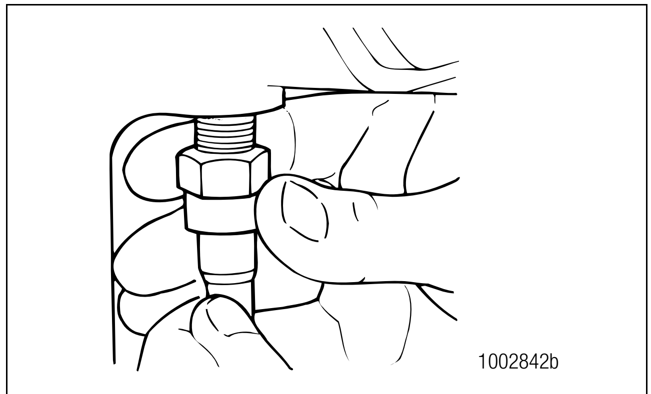


Figure 6.24

13. Connect a volt-ohm meter to the sensor switch. Select ohms on the meter. With the DCDL engaged, the circuit should be closed, showing less than one ohm resistance. If the resistance is over one ohm, check the sensor.

    A. Verify that the fork is aligned with the sensor switch when it is in the engaged position.

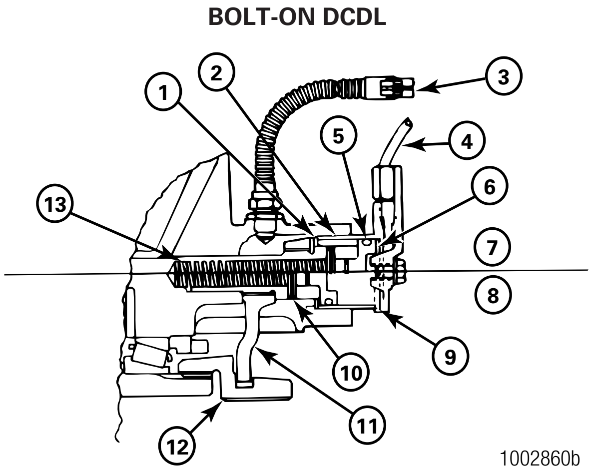
    B. Check for a loose wiring connection. The connector must be tightly seated.

    C. Verify that the sensor switch is fully seated against the carrier.

    - **If the resistance is greater than one ohm after these checks:** Replace the sensor switch.

Bolt-On DCDL Shift Assembly

Install the differential shift assembly after the differential carrier is assembled and the gear and bearing adjustments are made. The bolt-on type shift assembly is shown in Figure 6.25.



1 FLAT WASHER OR SILASTIC AS REQUIRED
2 CYLINDER
3 ELECTRIC CONNECTION FOR SENSOR
4 AIR LINE
5 O-RING
6 PISTON
7 DISENGAGED
8 ENGAGED
9 COPPER GASKET
10 PIN
11 SHIFT FORK
12 COLLAR
13 SHIFT SHAFT AND SPRING

Figure 6.25

1. On carrier models with shift fork roll pins, install the two roll pins into the ends of the shift fork. Tap the pins into position until they are level with the inner yoke face. Figure 6.26. Do not install completely at this time.

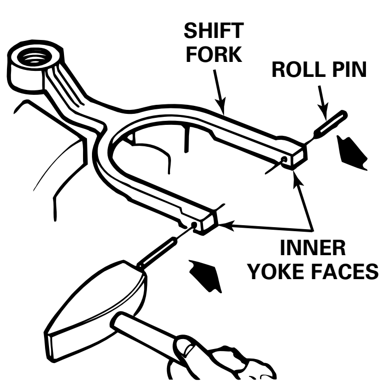


Figure 6.26

2. If the spring stop roll pin was removed from the head of the shift shaft, reinstall the pin at this time.
3. On models without roll pins, snap the fork into position.
4. Apply Loctite® 222 threadlocker, Meritor part number 2297-B-6112, to the threads of the shift shaft.
5. Install the shift fork into its correct position in the carrier case. Figure 6.27.

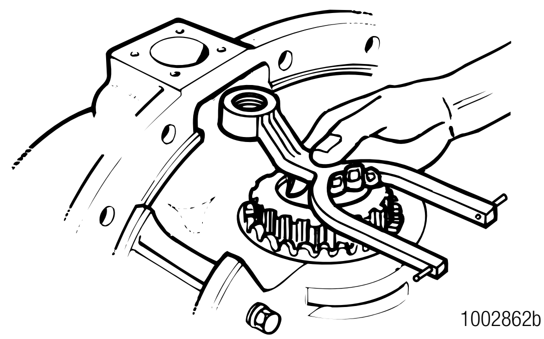


Figure 6.27

6. Hold the shift fork in position. Install the shift shaft spring into the shift shaft opening in the carrier, through the shift fork bore and into the bore for the shift shaft spring. Figure 6.28.

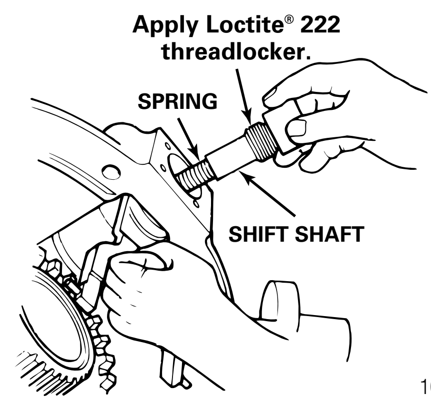


Figure 6.28

7. Slide the shift shaft over the spring. Install the shaft into the shift fork. Tighten it to 20-25 lb-ft (27-34 N•m).
8. Install the copper gasket or apply silastic sealant, Meritor part number 1199-Q-2981, to the bottom of the cylinder bore. Figure 6.29.

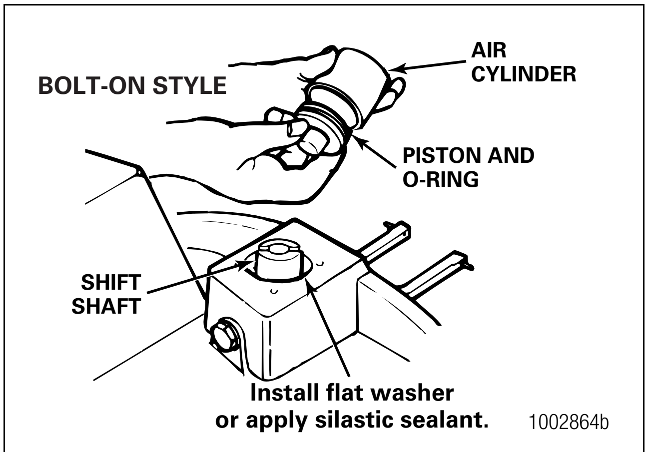


Figure 6.29

9. Lubricate the O-ring with axle lubricant. Install the O-ring into its groove on the piston. Carefully install the piston into the air cylinder. Figure 6.29. Do not damage the O-ring.
10. Install the cylinder into the housing bore. Verify that the pilot journal on the piston is against its bore on the shift shaft. Figure 6.30.

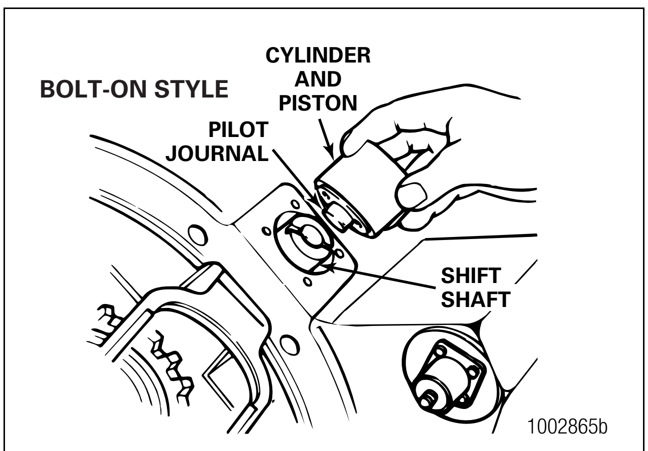


Figure 6.30

11. Install the copper gasket, if used, into its bore on the inside of the cylinder cover. Place the cover into position over the cylinder so that the air intake port will point up when the carrier is installed into the housing. Install the cover with the four attaching capscrews and washers. Tighten the capscrews to 4-6 lb-ft (5.5-8.5 N•m). Figure 6.31.

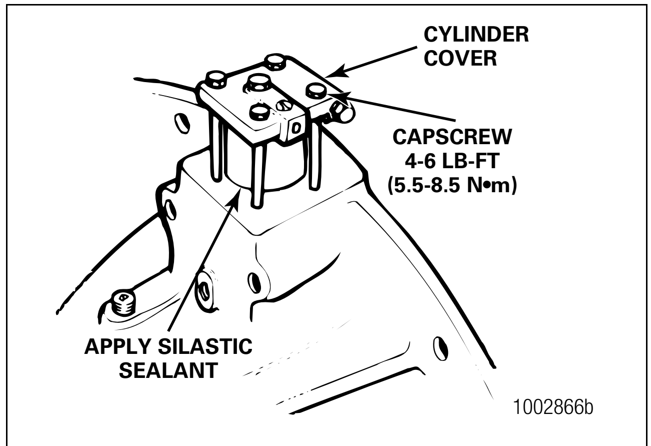


Figure 6.31

12. Apply a bead of silastic sealant, Meritor part number 1199-Q-2981, to the cylinder housing joint.
13. Slide the shift collar into the fork and engage the shift collar splines with the splines of the differential case. Use the manual actuation capscrew to move the shift collar splines onto the differential case splines. Refer to Engagement or Lockout of the DCDL in this section.
14. Hold the shift collar in the locked or engaged position and tap in the two roll pins in the shift fork ends until they are even with the outer yoke faces. Figure 6.32.

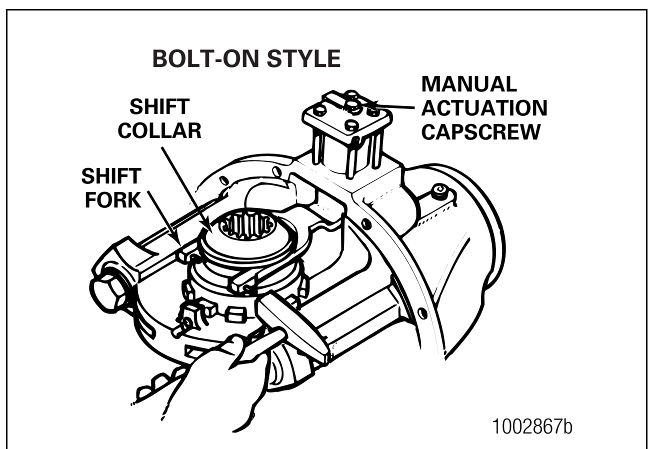


Figure 6.32

15. While the shift collar is still in the locked position, place the sensor switch, with the locknut loosely attached, into its hole.

16. Connect a volt-ohm meter to the sensor switch. Select ohms on the meter. Rotate the switch CLOCKWISE until the meter reading changes from infinity to less than one ohm. Turn the switch one additional turn and tighten the locknut to 25-35 lb-ft (35-45 N•m).

Differential Lock Assembly Cover Plates

For carriers without the differential lock or air shift, assemble the sensor switch plug and cover plate as follows.

Bolt-On DCDL Cover Plate Assemblies

1. Install the washer and plug into the hole for the sensor switch. Tighten the plug from 45-55 lb-ft (60-74 N•m). Figure 6.33.

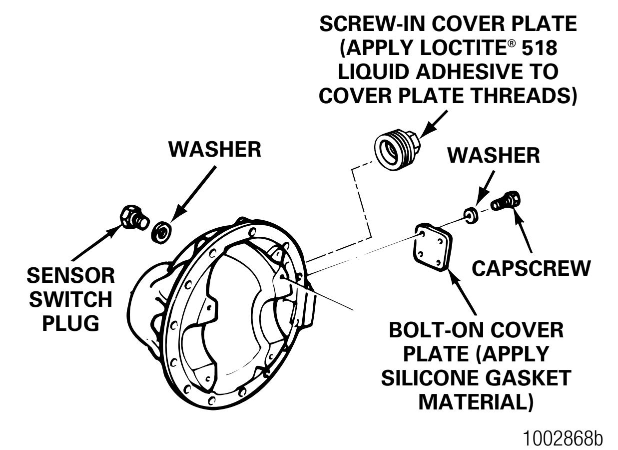


Figure 6.33

2. Apply silicone gasket material to the cover plate mounting surface on the carrier. Refer to Section 4.
3. Install the four washers and capscrews. Tighten the capscrews to 7.4-8.9 lb-ft (10-12 N•m). Figure 6.33.

Screw-In DCDL Cover Plate Assemblies

1. Apply Loctite® 518 liquid adhesive to the plate threads.
2. Install the bolts and washers and tighten the plate into the carrier opening to 7.5-9.0 lb-ft (10-12 N•m).

Differential Carrier Into the Forward Axle Housing

WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

NOTE: When you install the carrier into the axle housing, the shift collar must be held in the engaged position. This can be done by keeping the air pressure applied to the shift cylinder by using the manual engaging capscrew. Refer to the procedure in this section. The differential must be in the locked or engaged position to install the carrier assembly into the axle housing. After you install the carrier into the axle housing, shift the differential into the unlocked or disengaged position to permit the installation of the left-hand axle shaft.

Manual Method

1. Use a cleaning solvent and rags to clean the inside of the axle housing and the carrier mounting surface. Refer to Section 4.
2. Check the axle housing for damage. If necessary, repair or replace the housing. Refer to Section 4.
3. Check for loose studs in the carrier mounting surface. Remove and replace the studs where required. Apply liquid adhesive to the holes. Install and tighten the stud to 150-230 lb-ft (204-312 N•m).
4. The differential lock must be manually engaged before installing the differential carrier into the housing. Refer to the procedure in this section.
5. Install the differential carrier into the housing. Refer to Section 5.

6. Install and tighten the carrier-to-housing capscrews to the specified torque.
7. Install the right- and left-hand axle shafts. Refer to Section 5.

NOTE: When the manual engaging capscrew is removed from the service position in the center of the DCDL actuator, the main differential lock is disengaged.

8. Remove the long manual engaging capscrew from the center of either the bolt-on or screw-in DCDL.
9. Clean the plug, gasket, cylinder cover and threaded service position hole in the center of the bolt-on DCDL cylinder cover, or in the center of the screw-in DCDL.
10. Verify that the sealing gasket is under the head of the capscrew.
11. Install the manual engaging capscrew into the DCDL storage hole in the bolt-on or the screw-in DCDL assembly. Figure 6.34 and Figure 6.35.
    A. On a bolt-on DCDL shift assembly, remove the short plug and gasket from the storage hole of the DCDL.

       Install the short plug and gasket into the service position hole in the center of the DCDL. Figure 6.34.
    B. On a screw-in DCDL shift assembly, install the short screw or plug into the storage hole located in the top of the screw-in DCDL shift assembly. Figure 6.35.

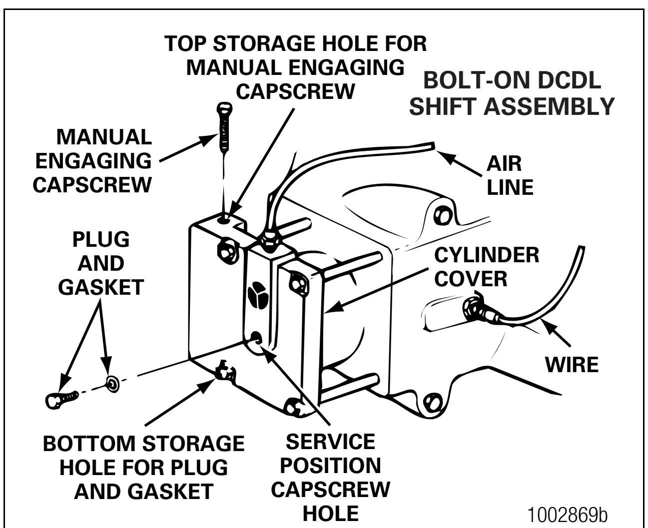


Figure 6.34

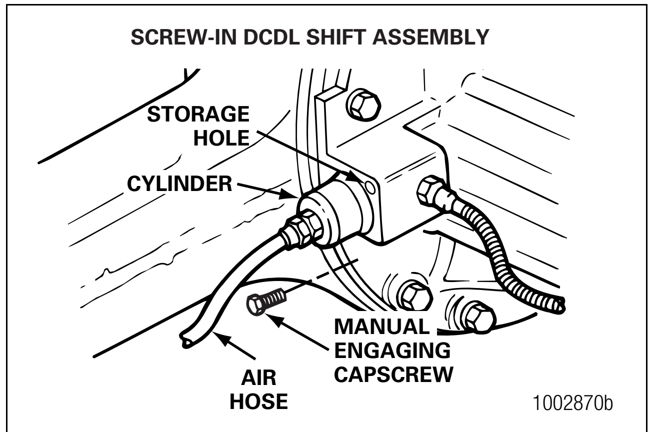


Figure 6.35

12. Tighten the plug to 44-55 lb-ft (60-75 N•m). Tighten the manual engaging capscrew to 22-28 lb-ft (30-38 N•m) for bolt-on DCDL style cylinders and to 7-11 lb-ft (10-15 N•m) for screw-in DCDL type reverse shifters.
13. Connect the vehicle air line to the differential lock actuator assembly.
14. Install the electrical connection on the sensor switch located in the carrier, below the actuator assembly.
15. Remove the jackstand from under the drive axle. Lower the vehicle to the floor.
16. Fill the axle with lubricant. Refer to Section 7.
17. Proceed to Check the Differential Lock in this section.

Auxiliary Air Supply Method

1. Use a cleaning solvent and rags to clean the inside of the axle housing and the carrier mounting surface. Refer to Section 4.
2. Check the axle housing for damage. If necessary, repair or replace the housing. Refer to Section 4.
3. Check for loose studs in the carrier mounting surface. Remove and replace the studs where required. Apply liquid adhesive to the holes. Install and tighten the stud to 150-230 lb-ft (204-312 N•m).
4. Connect an air line to the main differential lock actuator assembly coupling.
5. Supply 120 psi (827 kPa) regulated air pressure through the air line.
6. Verify that the DCDL engaged.

7. Install the differential carrier into the housing. Refer to Section 5.
8. Install and tighten the carrier-to-housing capscrews to the specified torque.
9. Install the right- and left-hand axle shafts. Refer to Section 5.
10. Remove the air line coupling from the main differential actuator assembly.
11. Clean the plug, gasket, cylinder cover and threaded service position hole in the center of the bolt-on DCDL cylinder cover, or in the center of the screw-in DCDL.
12. Tighten the plug to 44-55 lb-ft (60-75 N•m). Tighten the manual engaging capscrew to 22-28 lb-ft (30-38 N•m) for bolt-on DCDL style cylinders and to 7-11 lb-ft (10-15 N•m) for screw-in DCDL type reverse shifters.
13. Connect the vehicle air line to the differential lock actuator assembly.
14. Install the electrical connection onto the sensor switch located in the carrier, below the actuator assembly.
15. Remove the jackstand from under the drive axle. Lower the vehicle to the floor.
16. Fill the axle with lubricant. Refer to Section 7.
17. Proceed to Check the Differential Lock which follows.

Check the Differential Lock

1. Shift the vehicle transmission into neutral. Start the engine to get the system air pressure to the normal level.

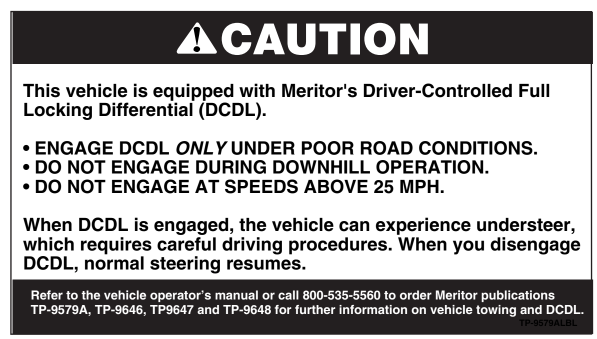
WARNING

During DCDL disassembly, when the DCDL is in the locked or engaged position and one of the vehicle's wheels is raised from the floor, do not start the engine and engage the transmission. The vehicle can move and cause serious personal injury and damage to components.

2. Place the differential lock switch in the cab of the vehicle in the unlocked or disengaged position.
3. Drive the vehicle at 5-10 mph (8-16 km/h) and check the differential lock indicator light. The light must be off when the switch is in the unlocked or disengaged position.
4. Continue to drive the vehicle and place the differential lock switch in the locked or engaged position. Let up on the accelerator to remove the driveline torque and permit the shift. The light must be on when the switch is in the locked position.
   - **If the indicator light remains ON with the switch in the unlocked position:** The differential is still in the locked position. Verify that the manual engaging capscrew was removed from the cylinder cover of the DCDL shift assembly. Refer to the procedure in this section.

DCDL Driver Caution Label

Verify that the driver caution label is installed in the vehicle cab. Figure 6.36. The caution label must be placed in a location that is easily visible to the driver. The recommended location is on the instrument panel, next to the differential lock switch and lock indicator light.



1003395b

Figure 6.36

Technical Publications

To obtain these items, refer to the Service Notes page on the front inside cover of this manual.

- DCDL driver caution label, TP-86101
- DCDL Driver Instruction Kit (includes DCDL label and technical bulletin), TP-9579
- Traction-Control Video package, T-95125V

Specifications

Meritor recommends using a lubricant analysis program. Perform lubricant analysis at regularly-scheduled preventive maintenance intervals.

For complete information on lubricating drive axles and carriers, refer to Maintenance Manual 1, Preventive Maintenance and Lubrication. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Refer to Table O, Table P and Table Q for standard information on lubricants, schedules and capacities.

Table O: Lubricant Cross Reference (Viscosity) and Temperature Chart

Meritor Lubricant Specification	Description	Cross Reference	Minimum Outside Temperature	Maximum Outside Temperature
O-76-A	Hypoid Gear Oil	GL-5, S.A.E. 85W/140	+10°F (–12.2°C)	*
O-76-B	Hypoid Gear Oil	GL-5, S.A.E. 80W/140	–15°F (–26.1°C)	*
O-76-D	Hypoid Gear Oil	GL-5, S.A.E. 80W/90	–15°F (–26.1°C)	*
O-76-E	Hypoid Gear Oil	GL-5, S.A.E. 75W/90	–40°F (–40°C)	*
O-76-J	Hypoid Gear Oil	GL-5, S.A.E. 75W	–40°F (–40°C)	+35°F (+1.6°C)
O-76-L	Hypoid Gear Oil	GL-5, S.A.E. 75W/140	–40°F (–40°C)	*

* There is no upper limit on these outside temperatures, but the axle sump temperature must never exceed 250°F (+121°C).

Table P: Oil Change Intervals and Specifications for All Rear Drive Axles

Vocation or Vehicle Operation	Linehaul Intercity Coach	City Delivery School Bus Fire Truck Motorhome	Construction Transit Bus Refuse Yard Tractor Logging Heavy Haul Mining Oil Field Rescue
Initial Oil Change	No longer required as of January 1, 1993		
Check Oil Level	Every 25,000 miles (40 000 km) or the fleet maintenance interval, whichever comes first	Every 10,000 miles (16 000 km), once a month or the fleet maintenance interval, whichever comes first	Every 5,000 miles (8000 km), once a month or the fleet maintenance interval, whichever comes first[1]
Petroleum-based oil change on axle with or without pump and filter system	Every 100,000 miles (160 000 km) or annually, whichever comes first	Every 50,000 miles (80 000 km) or annually, whichever comes first	Every 25,000 miles (40 000 km) or annually, whichever comes first
Synthetic oil change on axle with or without pump and filter system[2]	Every 500,000 miles (800 000 km)	Every 100,000 miles (160 000 km) or annually, whichever comes first	Every 50,000 miles (80 000 km) or annually, whichever comes first
Filter change on axle with pump and filter system	Every 100,000 miles (160 000 km)	Every 100,000 miles (160 000 km)	Every 100,000 miles (160 000 km)

1 For continuous heavy-duty operation, check the oil level every 1,000 miles (1600 km). Add the correct type and amount of oil as required.

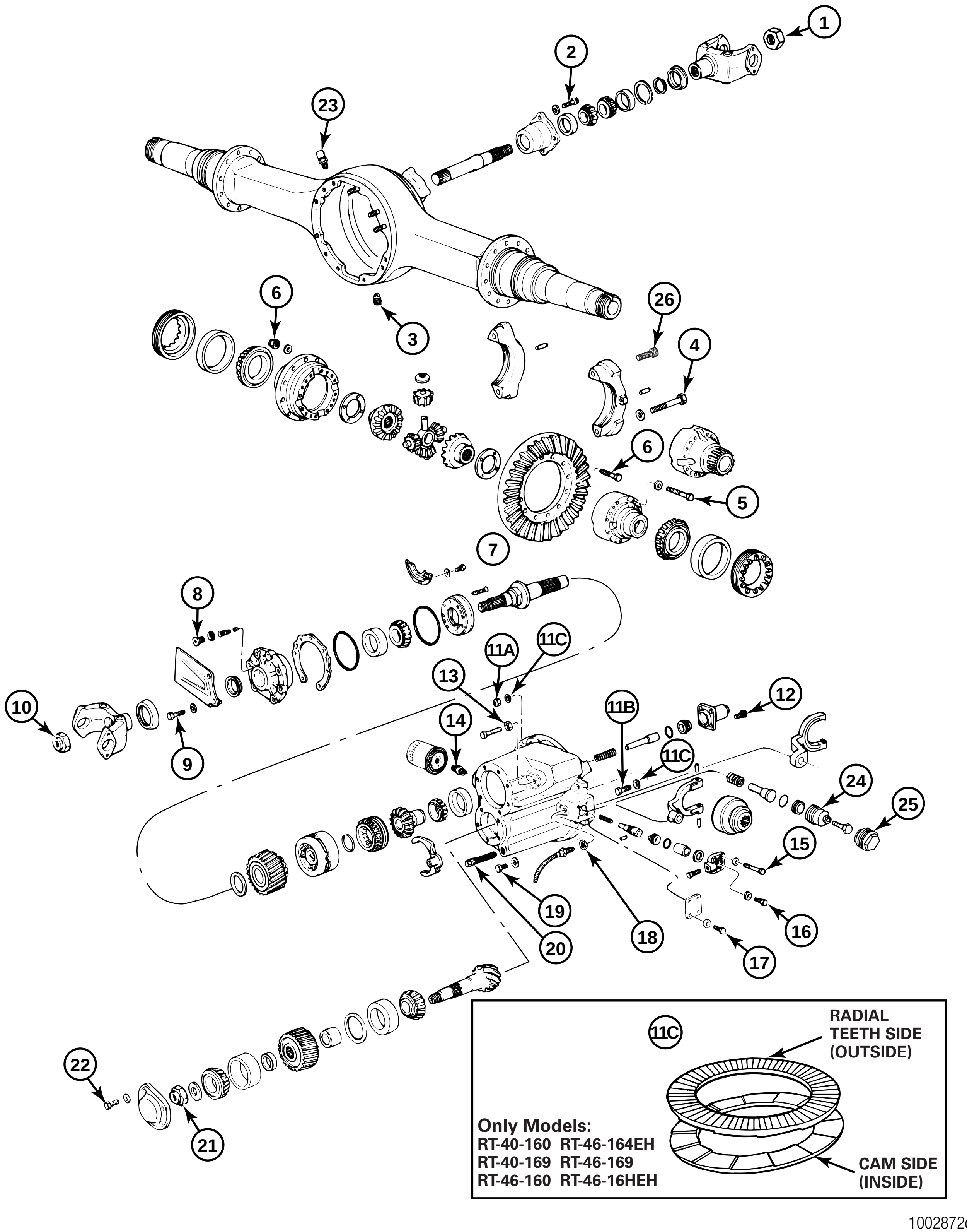
2 This interval applies to approved semi-synthetic and full-synthetic oils only. For a list of approved extended-drain axle oils, refer to TP-9539, Approved Rear Drive Axle Lubricants. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Table Q: Tandem and Tridem Rear Drive Axle Oil Capacities

Axle Model	Carrier	Oil Capacity[1] Pints	Oil Capacity[1] Liters
RT-34-140	Forward	26.0	12.3
	Rear	35.0	16.6
RT-34-145	Forward	29.6	14.0
	Rear	25.4	12.0
RT-34-145P	Forward	29.6	14.0
	Rear	25.4	12.0
RT-40-140	Forward	30.2	14.3
	Rear	22.8	10.8
RT-40-145	Forward	30.2	14.3
	Rear	25.8	12.2
RT-40-145A	Forward	30.2	14.3
	Rear	25.8	12.2
RT-40-145P	Forward	30.2	14.3
	Rear	25.8	12.2
RT-40-149	Forward	30.2	14.3
	Rear	25.8	12.2
RT-40-149A	Forward	30.2	14.3
	Rear	25.8	12.2
RT-40-149P	Forward	30.2	14.3
	Rear	25.8	12.2
RT-40-160	Forward	39.1	18.5
	Rear	34.4	16.3
RT-40-160A	Forward	39.1	18.5
	Rear	34.4	16.3
RT-40-160P	Forward	39.1	18.5
	Rear	34.4	16.3
RT-40-169	Forward	39.1	18.5
	Rear	34.4	16.3
RT-40-169A	Forward	39.1	18.5
	Rear	34.4	16.3
RT-40-169P	Forward	39.1	18.5
	Rear	34.4	16.3
RT-44-145	Forward	29.3	13.9
	Rear	25.1	11.9
RT-44-145P	Forward	29.3	13.9
	Rear	25.1	11.9
RT-46-160	Forward	39.1	18.5
	Rear	34.4	16.3
RT-46-160A	Forward	39.1	18.5
	Rear	34.4	16.3
RT-46-160P	Forward	39.1	18.5
	Rear	34.4	16.3
RT-46-169	Forward	39.1	18.5
	Rear	34.4	16.3
RT-46-169A	Forward	39.1	18.5
	Rear	34.4	16.3
RT-46-169P	Forward	39.1	18.5
	Rear	34.4	16.3
RT-46-164 EH	Forward	38.1	18.0
	Rear	33.2	15.7
RT-46-164P	Forward	38.1	18.0
	Rear	33.2	15.7
RT-46-16H EH	Forward	38.1	18.0
	Rear	33.2	15.7
RT-46-16HP	Forward	38.1	18.0
	Rear	33.2	15.7
RT-48-180[2]	Forward	61.1	28.9
	Rear	36.8	17.4
RT-48-380[1]	Forward	61.1	28.9
	Rear	63.6	30.1
RT-50-160	Forward	38.1	18.0
	Rear	33.2	15.7
RT-50-160P	Forward	38.1	18.0
	Rear	33.2	15.7
RT-52-160	Forward	44.1	20.9
	Rear	41.2	19.5
RT-52-160P	Forward	44.1	20.9
	Rear	41.2	19.5
RT-52-180[1]	Forward	56.1	26.5
	Rear	36.1	17.1
RT-52-185	Forward	56.1	26.5
	Rear	36.1	17.1
RT-52-380[1]	Forward	56.1	26.5
	Rear	58.2	27.5
RT-58-180[1]	Forward	56.1	26.5
	Rear	36.1	17.1
RT-58-185	Forward	56.1	26.5
	Rear	36.1	17.1
RT-58-380[1]	Forward	56.1	26.5
	Rear	58.2	27.5
RT-70-380[1]	Forward	54.4	25.7
	Rear	53.1	25.1
RZ-166	Axle 1	39.1	18.5
	Axle 2	39.1	18.5
	Axle 3	34.4	16.3
RZ-186	Axle 1	56.1	26.5
	Axle 2	39.1	18.5
	Axle 3	34.4	16.3
RZ-188	Axle 1	56.1	56.5
	Axle 2	56.1	26.5
	Axle 3	36.1	17.1

1 The oil capacities are for standard track axles that have been measured at various common drive pinion angles. The quantities listed include oil for both wheel ends. The oil capacities will change if the track or the drive pinion angle is different.

2 Forward carrier with oil pump system.



1
2
23
6
3
26
4
6
5
7
8
11A
11C
13
12
10
14
11B
9
11C
24
25
15
19
20
18
16
17
11C
RADIAL
TEETH SIDE
(OUTSIDE)
22
Only Models:
RT-40-160 RT-46-164EH
RT-40-169 RT-46-169
RT-46-160 RT-46-16HEH
CAM SIDE
(INSIDE)
21
1002872c

Table R: Torque Specifications

Item	Description	Axle Application	Size	Torque Lb-Ft	Torque N•m
1	Output Yoke-to-Thru-Shaft Nut	Refer to Table S, Table T or Table U			
2	Output Bearing Cage-to-Carrier Capscrew	All	0.38"-16	35-50	47-68
3	Drain and Fill Plugs*	All	0.75"-14	35 Min.	47.5 Min.
4	Bearing Cap-to-Carrier Capscrew	140 and 145	M30 x 2.5	320-400	430-540
		160	M22 x 2.5	480-600	650-810
5	Main Differential Case Halves Capscrew	140 and 145	M12 x 1.75 Class 12.9 Std. Hex Head	105-125	143-168
		140 and 145	M12 x 1.75 Class 10.9	75-95	100-127
		160	M16 x 2.0 Class 12.9 Std. Hex Head	220-310	300-420
6	Ring Gear-to-Case Nut and Bolt	180 and 380	0.87-14	600-700	816-952
		145	M16 x 1.5 Class 10 Std. Hex Head	160-210	220-290
		160	M16 x 1.5 Class 12 Std. Hex Head	196-262	265-355
7	Oil Pump-to-Input Bearing Cage Capscrew	145 and 160	M8 x 1.25	22-33	30-45
8	Pressure Relief Valve Plug	145 and 160	M16 x 1.5	20-40	27-54
9	Input Bearing Cage-to-Carrier Capscrew	All	M12 x 1.75	75-95	100-129
10	Input Yoke-to-Input Shaft Nut	Refer to Table S, Table T or Table U			
11A	Differential Carrier-to-Axle Housing Nut	All	5/8"-18	150-230	203-312
11B	Differential Carrier-to-Axle Housing Capscrew	All — Standard or Nylon Fasteners	5/8"-11	150-230	203-312
11C	Nord-Lock® Washer	RT-40-160 RT-40-169 RT-46-160 RT-46-164EH RT-46-169 RT-46-16HEH	—	210	285
12	Air Shift Cylinder-to-Carrier Capscrew — Inter-Axle Differential	All	M6 x 1.0	7-12	10-16
13	Air Shift Adjusting Screw Jam Nut — Inter-Axle Differential	All	M12 x 1.5	40-55	55-75
14	Oil Filter Adapter-to-Carrier	145 and 160	M22 x 2.5	40-60	55-80
15	Main Differential Lock Cover-to-Carrier Capscrew	All	M6 x 1.0	7-12	10-16
16	Manual Actuation Plug — Main Differential Lock	All	M10 x 1.5	15-25	20-35
17	Cover Capscrew — Axles without Main Differential Lock	All	M6 x 1.0	7-12	10-16
—	Air Line-to-Main Differential Lock Cover Adapter	All	M12 x 1.5	22-30	30-40
18	Main Differential Lock Sensor Jam Nut	All	M16 x 1.0	25-35	35-45

Table Q: Torque Specifications

Item	Description	Axle Application	Size	Torque Lb-Ft	Torque N•m
19	Plug — Axles without Main Differential Lock Sensor	All	M16 x 1.0	45-55	60-75
20	Carrier Oil Screen and Plug Assembly	All	M26 x 1.5	48 Min.	65 Min.
21	Drive Pinion Nut	All	M50 x 2.0	1200-1500	1625-2035
22	Drive Pinion Cover-to-Carrier Capscrew	All	M10 x 1.5	35-50	48-68
23	Breather Vent	All	3/8"-18	20 Min.	27 Min.
—	Heat Indicator Plug	All	1/2"-14	25 Min.	34 Min.
—	Axle Shaft-to-Wheel Hub Capscrew	All	1/2"-13	85-115	115-156
—	Axle Shaft-to-Wheel Hub Nut	All	Plain Nut 1/2"-20 5/8"-18	75-115 150-230	102-156 203-312
			Locknut 1/2"-20 5/8"-18	65-100 130-190	88-136 176-258
—	Inter-Axle Differential Case Half	All	M10 x 1.5	45-55	60-75
—	Stud-to-Carrier	All	5/8" x 11	150-230	203-312
—	Axle Shaft Stud Nut	All	Plain Nut 3/4"-16	310-400	420-542
			Locknut 3/4"-16	270-350	366-475
24	Screw-In DCDL Assembly Housing	Current DCDL Option	M60 x 2.0	80-100	109-136
25	Screw-In DCDL Plug or Cap	Non-DCDL Options	M60 x 2.0	80-100	109-136
26	Adjusting Rings Capscrews	145 and 160	—	21-28	28-38

* Minimum torque. Tighten until one thread is visible.

Input and Output Yoke Pinion Nut Fastener Torque Specifications

Table S: Single Axles

Axle Model Pinion Nut Location	RS-120, RS-125, RS-140	RS-145	RS-160, RS-161, RS-185, RS-186	RS-210, RS-220, RS-230	RS-240	RS-380
Carrier Input Yoke	740-920 lb-ft (1000-1245 N•m)	920-1130 lb-ft (1250-1535 N•m)	1000-1230 lb-ft (1350-1670 N•m)	740-920 lb-ft (1000-1245 N•m)	740-920 lb-ft (1000-1245 N•m)	800-1100 lb-ft (1085-1496 N•m)
Fastener Size	M32 X 1.5	M39 X 1.5	M45 X 1.5	M32 X 1.5	M39 X 1.5	1-1/2 - 12 UNF

Table T: Tandem Axles

Axle Model Pinion Nut Location	RT-140	RT-145, RT-149	RT-160, RT-164, RT-169	RT-185	RT-380 With IAD	RT-380 Without IAD
First Carrier Input Yoke	750-850 lb-ft (1020-1150 N•m)	750-850 lb-ft (1020-1150 N•m)	750-850 lb-ft (1020-1150 N•m)	750-850 lb-ft (1020-1150 N•m)	750-850 lb-ft (1020-1150 N•m)	900-1200 lb-ft (1224-1632 N•m)
Fastener Size	M45 X 1.5	M45 X 1.5	M45 X 1.5	1-3/4 - 12 UN	1-3/4 - 12 UN	1-3/4 - 12 UN
First Carrier Output Yoke	600-700 lb-ft (815-950 N•m)	600-700 lb-ft (815-950 N•m)	600-700 lb-ft (815-950 N•m)	600-700 lb-ft (815-950 N•m)	600-700 lb-ft (815-950 N•m)	600-700 lb-ft (815-950 N•m)
Fastener Size	M32 X 1.5	M39 X 1.5	M39 X 1.5	1-1/2 - 12 UNF	1-1/2 - 12 UNF	1-1/2 - 12 UNF
Second Carrier Input Yoke	740-920 lb-ft (1000-1245 N•m)	920-1130 lb-ft (1250-1535 N•m)	1000-1230 lb-ft (1350-1670 N•m)	1000-1230 lb-ft (1350-1670 N•m)	800-1100 lb-ft (1085-1496 N•m)	800-1100 lb-ft (1085-1496 N•m)
Fastener Size	M32 X 1.5	M39 X 1.5	M45 X 1.5	M45 X 1.5	1-1/2 - 12 UNF	1-1/2 - 12 UNF

Table U: Tridem Axles

Axle Model Pinion Nut Location	RZ-164	RZ-166	RZ-186	RZ-188
First Carrier Input Yoke	600-800 lb-ft (815-1085 N•m)	600-800 lb-ft (815-1085 N•m)	600-800 lb-ft (815-1085 N•m)	600-800 lb-ft (815-1085 N•m)
Fastener Size	M45 X 1.5	M45 X 1.5	1-3/4 - 12 UN	1-3/4 - 12 UN
First Carrier Output Yoke	450-650 lb-ft (610-880 N•m)	450-650 lb-ft (610-880 N•m)	450-650 lb-ft (610-880 N•m)	450-650 lb-ft (610-880 N•m)
Fastener Size	M39 X 1.5	M39 X 1.5	1-1/2 -12 UNF	1-1/2 - 12 UNF
Second Carrier Input Yoke	600-800 lb-ft (815-1085 N•m)	600-800 lb-ft (815-1085 N•m)	600-800 lb-ft (815-1085 N•m)	600-800 lb-ft (815-1085 N•m)
Fastener Size	M45 X 1.5	M45 X 1.5	M45 X 1.5	1-3/4 - 12 UN
Second Carrier Output Yoke	450-650 lb-ft (610-880 N•m)	450-650 lb-ft (610-880 N•m)	450-650 lb-ft (610-880 N•m)	450-650 lb-ft (610-880 N•m)
Fastener Size	M39 X 1.5	M39 X 1.5	M39 X 1.5	1-1/2 - 12 UNF
Third Carrier Input Yoke	920-1130 lb-ft (1250-1535 N•m)	1000-1230 lb-ft (1350-1670 N•m)	1000-1230 lb-ft (1350-1670 N•m)	1000-1230 lb-ft (1350-1670 N•m)
Fastener Size	M39 X 1.5	M45 X 1.5	M45 X 1.5	M45 X 1.5

Table V: Drive Pinion Bearings — Preload

Specification	New bearings 5-45 lb-in (0.56-5.08 N•m) Used bearings in good condition 10-30 lb-in (1.13-3.39 N•m)
Adjustment	Preload is controlled by the thickness of the spacer between bearing cones. To increase preload, install a thinner spacer. To decrease preload, install a thicker spacer.

Table W: Drive Pinion — Depth in Carrier

Specification	Install the correct amount of shims between the inner bearing cup of the drive pinion and the carrier. To calculate, use the old shim pack thickness and the new and old pinion cone numbers.
Adjustment	Change the thickness of the shim pack to get a good gear tooth contact pattern.

Table X: Hypoid Gear Set — Tooth Contact Patterns (Hand Rolled)

Specification	Toward the toe of the gear tooth and in the center between the top and bottom of the tooth.
Adjustment	Tooth contact patterns are controlled by the thickness of the shim pack between the inner bearing cone of the drive pinion and the carrier and by ring gear backlash. To move the contact pattern lower, increase the thickness of the shim pack between the inner bearing cup of the drive pinion and the carrier. To move the contact pattern higher, decrease the thickness of the shim pack between the inner bearing cup of the drive pinion and the carrier. To move the contact pattern toward the toe of the tooth, decrease backlash of the ring gear. To move the contact pattern toward the heel of the tooth, increase backlash of the ring gear.

Table Y: Main Differential Bearings — Preload

Specification	15-35 lb-in (1.7-3.9 N•m) or Expansion between bearing caps 140 and 145 Series — 0.003-0.009-inch (0.08-0.22 mm) 160 Series — 0.006-0.013-inch (0.15-0.33 mm)
Adjustment	Preload is controlled by tightening both adjusting rings after zero end play is reached.

Table Z: Main Differential Gears — Rotating Resistance

Specification	50 lb-ft (68 N•m) maximum torque applied to one side gear

Table AA: Input Shaft End Play Adjustment

End Play of the Input Shaft	0.002-0.008-inch (0.050-0.200 mm)

Table AB: Output Bearing — End Play and Preload

Specification	0.001-0.004-inch (0.025-0.102 mm) bearing end play
Adjustment	End play is controlled by the size of the snap ring in the output bearing cage. Increase end play by installing a thinner snap ring. Decrease end play by installing a thicker snap ring. **NOTE:** If the end play on the output bearing measures ZERO, a thinner snap ring is required.

Table AC: Ring Gear — Backlash

Specification	145 Series: Range: 0.008-0.018-inch (0.20-0.460 mm) Backlash setting for new gear sets: 0.012-inch (0.300 mm) 160 Series: Range: 0.010-0.020-inch (0.25-0.510 mm) Backlash setting for new gear sets: 0.012-inch (0.300 mm)
Adjustment	Backlash is controlled by the position of the ring gear. Change backlash within specifications to get a good tooth contact pattern. To increase backlash, move the ring gear away from the drive pinion. To decrease backlash, move the ring gear toward the drive pinion.

Table AD: Ring Gear — Runout

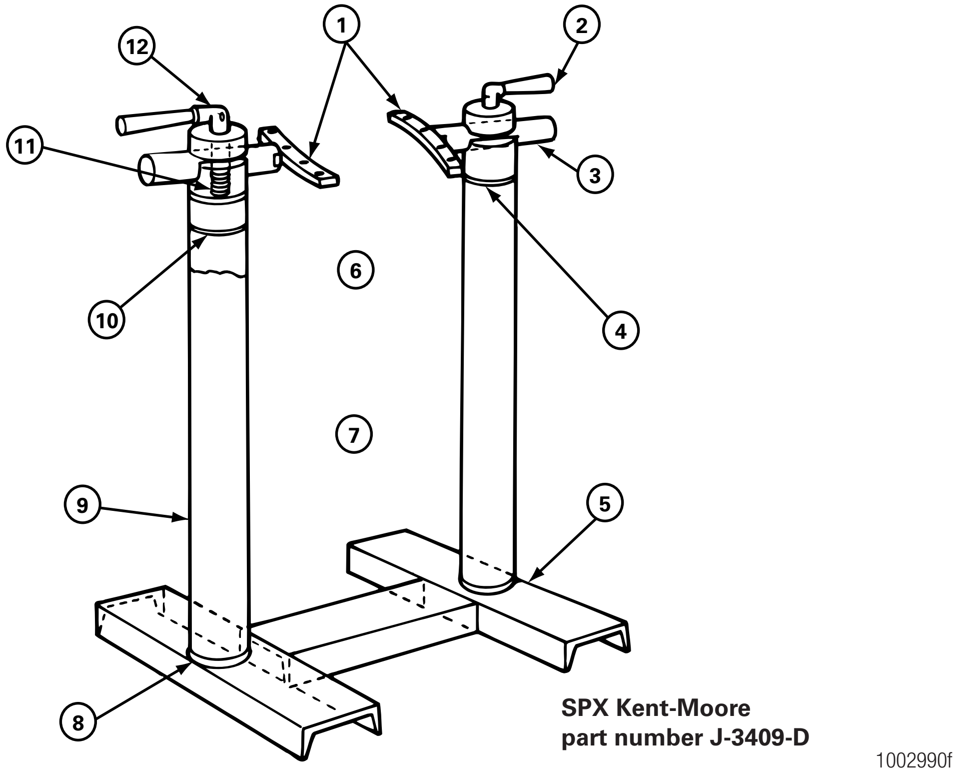
Specification	0.008-inch (0.200 mm) maximum

Table AE: Sensor Switch — Installation (Carriers with Differential Lock Only)

Adjustment	Shift the differential to the locked position. Tighten the sensor switch into the carrier until the test light illuminates. Tighten the sensor switch one additional turn. Tighten the jam nut to the specified torque.

Specifications

Carrier Repair Stand



1 PLATES 8′ LONG x 3/4″ THICK x 1-1/4″ WIDE WITH A TONGUE TO FIT SLOT IN BAR WELD PLATES TO BAR
2 HANDLE 7″ LONG WITH SLOT IN ONE END TO FIT CLAMP SCREW
3 BAR 2″ DIAMETER x 9″ LONG WITH ONE END SLOTTED TO FIT PLATE
4 WELD ALL AROUND AFTER PRESSING PLUG IN PIPE
5 WELD
6 SHAPE AND SIZE OF HOLES TO FIT CARRIER
7 23-1/2″ CENTER TO CENTER OF PIPE
8 CHAMFER END OF PIPE FOR WELDING
9 4″ DIAMETER PIPE
10 PLUG 4″ DIAMETER x 7″ LONG WITH ONE END TURNED 3″ LONG TO FIT PIPE. DRILL 2″ HOLE AND MILL 3/16″ WIDE SLOT 2″ FROM TOP
11 SCREW 3-1/2″ LONG x 5/8″ DIAMETER WITH FLATS ON END TO FIT HANDLE AND 2-1/2″ LENGTH OF THREAD ON OTHER END
12 DRILL 3/8″ HOLE THROUGH HANDLE AND SCREW

To obtain a repair stand, refer to the Service Notes page on the front inside cover of this manual.

How to Make a Yoke Bar

1. Measure dimensions A and B of the yoke you are servicing. Figure 10.1.

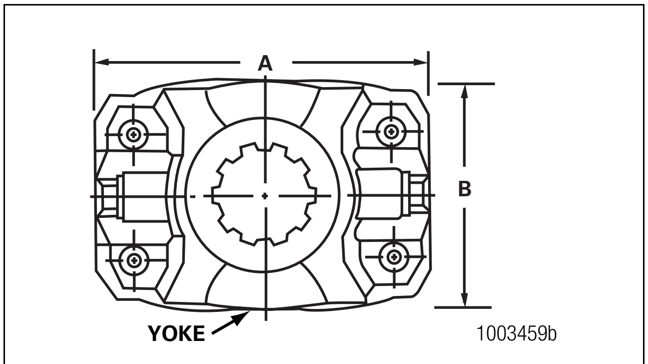


Figure 10.1

2. Calculate dimensions C and D of the yoke bar by adding 0.125-0.250-inch to dimensions A and B of the yoke. Figure 10.2.

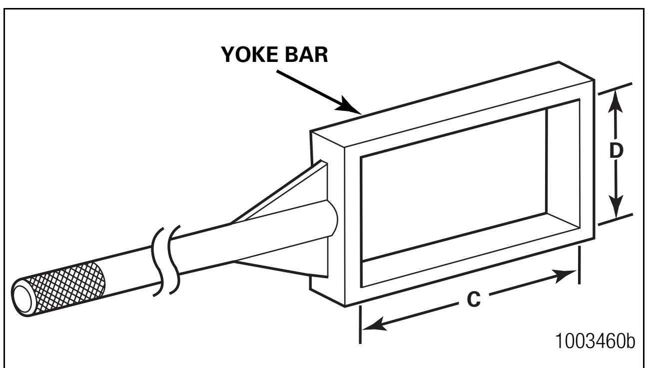


Figure 10.2

WARNING

Wear safe clothing and eye protection when you use welding equipment. Welding equipment can burn you and cause serious personal injury. Follow the operating instructions and safety procedures recommended by the welding equipment manufacturer.

3. To make the box section, cut and weld one-inch x two-inch mild steel square stock according to dimensions C and D. Figure 10.2.

4. Cut a four-foot x 1.25-inch piece of mild steel round stock to make the yoke bar handle. Center weld this piece to the box section. Figure 10.2.
   - **To increase yoke bar rigidity:** Weld two angle pieces onto the handle. Figure 10.2.

Unitized Pinion Seals and Seal Drivers

Refer to Table AF and Figure 10.3 for information on unitized pinion seals and seal drivers. To obtain Meritor seal driver KIT 4454, refer to the Service Notes page on the front inside cover of this manual.

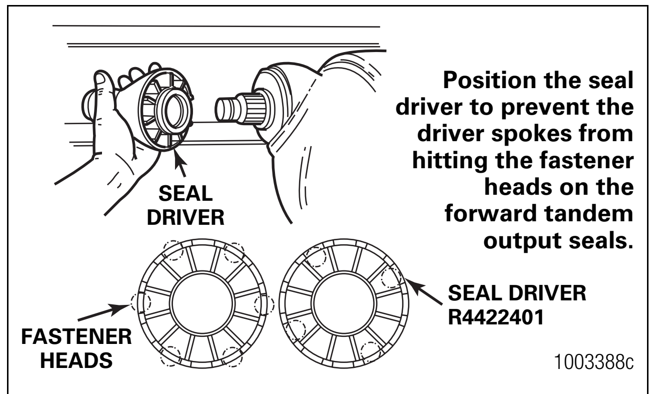


Figure 10.3

Table AF: Unitized Pinion Seals and Seal Drivers*

Single Models	Tandem Models	Axle Model and Position	Seal Service Part Number	Previous Seal Part Number	Seal Drivers	Sleeve Drivers
MX-21-160	RT-34-144 /P	14X/16X/18X/38X Forward-Rear Unit Input (FUI)	A1-1205X2728	A-1205R2592	2728T1	2728T2
MX-23-160R	RT-34-145 /P					
RF-16-145	MT-40-143					
RF-21-160	RT-40-145 /A /P	14X/16X Forward-Rear Unit Output (FUO)	A1-1205Y2729	A-1205P2590	2729T1	2729T2
RF-22-166	RT-40-149 /A /P	14X Rear-Rear Unit Input (RUI)	A1-1205Z2730	A-1205N2588	2730T1	Not Required — Sleeve is unitized
RF-23-185	RT-44-145 /P					
RS-17-145	RT-40-160 /A /P					
RS-19-145	RT-40-169 /A /P	16X/18X Rear-Rear Unit Input (RUI)	A1-1205A2731	A-1205Q2591	2731T1	Not Required — Sleeve is unitized
RS-21-145	RT-46-160 /A /P					
RS-21-160	RT-46-169 /A /P					
RS-23-160 /A	RT-46-164EH /P					
RS-23-161 /A	RT-46-16HEH /P					
RS-25-160 /A	RT-50-160 /P					
RS-23-186	RT-52-185*					
RS-26-185	RT-58-185*					
RS-30-185						

* Forward and rear input only.

Forward input and output seals must be serviced with the seal and sleeve. The service part number provides both when required.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Before you service a spring chamber, carefully follow the manufacturer's instructions to compress and lock the spring to completely release the brake. Verify that no air pressure remains in the service chamber before you proceed. Sudden release of compressed air can cause serious personal injury and damage to components.

Engage the parking brake to prevent the vehicle from moving before you begin maintenance or service procedures that require you to be under the vehicle. Serious personal injury can result.

⚠ CAUTION

If the vehicle is equipped with a front drive axle, tow the vehicle from the front, with the front wheels off the ground. If this is not possible, you must remove the front drive shaft before towing. Damage to components can result.

Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. A chisel or wedge can result in damage to the axle shaft, the gasket and seal, and the axle hub.

NOTE: For complete towing information, refer to Technical Bulletin TP-9579, Driver Instruction Kit. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

These instructions supersede all other instructions for the purpose of transporting vehicles for service or new vehicle drive-away dated before April 1995, including those contained in Meritor maintenance manuals.

When transporting a vehicle with the wheels of one or both drive axles on the road, it is possible to damage the axles if the wrong procedure is used before transporting begins. Meritor recommends that you use the following procedure.

Type of Axle

Forward Tandem Axle, with Driver-Controlled Main Differential Lock (DCDL — Screw-In DCDL Shift Assembly) and with Inter-Axle Differential (IAD)

Before Towing or Drive-Away

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Apply the vehicle parking brakes using the switch inside the cab of the vehicle.
3. Shift the transmission into neutral and start the vehicle's engine.
4. Shift the DCDL and the IAD to the unlocked or disengaged positions using the switches inside the cab of the vehicle. The indicator lights in the cab will go off.
5. Stop the engine.

NOTE: Remove only the axle shaft(s), shown in Table AG at this time, from the axle(s) that will remain on the road when the vehicle is transported.

6. Remove the stud nuts or capscrews, washers and tapered dowels, if equipped, from the flange of the axle shaft. Refer to Section 3 for the recommended tools and removal procedures. Figure 11.1.

Table AG

Single Axles
Remove the left-hand, road side, axle shaft
Tandem Axles
Forward Axle
Remove the right-hand, curbside, axle shaft
Rear Axle
Remove the left-hand, roadside, axle shaft

7. Install a cover over the open end of each hub where an axle shaft was removed. This will prevent dirt from entering the bearing cavity and loss of lubricant.

NOTE: If an air supply will be used for the brake system of the transported vehicle, continue with Steps 8 and 9, otherwise continue with Step 10.

8. Connect an auxiliary air supply to the brake system of the vehicle that is being transported. Before moving the vehicle, charge the brake system with the correct amount of air pressure to operate the brakes. Refer to the instructions supplied by the manufacturer of the vehicle for procedures and specifications. If an auxiliary air supply is not used, continue with Step 10.
9. When the correct amount of air pressure is in the brake system, release the parking brakes of the vehicle that is being transported. Step 10 is not required.
10. If there are spring or parking brakes on the axle(s) that will remain on the road when the vehicle is transported, and they cannot be released by air pressure, manually compress and lock each spring so that the brakes are released. Refer to the manufacturer's instructions.

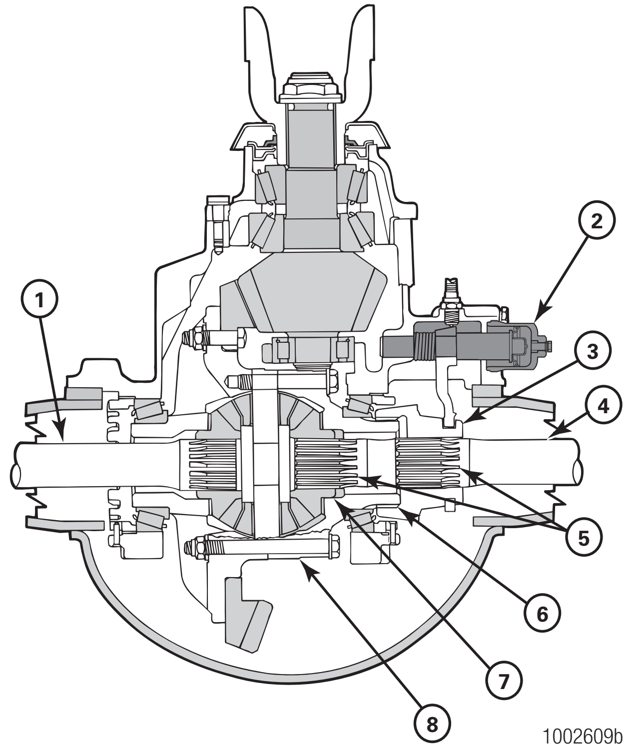
After Towing or Drive-Away

1. If an auxiliary air supply was used, apply the vehicle parking brakes using the switch inside the cab of the vehicle. If an auxiliary air supply was not used, begin with Step 2.
2. Apply the vehicle spring or parking brakes by manually releasing each spring that was compressed before transporting started. Refer to the manufacturer's instructions.
3. Disconnect the auxiliary air supply, if used, from the brake system of the vehicle that was transported. Connect the vehicle's air supply to the brake system.
4. Remove the covers from the hubs.

NOTE: Install only the axle shaft(s) shown in Table AH at this time. These axle shafts have a double row of splines that engage with splines of the side gear and shift collar in the main differential. Figure 11.1.

5. Install the gasket, if used, and axle shaft into the axle housing and carrier in the same location. The gasket and flange of the axle shaft must be flat against the hub. Rotate the axle shaft or the driveline as necessary to align the splines and the holes in the flange with the studs in the hub. Figure 11.1.

SINGLE AXLE OR REAR AXLE OF TANDEM SHOWN WITH SCREW-IN DCDL SHIFT ASSEMBLY AND SHOWN IN THE LOCKED OR ENGAGED POSITION



1 LEFT-HAND, ROADSIDE, AXLE SHAFT
2 SHIFT ASSEMBLY
3 SHIFT COLLAR
4 RIGHT-HAND, CURBSIDE, AXLE SHAFT
5 DOUBLE ROW OF SPLINES
6 SHIFT COLLAR AND DIFFERENTIAL CASE SPLINES ENGAGED OR LOCKED
7 SIDE GEAR
8 DIFFERENTIAL CASE

Figure 11.1

Table AH

Single Axles

Install the right-hand, curbside, axle shaft

Tandem Axles

Forward Axle

Install the left-hand, roadside, axle shaft

Rear Axle

Install the right-hand, curbside, axle shaft

6. Install the dowels, if used, over each stud and into the tapered holes of the flange.
7. Install the washers and capscrews or stud nuts. Determine the size of the fasteners and tighten the capscrews or nuts to the corresponding torque value shown in Table AI.

Table AI

Fastener	Thread Size	Torque Value lb-ft (N•m)
Capscrews	0.31"-24	18-24 (24-33)
	0.50"-13	85-115 (115-156)
Stud Nuts	0.44"-20	50-75 (68-102)
Plain Nuts	0.50"-20	75-115 (102-156)
	0.56"-18	110-165 (149-224)
	0.62"-18	150-230 (203-312)
	0.75"-16	310-400 (420-542)
Locknut	0.44"-20	40-65 (54-88)
	0.50"-20	65-100 (88-136)
	0.56"-18	100-145 (136-197)
	0.62"-18	130-190 (176-258)
	0.75"-16	270-350 (366-475)

8. Unlock or disengage the DCDL by removing the manual engaging capscrew from the shift assembly.
9. Install the manual engaging capscrew into the storage hole. The storage hole of threaded shift assemblies is located in the shift tower of the carrier next to the cylinder. Tighten the capscrew to 15-25 lb-ft (20-35 N•m). Figure 11.2.
10. Connect the air hose to the shift cylinder. Tighten the air hose to 22-30 lb-ft (30-40 N•m).
11. Install the remaining axle shaft into the axle housing and carrier.
12. Check the lubricant level in the axles and hubs where the axle shafts were removed. Add the correct type and amount of lubricant if necessary. Refer to Section 7.

Forward Tandem Axle, with Driver-Controlled Main Differential Lock (DCDL — Bolt-On DCDL Shift Assembly) and with Inter-Axle Differential (IAD)

Before Towing or Drive-Away

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Apply the vehicle parking brakes using the switch inside the cab of the vehicle.
3. Shift the transmission into neutral and start the vehicle's engine.
4. Shift the DCDL and the IAD to the unlocked or disengaged positions using the switches inside the cab of the vehicle. The indicator lights in the cab will go off.
5. Stop the engine.

NOTE: Remove only the axle shaft(s), shown in Table AJ at this time, from the axle(s) that will remain on the road when the vehicle is transported.

6. Remove the stud nuts or capscrews, washers and tapered dowels, if equipped, from the flange of the axle shaft. Refer to Section 3 for the recommended tools and removal procedures. Figure 11.2.

Table AJ

Single Axles

Remove the left-hand, roadside, axle shaft

Tandem Axles

Forward Axle

Remove the right-hand, curbside, axle shaft

Rear Axle

Remove the left-hand, roadside, axle shaft

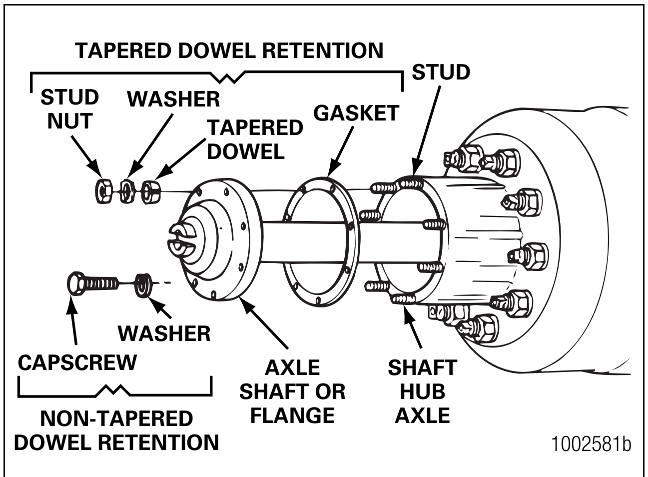


Figure 11.2

7. Install a cover over the open end of each hub where an axle shaft was removed. This will prevent dirt from entering the bearing cavity and loss of lubricant.

NOTE: If an air supply will be used for the brake system of the transported vehicle, continue with Step 8 and Step 9. Otherwise, continue with Step 10.

8. Connect an auxiliary air supply to the brake system of the vehicle that is being transported. Before moving the vehicle, charge the brake system with the correct amount of air pressure to operate the brakes. Refer to the instructions supplied by the manufacturer of the vehicle for procedures and specifications. If an auxiliary air supply is not used, continue with Step 10.
9. When the correct amount of air pressure is in the brake system, release the parking brakes of the vehicle that is being transported. Step 10 is not required.
10. If there are spring or parking brakes on the axle(s) that will remain on the road when the vehicle is transported, and they cannot be released by air pressure, manually compress and lock each spring so that the brakes are released. Refer to the manufacturer's instructions.

After Towing or Drive-Away

1. If an auxiliary air supply was used, apply the vehicle parking brakes using the switch inside the cab of the vehicle. If an auxiliary air supply was not used, begin with Step 2.
2. Apply the vehicle spring or parking brakes by manually releasing each spring that was compressed before transporting started. Refer to the manufacturer's instructions.
3. Disconnect the auxiliary air supply, if used, from the brake system of the vehicle that was transported. Connect the vehicle's air supply to the brake system.
4. Remove the covers from the hubs.

NOTE: Install only the axle shaft(s) shown in Table AK at this time. These axle shafts have a double row of splines that engage with splines of the side gear and shift collar in the main differential. Figure 11.5.

5. Install the gasket, if used, and axle shaft into the axle housing and carrier in the same location. The gasket and flange of the axle shaft must be flat against the hub. Rotate the axle shaft or the driveline as necessary to align the splines and the holes in the flange with the studs in the hub. Figure 11.2.

Table AK

Single Axles
Install the right-hand, curbside, axle shaft
Tandem Axles
Forward Axle
Install the left-hand, roadside, axle shaft
Rear Axle
Install the right-hand, curbside, axle shaft

6. Install the dowels, if used, over each stud and into the tapered holes of the flange.
7. Install the washers and capscrews or stud nuts. Determine the size of the fasteners and tighten the capscrews or nuts to the torque value shown in Table AL.

Table AL

Fastener	Thread Size	Torque Value lb-ft (N•m)
Capscrews	0.31"-24	18-24 (24-33)
	0.50"-13	85-115 (115-156)
Stud Nuts	0.44"-20	50-75 (68-102)
Plain Nuts	0.50"-20	75-115 (102-156)
	0.56"-18	110-165 (149-224)
	0.62"-18	150-230 (203-312)
	0.75"-16	310-400 (420-542)
Locknut	0.44"-20	40-65 (54-88)
	0.50"-20	65-100 (88-136)
	0.56"-18	100-145 (136-197)
	0.62"-18	130-190 (176-258)
	0.75"-16	270-350 (366-475)

8. Unlock or disengage the DCDL by removing the manual engaging capscrew from the shift assembly.
9. Install the manual engaging capscrew into the storage hole. The storage hole of bolted-on shift assemblies is located in the top side of the shift cylinder cover. Tighten the capscrew to 15-25 lb-ft (20-35 N•m). Figure 11.3. T
10. Remove the plug and gasket from the storage hole. Install the plug and gasket into the threaded hole in the center of the shift cylinder cover. Tighten the plug to 15-25 lb-ft (20-35 N•m). T
11. Install the remaining axle shaft into the axle housing and carrier.
12. Check the lubricant level in the axles and hubs where the axle shafts were removed. Add the correct type and amount of lubricant if necessary. Refer to Section 7.

Forward Tandem Axle, without Driver-Controlled Main Differential Lock (DCDL), with Inter-Axle Differential (IAD)

Before Towing or Drive-Away

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Apply the vehicle parking brakes using the switch inside the cab of the vehicle.
3. Shift the transmission into neutral and start the vehicle's engine.
4. Shift the IAD to the unlocked or disengaged position using the switch inside the cab of the vehicle. The indicator light in the cab will go off.
5. Stop the engine.

NOTE: Remove both axle shafts from the axle(s) that will remain on the road when the vehicle is transported.

6. Remove the stud nuts or capscrews and washers from the flange of the axle shaft. Figure 11.3.
7. Loosen the tapered dowels, if used, in the flange of the axle shaft. Figure 11.3. Refer to Section 3.

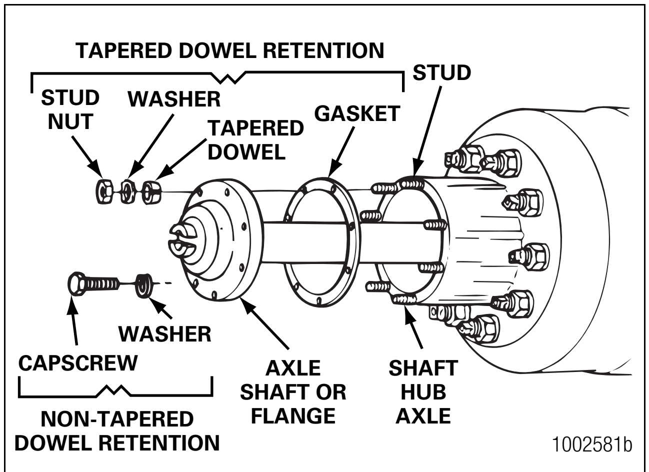


Figure 11.3

8. Identify each axle shaft that is removed from the axle assembly so they can be installed in the same location after transporting or repair is completed.
9. Remove the tapered dowels, gasket, if used, and the axle shaft from the axle assembly. Figure 11.3.
10. Install a cover over the open end of each hub where an axle shaft was removed. This will prevent dirt from entering the bearing cavity and loss of lubricant.

NOTE: If an air supply will be used for the brake system of the transported vehicle, continue with Step 11 and Step 12, otherwise continue with Step 13.

11. Connect an auxiliary air supply to the brake system of the vehicle that is being transported. Before moving the vehicle, charge the brake system with the correct amount of air pressure to operate the brakes. Refer to the instructions supplied by the manufacturer of the vehicle for procedures and specifications. If an auxiliary air supply is not used, continue with Step 13.
12. When the correct amount of air pressure is in the brake system, release the parking brakes of the vehicle that is being transported. Step 13 is not required.
13. If there are spring or parking brakes on the axle(s) that will remain on the road when the vehicle is transported, and they cannot be released by air pressure, manually compress and lock each spring so that the brakes are released. Refer to the manufacturer's instructions.

After Towing or Drive-Away

1. If an auxiliary air supply was used, apply the vehicle parking brakes using the switch inside the cab of the vehicle. If an auxiliary air supply was not used, begin with Step 2.
2. Apply the vehicle spring or parking brakes by manually releasing each spring that was compressed before transporting started. Refer to the manufacturer's instructions.
3. Disconnect the auxiliary air supply, if used, from the brake system of the vehicle that was transported. Connect the vehicle's air supply to the brake system.
4. Remove the covers from the hubs.
5. Install the gasket, if used, and axle shaft into the axle housing and carrier in the same location. The gasket and flange of the axle shaft must be flat against the hub. Rotate the axle shaft or the driveline as necessary to align the splines and the holes in the flange with the studs in the hub. Figure 11.3.
6. Install the dowels, if used, over each stud and into the tapered holes of the flange.
7. Install the washers and capscrews or stud nuts. Determine the size of the fasteners and tighten the capscrews or nuts to the torque value shown in Table AM.

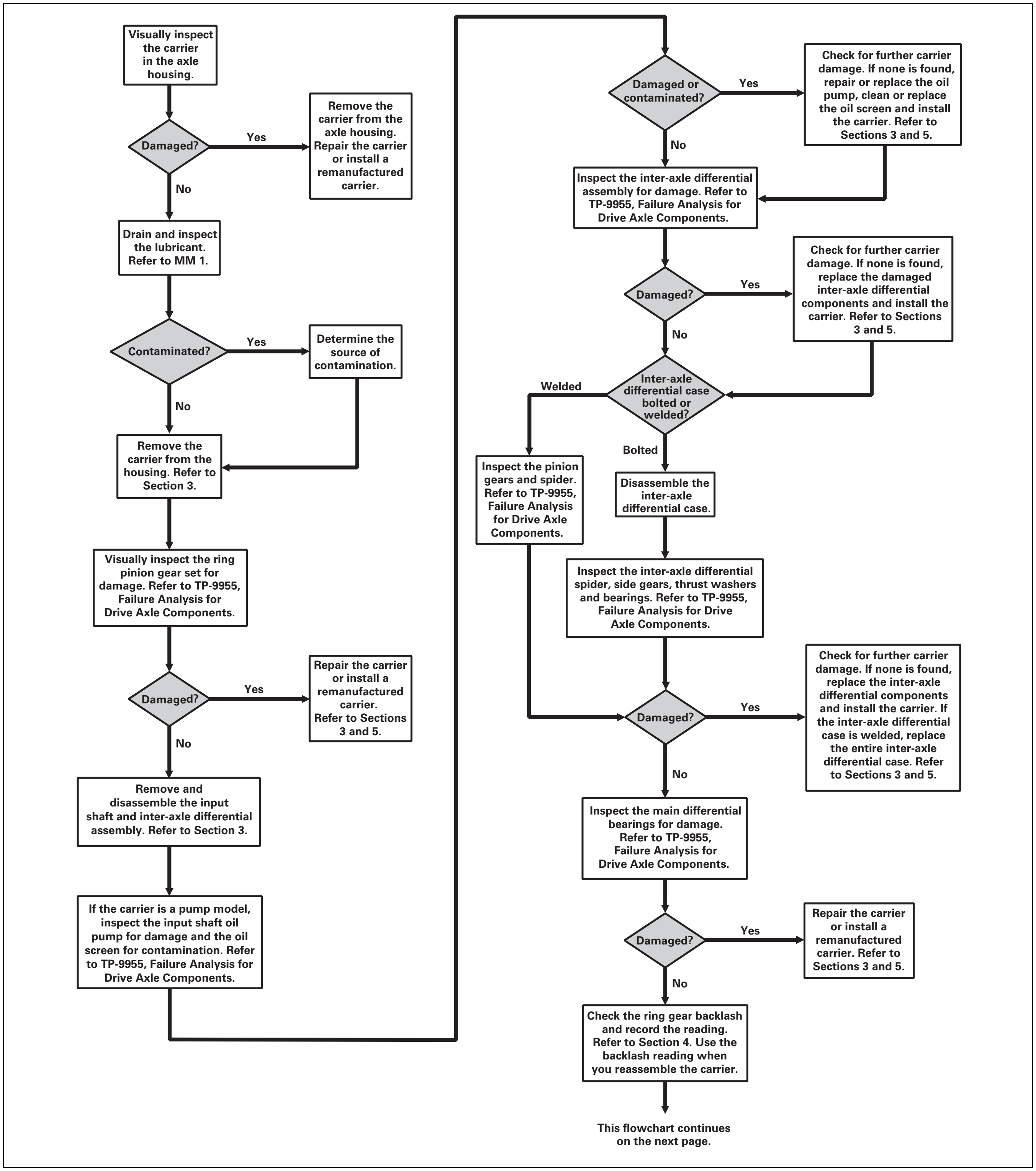
Table AM

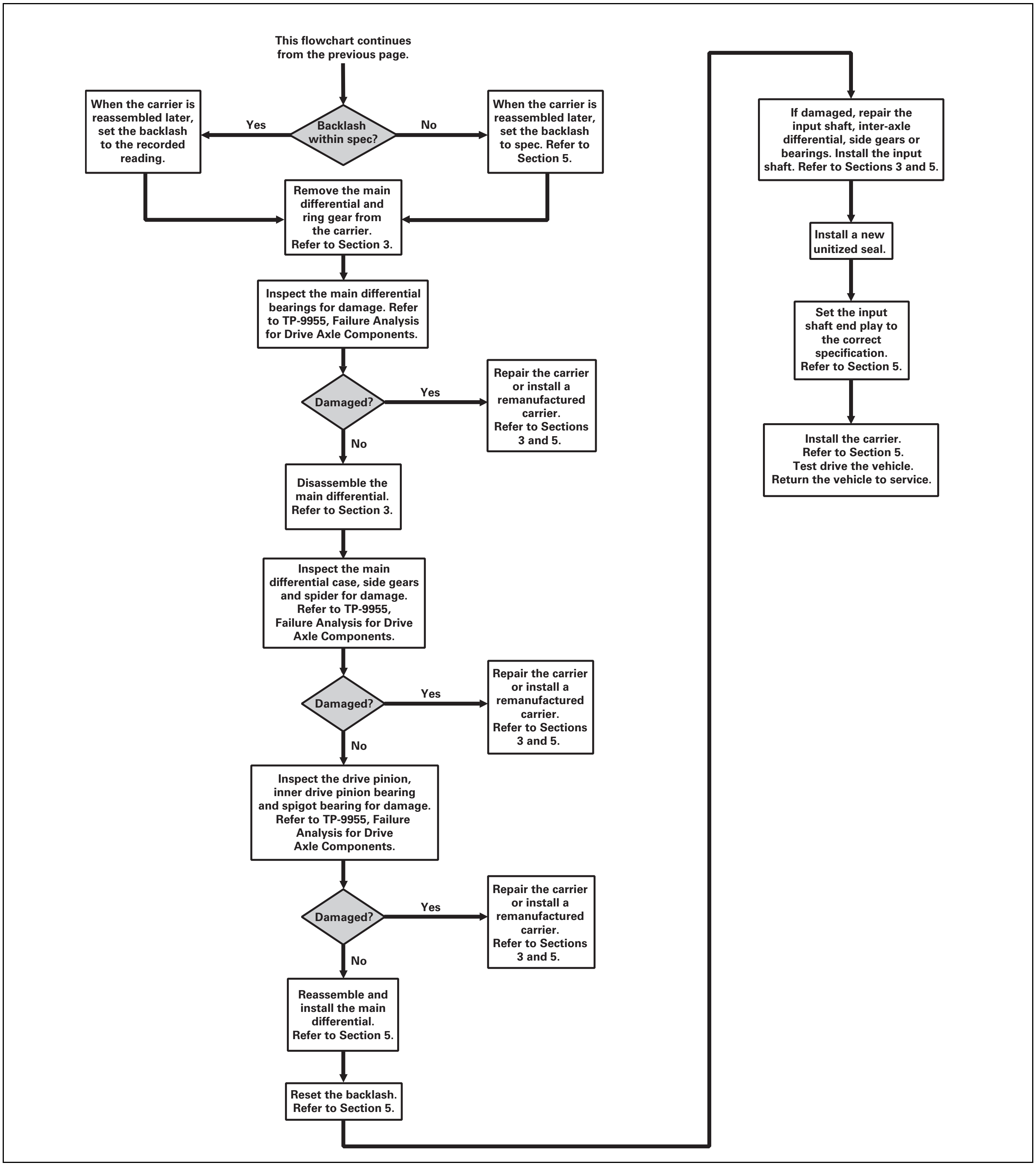
Fastener	Thread Size	Torque Value lb-ft (N•m)
Capscrews	0.31"-24	18-24 (24-33)
	0.50"-13	85-115 (115-156)
Stud Nuts	0.44"-20	50-75 (68-102)
Plain Nuts	0.50"-20	75-115 (102-156)
	0.56"-18	110-165 (149-224)
	0.62"-18	150-230 (203-312)
	0.75"-16	310-400 (420-542)
Locknut	0.44"-20	40-65 (54-88)
	0.50"-20	65-100 (88-136)
	0.56"-18	100-145 (136-197)
	0.62"-18	130-190 (176-258)
	0.75"-16	270-350 (366-475)

8. Check the lubricant level in the axles and hubs where the axle shafts were removed. Add the correct type and amount of lubricant if necessary. Refer to Section 7.

Troubleshooting

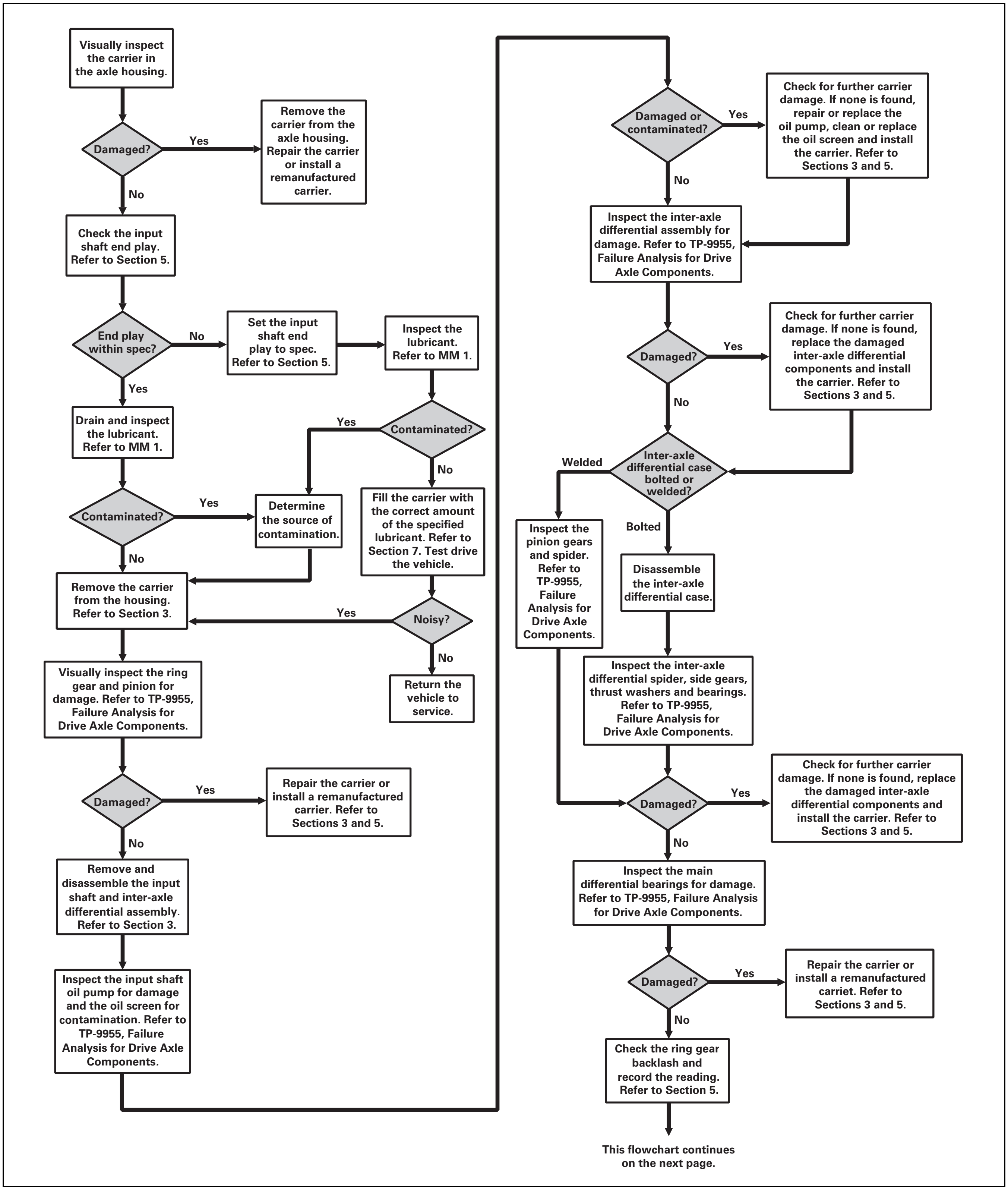
Vehicle Will Not Move

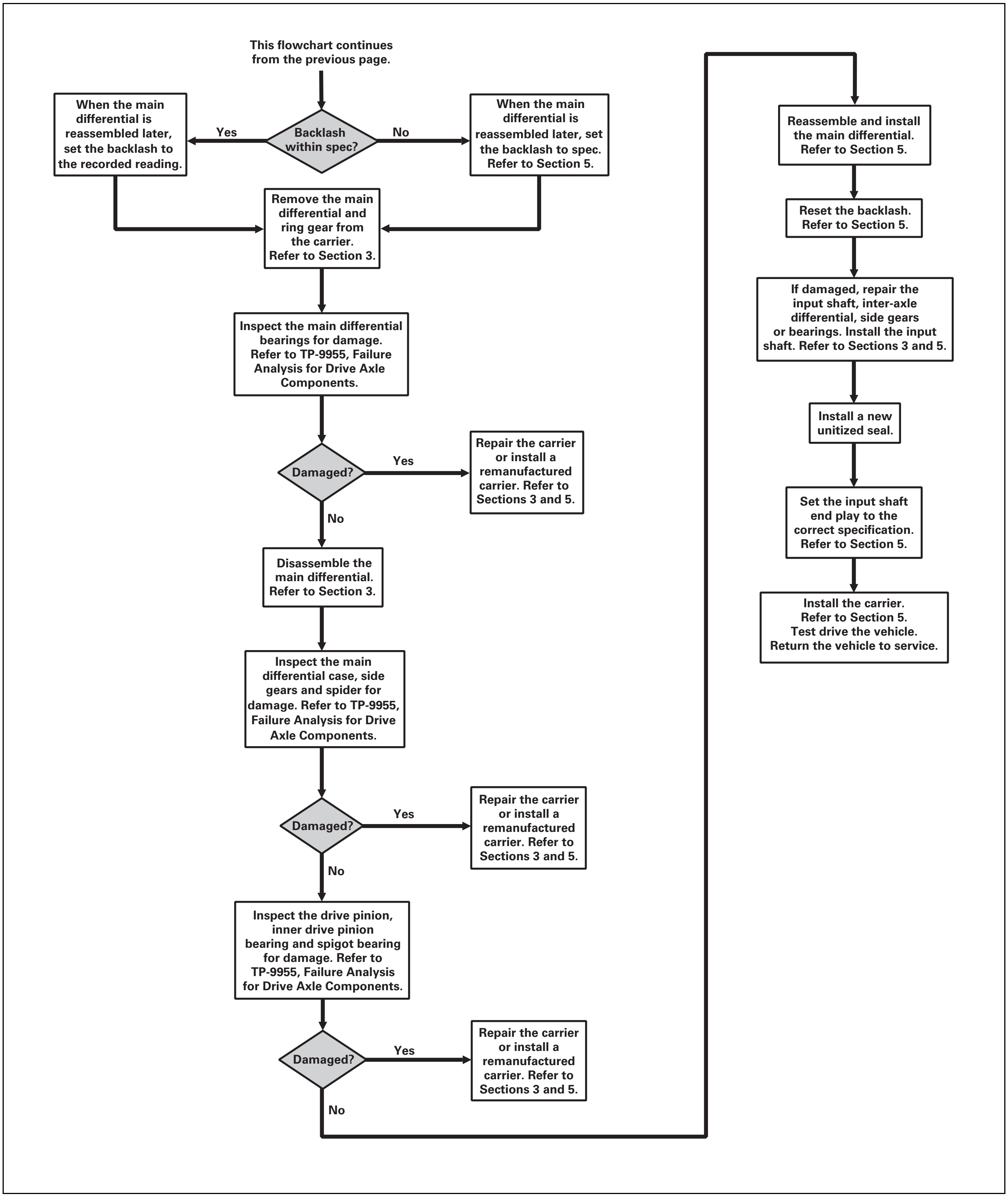




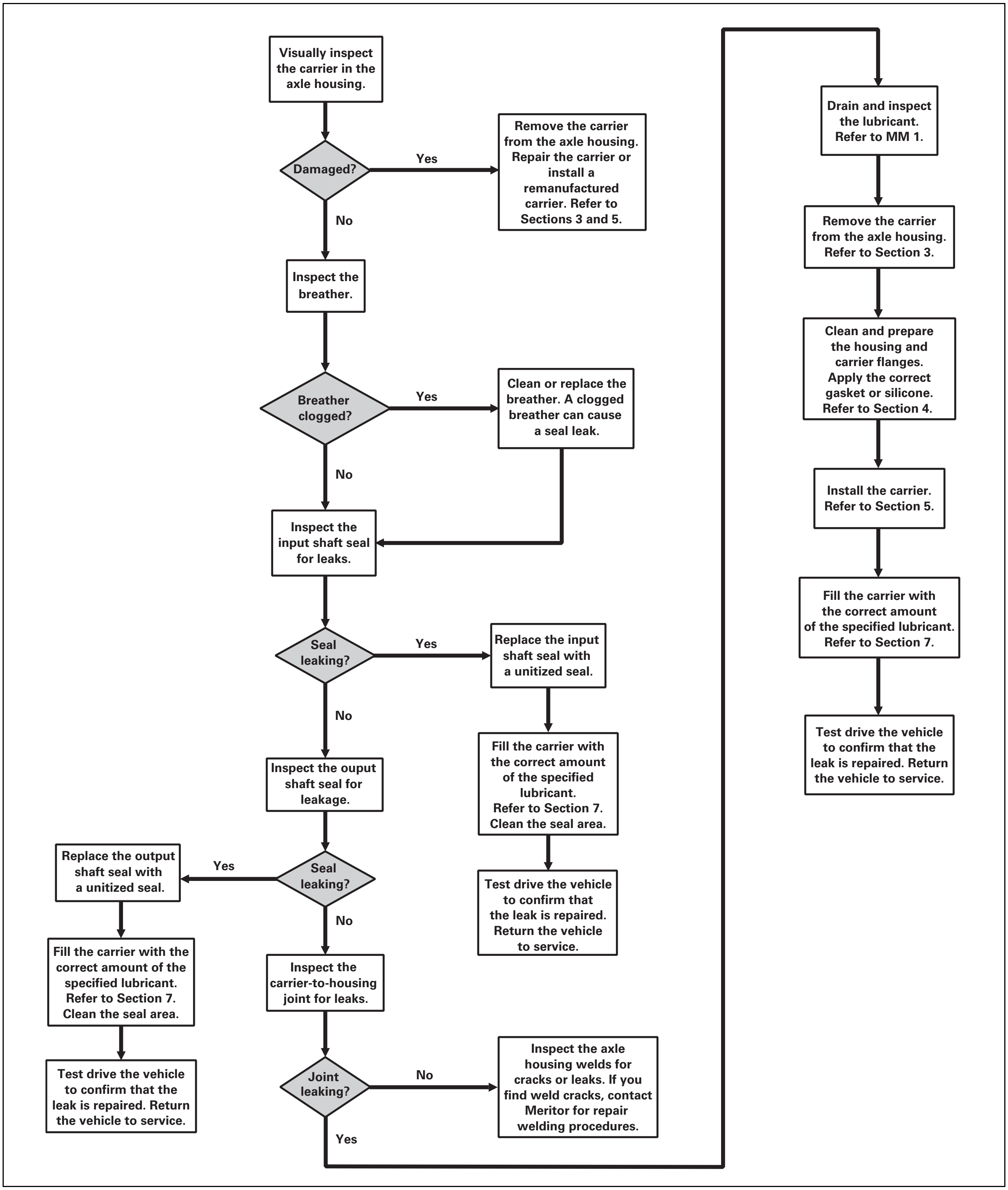
This flowchart continues from the previous page.
Backlash within spec?
Yes
When the carrier is reassembled later, set the backlash to the recorded reading.
No
When the carrier is reassembled later, set the backlash to spec. Refer to Section 5.
Remove the main differential and ring gear from the carrier. Refer to Section 3.
Inspect the main differential bearings for damage. Refer to TP-9955, Failure Analysis for Drive Axle Components.
Damaged?
Yes
Repair the carrier or install a remanufactured carrier. Refer to Sections 3 and 5.
No
Disassemble the main differential. Refer to Section 3.
Inspect the main differential case, side gears and spider for damage. Refer to TP-9955, Failure Analysis for Drive Axle Components.
Damaged?
Yes
Repair the carrier or install a remanufactured carrier. Refer to Sections 3 and 5.
No
Inspect the drive pinion, inner drive pinion bearing and spigot bearing for damage. Refer to TP-9955, Failure Analysis for Drive Axle Components.
Damaged?
Yes
Repair the carrier or install a remanufactured carrier. Refer to Sections 3 and 5.
No
Reassemble and install the main differential. Refer to Section 5.
Reset the backlash. Refer to Section 5.
If damaged, repair the input shaft, inter-axle differential, side gears or bearings. Install the input shaft. Refer to Sections 3 and 5.
Install a new unitized seal.
Set the input shaft end play to the correct specification. Refer to Section 5.
Install the carrier. Refer to Section 5. Test drive the vehicle. Return the vehicle to service.

Differential Making Noise



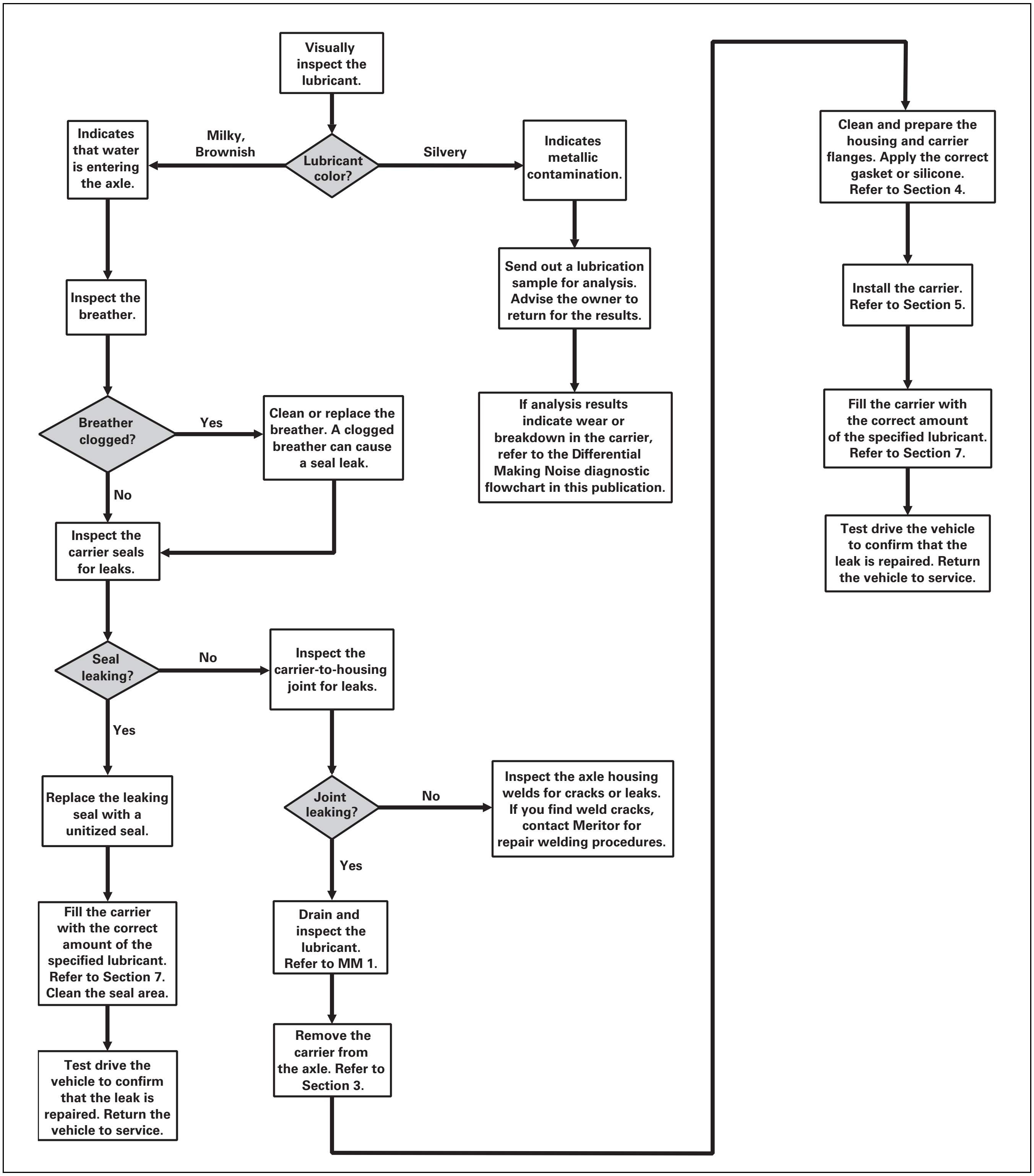

This flowchart continues from the previous page.
Backlash within spec?
Yes
When the main differential is reassembled later, set the backlash to the recorded reading.
No
When the main differential is reassembled later, set the backlash to spec. Refer to Section 5.
Remove the main differential and ring gear from the carrier. Refer to Section 3.
Inspect the main differential bearings for damage. Refer to TP-9955, Failure Analysis for Drive Axle Components.
Damaged?
Yes
Repair the carrier or install a remanufactured carrier. Refer to Sections 3 and 5.
No
Disassemble the main differential. Refer to Section 3.
Inspect the main differential case, side gears and spider for damage. Refer to TP-9955, Failure Analysis for Drive Axle Components.
Damaged?
Yes
Repair the carrier or install a remanufactured carrier. Refer to Sections 3 and 5.
No
Inspect the drive pinion, inner drive pinion bearing and spigot bearing for damage. Refer to TP-9955, Failure Analysis for Drive Axle Components.
Damaged?
Yes
Repair the carrier or install a remanufactured carrier. Refer to Sections 3 and 5.
No
Reassemble and install the main differential. Refer to Section 5.
Reset the backlash. Refer to Section 5.
If damaged, repair the input shaft, inter-axle differential, side gears or bearings. Install the input shaft. Refer to Sections 3 and 5.
Install a new unitized seal.
Set the input shaft end play to the correct specification. Refer to Section 5.
Install the carrier. Refer to Section 5. Test drive the vehicle. Return the vehicle to service.

Oil Leak



Visually inspect the carrier in the axle housing.
Damaged?
Yes
Remove the carrier from the axle housing. Repair the carrier or install a remanufactured carrier. Refer to Sections 3 and 5.
No
Inspect the breather.
Breather clogged?
Yes
Clean or replace the breather. A clogged breather can cause a seal leak.
No
Inspect the input shaft seal for leaks.
Seal leaking?
Yes
Replace the input shaft seal with a unitized seal.
Fill the carrier with the correct amount of the specified lubricant. Refer to Section 7. Clean the seal area.
Test drive the vehicle to confirm that the leak is repaired. Return the vehicle to service.
No
Inspect the ouput shaft seal for leakage.
Seal leaking?
Yes
Replace the output shaft seal with a unitized seal.
Fill the carrier with the correct amount of the specified lubricant. Refer to Section 7. Clean the seal area.
Test drive the vehicle to confirm that the leak is repaired. Return the vehicle to service.
No
Inspect the carrier-to-housing joint for leaks.
Joint leaking?
No
Inspect the axle housing welds for cracks or leaks. If you find weld cracks, contact Meritor for repair welding procedures.
Yes
Drain and inspect the lubricant. Refer to MM 1.
Remove the carrier from the axle housing. Refer to Section 3.
Clean and prepare the housing and carrier flanges. Apply the correct gasket or silicone. Refer to Section 4.
Install the carrier. Refer to Section 5.
Fill the carrier with the correct amount of the specified lubricant. Refer to Section 7.
Test drive the vehicle to confirm that the leak is repaired. Return the vehicle to service.

Contaminated Lubricant Found During Preventive Maintenance



Meritor Heavy Vehicle Systems, LLC
2135 West Maple Road
Troy, MI 48084 USA
800-535-5560
arvinmeritor.com

Printed in USA

Revised 11-06
Maintenance Manual 5L (16579/22882)

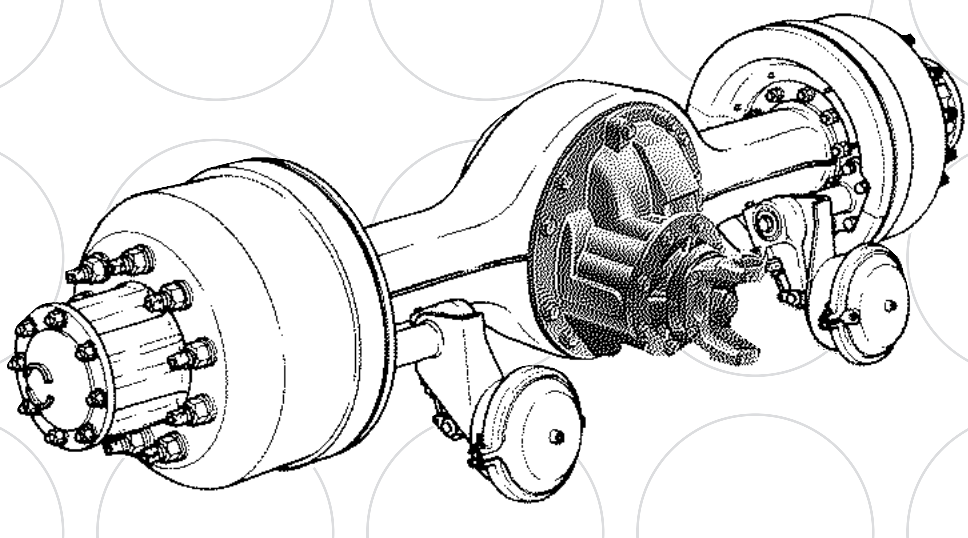
MERITOR®

Maintenance Manual 5A

Single-Reduction Differential Carriers

Single Rear Drive Axles, Rear-Rear Tandem Drive Axles and Front Drive Steer Axles

Revised 08-06



About This Manual

This manual provides instructions for the Meritor MX, RS, RT and RF Series axles and 59000 Series angle drive carrier.

Before You Begin

1. Read and understand all instructions and procedures before you begin to service components.
2. Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.
3. Follow your company's maintenance and service, installation, and diagnostics guidelines.
4. Use special tools when required to help avoid serious personal injury and damage to components.

Hazard Alert Messages and Torque Symbols

⚠ WARNING

A Warning alerts you to an instruction or procedure that you must follow exactly to avoid serious personal injury and damage to components.

⚠ CAUTION

A Caution alerts you to an instruction or procedure that you must follow exactly to avoid damage to components.

This symbol alerts you to tighten fasteners to a specified torque value.

How to Obtain Additional Maintenance and Service Information

On the Web

Visit Literature on Demand at meritorhvs.com to access product, service, aftermarket, and warranty literature for ArvinMeritor's truck, trailer and specialty vehicle components.

ArvinMeritor's Customer Service Center

Call ArvinMeritor's Customer Service Center at 800-535-5560.

Technical Electronic Library DVD

The DriveTrain Plus™ by ArvinMeritor Technical Electronic Library DVD contains product and service information for most Meritor and Meritor WABCO products. Specify TP-9853.

How to Obtain Tools and Supplies Specified in This Manual

Call ArvinMeritor's Commercial Vehicle Aftermarket at 888-725-9355 to obtain Meritor tools and supplies.

SPX Kent-Moore, 28635 Mound Road, Warren, Michigan, 48092. Call the company's customer service center at 800-345-2233, or visit their website at spxkentmoore.com.

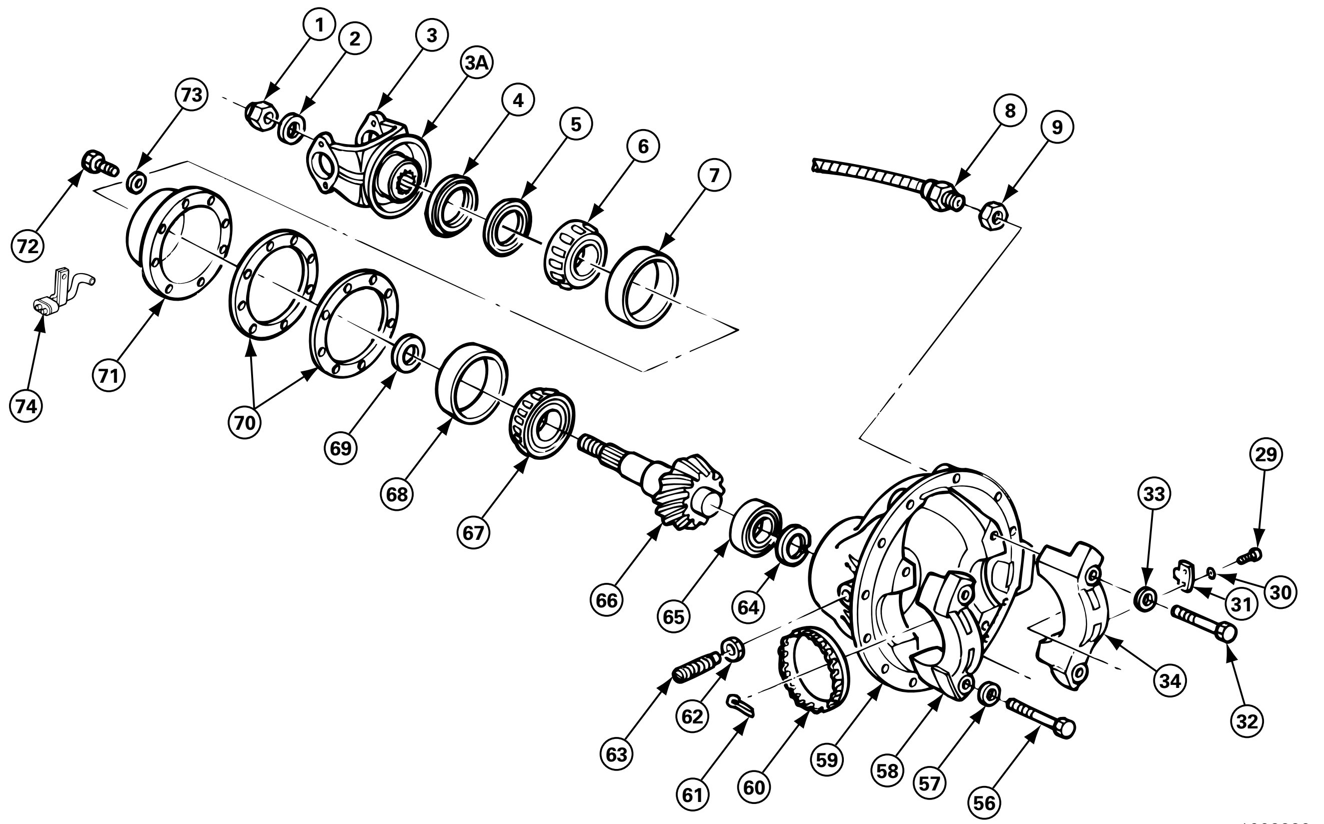
Kiene Diesel Accessories, Inc., 325 S. Fairbanks Street, Addison, IL 60101. Call the company's customer service center at 800-264-5950, or visit their website at kienediesel.com.

SPX/OTC Service Solutions, 655 Eisenhower Drive, Owatonna, MN 55060. Call the company's customer service center at 800-533-6128, or visit their website at otctools.com.

Contents

Contents

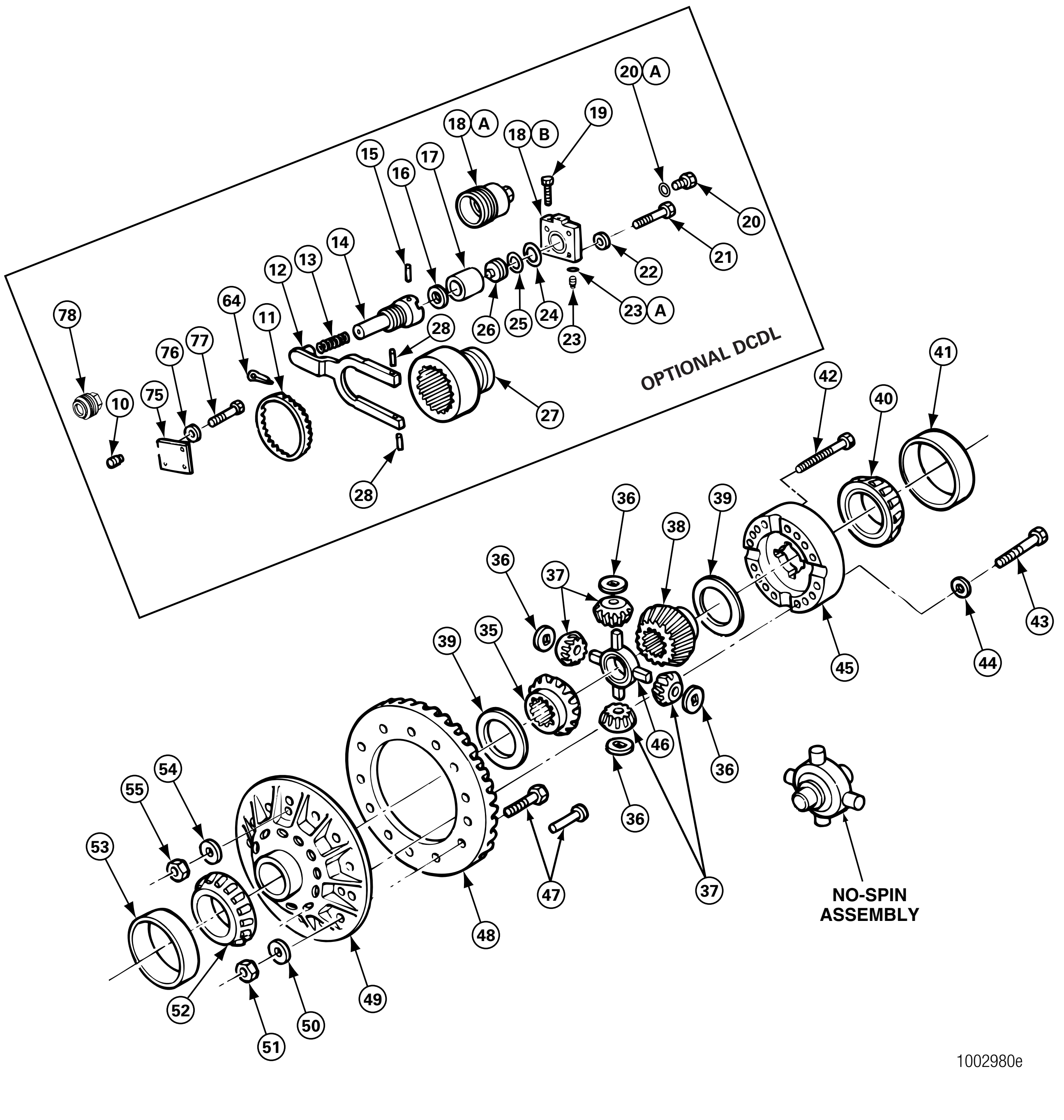
Single-Reduction Differential Carrier



1002980c

Item	Description
1	Drive Pinion Nut*
2	Drive Pinion Washer*
3	Input Yoke or Flange*
3A	Deflector
4	POSE™ Seal
5	Triple-Lip or Main Seal
6	Outer Bearing Cone
7	Inner Bearing Cup
8	Sensor Switch
9	Sensor Switch Locknut
29	Lock Plate Capscrews*
30	Lock Plate Washers*
31	Adjusting Ring Lock Plate
32	Differential Bearing Cap Capscrews
33	Washers
34	Differential Bearing Caps
56	Differential Bearing Cap Capscrews
57	Washers
58	Differential Bearing Cap
59	Carrier
60	Adjusting Ring
61	Adjusting Ring Cotter Pin, Spring Pin (Spirol™) or Capscrews
62	Thrust Screw Jam Nut*
63	Thrust Screw*
64	Snap Ring
65	Spigot Bearing
66	Drive Pinion
67	Pinion Inner Bearing Cone
68	Pinion Inner Bearing Cup
69	Pinion Bearing Spacer
70	Shims
71	Drive Pinion Bearing Cage
72	Bearing Cage Capscrew
73	Washer
74	Clip and Cable Holder
75	Bolt-On Cover
76	Washer
77	Bolt
78	Screw-In Cover

* Some Meritor carriers do not have these parts.


20 A
19
18 A
18 B
15
17
16
20
14
21
12
13
22
28
23 A
78
64
11
26
25
24
23
76
77
28
10
75
OPTIONAL DCDL
27
28
41
42
40
36
39
38
36
37
43
39
35
44
45
46
36
54
55
36
53
47
37
NO-SPIN ASSEMBLY
48
52
49
50
51
1002980e

Item	Description
10	Plug*
11	Right-Hand Adjusting Ring
12	Shift Fork
13	Shift Shaft Spring
14	Shift Shaft
15	Spring Retaining Pin
16	Air Cylinder Washer or Silastic*
17	Air Cylinder Tube
18A	Screw-In Differential Lock Cylinder
18B	Cylinder Cover
19	Manual Actuation Capscrew
20	Cylinder Cover Plug
20A	Cover Plug Gasket
21	Cylinder Cover Capscrews
22	Cylinder Cover Washers
23	Cylinder Cover Plug
23A	Cover Plug Gasket
24	Cylinder Cover Copper Gasket
25	Piston O-Ring
26	Piston
27	Shift Collar
28	Shift Fork Pins
35	Differential Side Gears
36	Differential Pinion Thrust Washers
37	Differential Pinions
38	Differential Side Gears
39	Differential Side Gear Thrust Washers
40	Differential Bearing Cone
41	Differential Bearing Cup
42	Thru Bolt
43	Differential Case Bolts*
44	Differential Case Washers
45	Main Differential Case Assembly
46	Differential Spider
47	Ring Gear and Case Half Bolts or Rivets*

Item	Description
48	Ring Gear
49	Flange Case Half
50	Case Half Washers
51	Case Half Nuts*
52	Left-Hand Differential Bearing Cone
53	Left-Hand Differential Bearing Cup
54	Thru Bolt Washer
55	Thru Bolt Nut
64	Snap Ring
75	Bolt-On Cover
76	Washer
77	Bolt
78	Screw-In Cover

* Some Meritor carriers do not have these parts.

Description

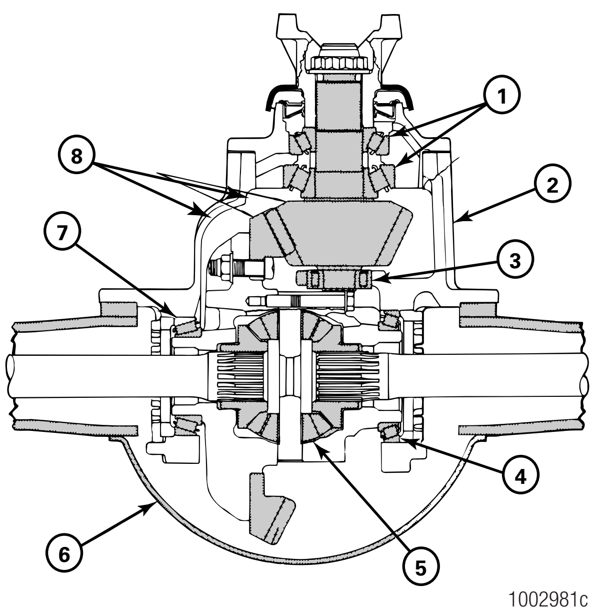
Standard Single-Reduction Carriers Without Differential Lock

Meritor single-reduction standard carriers are used in most Meritor single axles, rear of tandem axles and front drive steer axles. Figure 2.1.

The single-reduction carriers are front mounted into the axle housing. These carriers have a hypoid drive pinion and ring gear set and bevel gears in the differential assembly.

A straight roller bearing or spigot is mounted on the head of the drive pinion. All other bearings in the carrier are tapered roller bearings.

When the carrier operates, there is normal differential action between the wheels at all times.



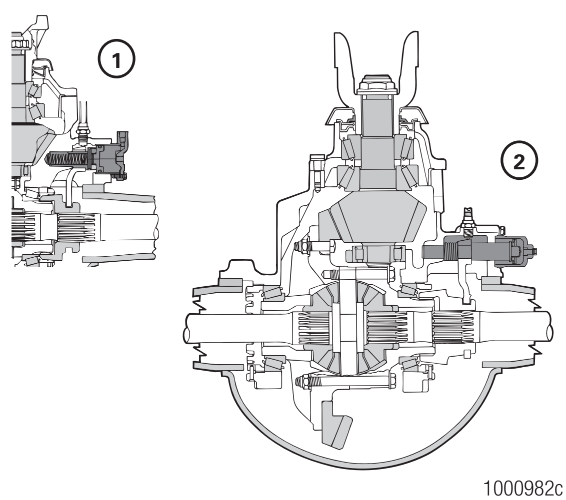
1 TAPERED ROLLER BEARINGS
2 CARRIER
3 STRAIGHT ROLLER BEARING
4 TAPERED ROLLER BEARING
5 BEVEL DIFFERENTIAL GEARS
6 HOUSING
7 TAPERED ROLLER BEARING
8 HYPOID DRIVE PINION AND RING GEAR

Figure 2.1

Single-Reduction Carriers with Driver-Controlled Main Differential Lock (DCDL)

Meritor single-reduction carriers with driver-controlled main differential lock (DCDL) have the same type of gears and bearings as the standard-type carriers. Figure 2.2. The differential lock is operated by an air-actuated shift assembly that is mounted on the carrier.

- When the differential lock is activated, the shift collar moves along the splines of the axle shaft toward the differential case.
- When the splines on the collar are engaged with splines on the differential case, the axle shafts and differential assembly are locked together.
- When the carrier operates with the DCDL in the locked position, there is no differential action between the wheels.
- When the carrier is operated in the unlocked position, there is normal differential action between the wheels at all times.



1 BOLT-IN STYLE
2 SCREW-IN OR THREADED STYLE

STANDARD CARRIER WITH DIFFERENTIAL LOCK (DCDL)

Figure 2.2

Axle Models Covered in This Manual

Table A, Table B, Table C and Table D list the axle models covered in this manual. For other models (non-MX, RS, RT and RF Series), refer to Maintenance Manual 5, Single-Reduction Differential Carriers. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Table A: RS Series Single Drive Axles

RS-13-120	RS-17-145	RS-21-160	RS-23-186
RS-15-120	RS-17-145A	RS-21-160A	RS-25-160
RS-16-140	RS-19-144	RS-23-160	RS-25-160A
RS-16-141	RS-19-144A	RS-23-160A	RS-26-160
RS-16-145	RS-19-145	RS-23-161	RS-26-180
RS-17-140	RS-19-145A	RS-23-161A	RS-26-185
RS-17-141	RS-21-145	RS-23-180	RS-30-180
RS-17-144	RS-21-145A	RS-23-185	RS-30-185
RS-17-144A			

Table B: Bus and Coach Application Single Drive Axles

59722	59753	61052	61152
59723	59842	61053	61153
59732	59843	61063	61163
59733	61042	61142	RC-23-160
59752	61043	61143	

Table C: Rear Axle of Tandem Axles

RT-34-140	RT-40-146	RT-44-145P	RT-46-169A
RT-34-144	RT-40-149	RT-44-149	RT-46-169P
RT-34-144A	RT-40-149A	RT-46-16HEH	RT-48-180
RT-34-144P	RT-40-149P	RT-46-16HP	RT-48-185
RT-34-145	RT-40-160	RT-46-160	RT-50-160
RT-34-145P	RT-40-160A	RT-46-160A	RT-50-160P
RT-34-146	RT-40-160P	RT-46-160P	RT-52-180
RT-40-140	RT-40-169	RT-46-164	RT-52-185
RT-40-145	RT-40-169A	RT-46-164EH	RT-58-180
RT-40-145A	RT-40-169P	RT-46-164P	RT-58-185
RT-40-145P	RT-44-145	RT-46-169	

Table D: Front Drive Steer Axles

MX-10-120	RF-7-120	RF-21-160
MX-12-120	RF-9-120	RF-21-185
MX-14-120	RF-12-120	RF-21-355
MX-16-120	RF-12-125	RF-22-166
MX-21-160	RF-16-145	RF-23-180
MX-21-160R	RF-21-155	RF-23-185
MX-23-160	RF-21-156	
MX-23-160R		

Stall-Testing Can Damage a Drive Axle

Stall-testing is a procedure used to troubleshoot transmissions, evaluate vehicle performance, and test the service and park brakes.

During stall-testing, or any similar procedure, the drive axle input receives multiplied torque, which can exceed the specified torque rating. Excessive torque can damage a drive axle, which will affect axle performance and component life. A drive axle damaged by stall-testing will void Meritor's warranty.

Call ArvinMeritor's Customer Service Center at 800-535-5560 if you have questions regarding stall-testing.

Use of Traction Chains

Meritor recommends that if you are using traction chains, you should install chains on both tires on each side of all drive axles on the vehicle.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury can result.

Use a brass or synthetic mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off. Serious personal injury and damage to components can result.

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

Removal

Axle Shaft Removal Methods

Use Special Tools Recommended by Meritor

To help prevent serious personal injury and damage to components when you remove the axle shaft from the housing, Meritor recommends that you use the following tools in the table below. Refer to the Service Notes page at the front inside cover of this manual for information on how to contact the manufacturers to obtain the tools.

- **If the tools are not available when you remove the axle shaft:** Follow procedures for using the Brass Drift Method or the Air Vibration Method.

Tool	Part Number	Manufacturer
Axle Shaft Remover	K-1280	Kiene Diesel Accessories, Inc.
Axle Stud Cone Plier	7077	SPX OTC

Brass Drift Method

WARNING

Do not strike the round driving lugs on the flange of an axle shaft. Pieces can break off and cause serious personal injury.

1. Hold a 1-1/2-inch diameter brass drift or brass hammer against the center of the axle shaft, inside the round driving lugs. Figure 3.1.

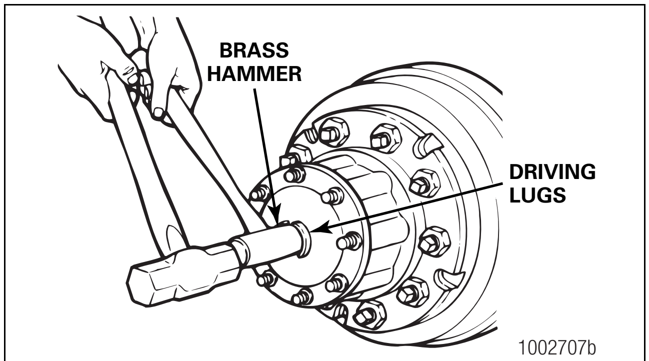


Figure 3.3

2. Strike the end of the drift with a large hammer, five to six pounds, and the axle shaft and tapered dowels will loosen.
3. Mark each axle shaft before it is removed from the axle assembly.
4. Remove the tapered dowels and separate the axle shafts from the main axle hub assembly. Figure 3.2.

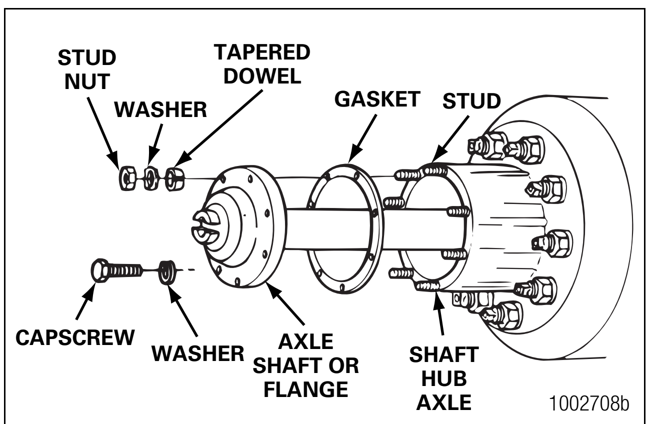


Figure 3.4

5. Install a cover over the open end of each axle assembly hub where an axle shaft was removed.

Air Hammer Vibration Method

WARNING

Wear safe eye protection when using an air hammer. When using power tools, axle components can loosen and break off causing serious personal injury.

CAUTION

Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. Using a chisel or wedge can result in damage to the axle shaft, the gasket and seal, and the axle hub.

1. Use a round hammer bit and an air hammer to loosen the tapered dowels and axle shaft.
2. Place the round hammer bit against the axle shaft or flange between the hub studs. Operate the air hammer at alternate locations between the studs to loosen the tapered dowels and axle shaft from the hub. Figure 3.3.

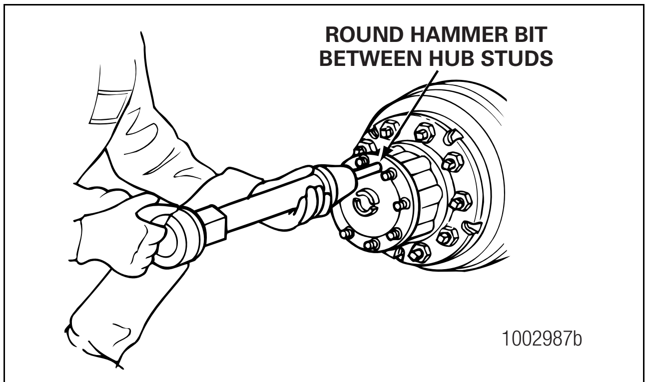


Figure 3.5

3. Mark each axle shaft before it is removed from the axle assembly.
4. Remove the tapered dowels and separate the axle shaft from the main axle hub assembly. Figure 3.2.

Axle Shafts from the Axle Housing

NOTE: If the vehicle is equipped with a driver-controlled main differential lock, the DCDL collar must be engaged before removing the axle shafts. Refer to Section 6.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Figure 3.1.

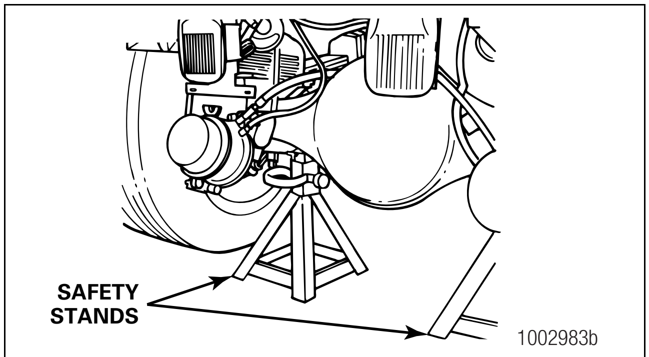
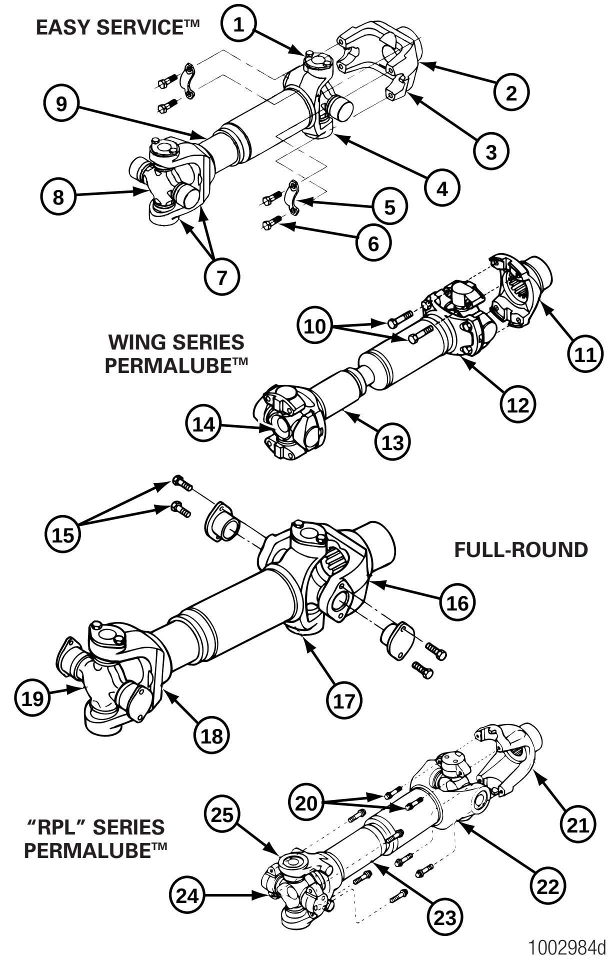


Figure 3.1

2. Use a jack or other lifting tool to raise the vehicle so that the wheels to be serviced are off the ground. Support the vehicle with safety stands. Figure 3.1.
3. Place a drain pan under the rear axle.
4. Remove the plug from the bottom of the axle housing. Drain the lubricant from the assembly.
5. Disconnect the driveline universal joint from the pinion input yoke or flange on the carrier. Figure 3.2.



1	FULL-ROUND BEARING CUPS	8	U-JOINT CROSS	17	WELD YOKE
		9	SLIP YOKE	18	SLIP YOKE
2	END YOKE	10	CAPSCREWS	19	U-JOINT CROSS
3	YOKE SADDLE	11	END YOKE	20	CAPSCREWS
4	WELD YOKE	12	WELD YOKE	21	END YOKE
5	BEARING STRAP	13	SLIP YOKE	22	SLIP YOKE
6	CAPSCREWS	14	U-JOINT CROSS	23	TUBING
7	EASY SERVICE™ BEARING CUPS	15	CAPSCREWS	24	U-JOINT CROSS
		16	END YOKE	25	WELD YOKE

Figure 3.2

6. Remove the capscrews and washers or stud nuts and washers, if equipped, from the flanges of both axle shafts.
7. Loosen the tapered dowels, if equipped, in the axle flanges of both axle shafts using one of the following methods. Refer to the procedures in this section.

Differential Carrier from the Axle Housing

1. Place a hydraulic roller jack under the differential carrier to support the assembly. Figure 3.3.

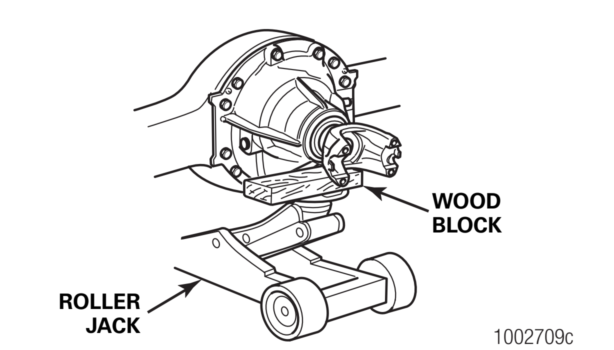


Figure 3.3

2. Remove all but the top two carrier-to-housing capscrews or stud nuts and washers.
3. Loosen the top two carrier-to-housing fasteners and leave attached to the assembly. The fasteners will hold the carrier in the housing.
4. Loosen the differential carrier in the axle housing. Use a leather mallet to hit the mounting flange of the carrier at several points.
5. After the carrier is loosened, remove the top two fasteners.

⚠ CAUTION

When you use a pry bar, be careful not to damage the carrier or housing flange. Damage to these surfaces will cause oil leaks.

6. Use the hydraulic roller jack to remove the carrier from the axle housing. Use a pry bar that has a round end to help remove the carrier from the housing.

NOTE: A carrier stand is available from SPX Kent-Moore. Refer to the Service Notes page on the front inside cover of this manual to obtain the stand.

7. Use a lifting tool to lift the differential carrier by the input yoke or flange and place the assembly in a repair stand. Figure 3.4. Do not lift by hand. A carrier stand can be built by referring to Figure 3.5.

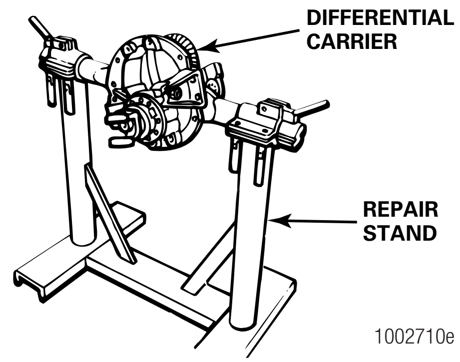
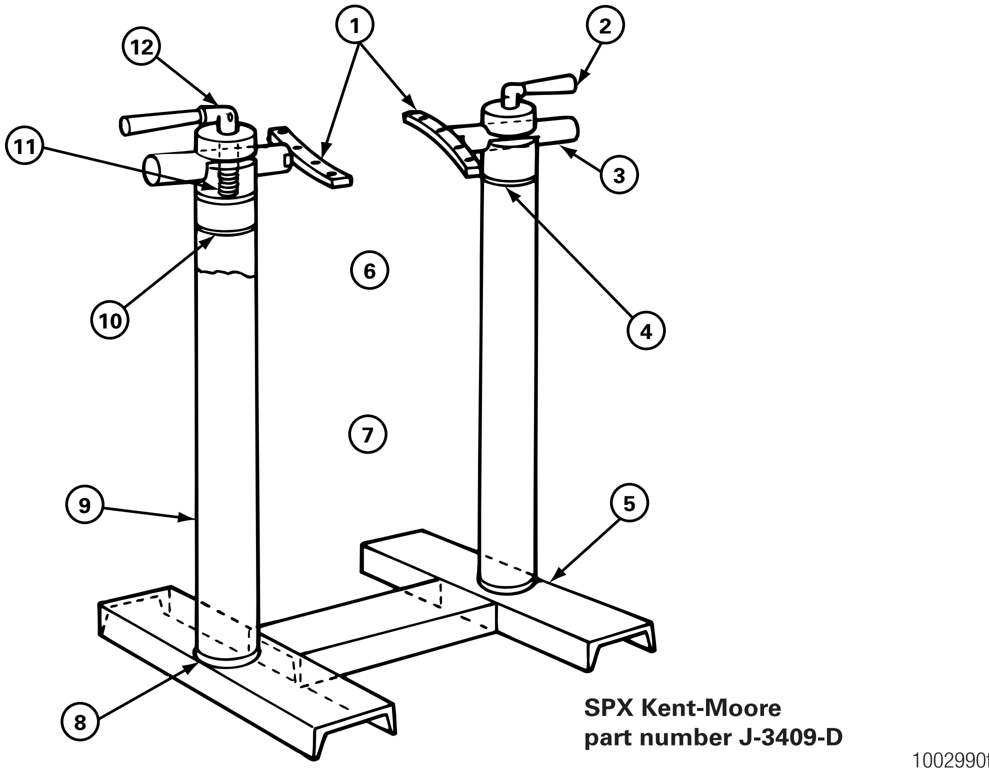


Figure 3.4



1 PLATES 8' LONG x 3/4" THICK x 1-1/4" WIDE WITH A TONGUE TO FIT SLOT IN BAR WELD PLATES TO BAR
2 HANDLE 7" LONG WITH SLOT IN ONE END TO FIT CLAMP SCREW
3 BAR 2" DIAMETER x 9" LONG WITH ONE END SLOTTED TO FIT PLATE
4 WELD ALL AROUND AFTER PRESSING PLUG IN PIPE
5 WELD
6 SHAPE AND SIZE OF HOLES TO FIT CARRIER
7 23-1/2" CENTER TO CENTER OF PIPE
8 CHAMFER END OF PIPE FOR WELDING
9 4" DIAMETER PIPE
10 PLUG 4" DIAMETER x 7" LONG WITH ONE END TURNED 3" LONG TO FIT PIPE. DRILL 2" HOLE AND MILL 3/16" WIDE SLOT 2" FROM TOP
11 SCREW 3-1/2" LONG x 5/8" DIAMETER WITH FLATS ON END TO FIT HANDLE AND 2-1/2" LENGTH OF THREAD ON OTHER END
12 DRILL 3/8" HOLE THROUGH HANDLE AND SCREW

CARRIER STAND

Figure 3.5

Measure Ring Gear Backlash

Before the differential carrier is disassembled, inspect the hypoid gear set for damage. If inspection shows no damage, the same gear set can be used again. Use a dial indicator to measure and record ring gear backlash at three locations on the ring gear. This will help you to correctly reassemble the ring gear and drive pinion.

1. Rotate the carrier in the stand to access the ring gear teeth.
2. Install a dial indicator onto the flange of the carrier. Place the tip of the indicator against the drive side of a ring gear tooth. Adjust the dial indicator to ZERO. Figure 3.6.

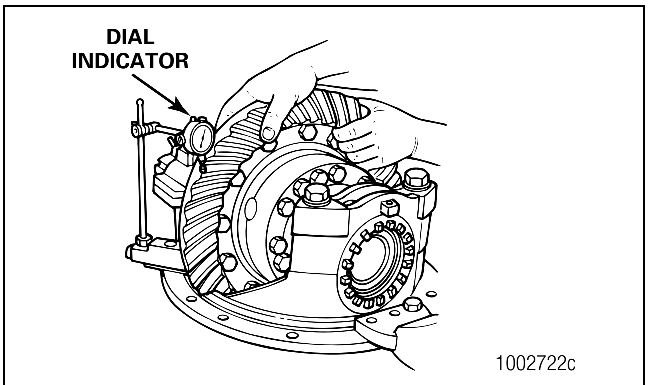


Figure 3.6

3. Read the dial indicator while you slightly rotate the ring gear in both directions. When you rotate the ring gear to measure the backlash, the drive pinion must not move. Record the reading on the dial indicator.
4. Repeat the procedure at two more locations on the ring gear.
   - **If the smallest of the three measurements is not 0.008-0.018-inch (0.20-0.46 mm) for ring gears with a pitch diameter less than 17-inches (431.8 mm) or 0.010-0.020-inch (0.25-0.51 mm) for ring gears with a pitch diameter greater than 17-inches (431.8 mm):** Replace the ring gear and drive pinion as a set.

Differential and Ring Gear from the Carrier

1. Loosen the jam nut on the thrust screw, if equipped.
2. Remove the thrust screw and jam nut, if equipped, from the differential carrier. Figure 3.7 and Figure 3.8.

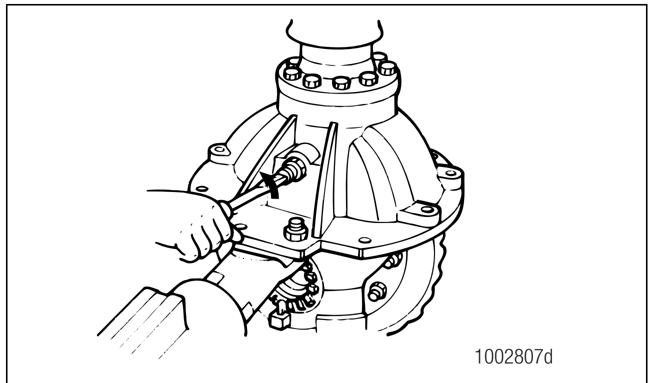


Figure 3.7

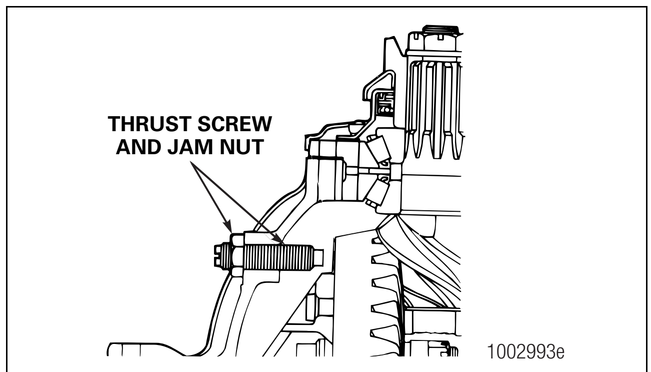


Figure 3.8

3. Rotate the differential carrier in the repair stand until the ring gear is at the top of the assembly.
4. Mark one carrier leg and bearing cap to correctly match the parts during carrier assembly. Mark the parts using a center punch and hammer. Figure 3.9.

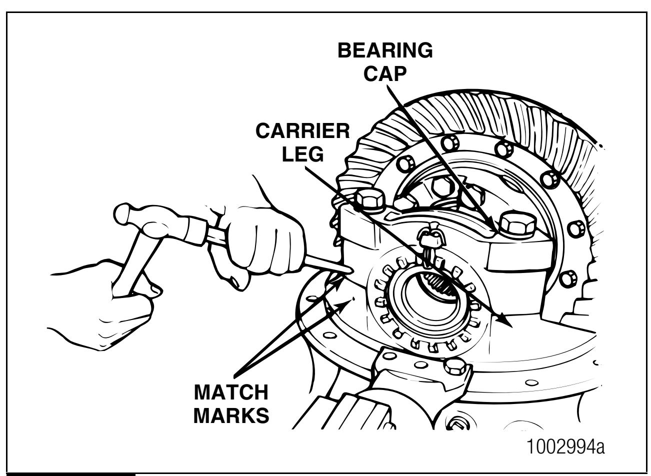


Figure 3.9

5. Remove the capscrews, cotter pins, roll pins or lock plates, if equipped, that hold the bearing adjusting rings in position. Use a small drift and hammer to remove the pins. Each lock plate is held in position by two capscrews. Figure 3.10.

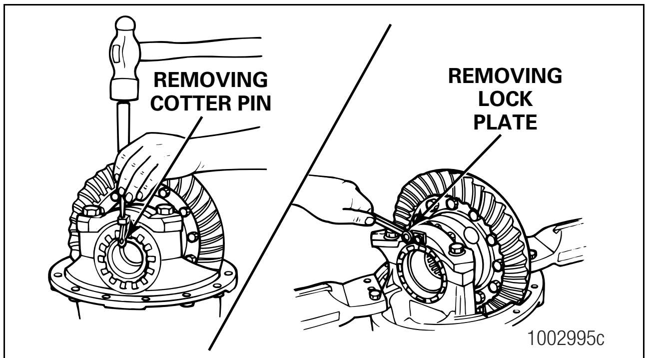


Figure 3.10

6. Remove the capscrews and washers that hold the two bearing caps on the carrier. Each cap is held in position by two capscrews and washers. Figure 3.11.

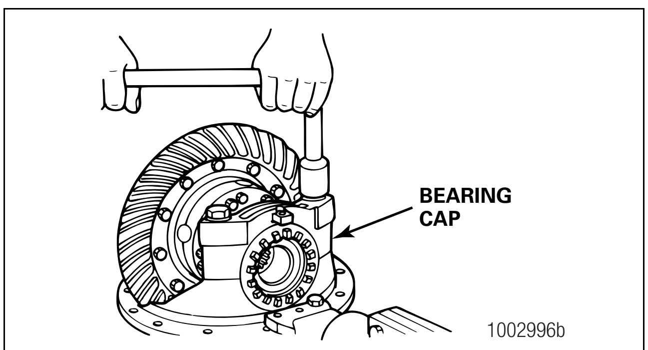


Figure 3.11

7. Remove the bearing caps and bearing adjusting rings from the carrier. Figure 3.12.

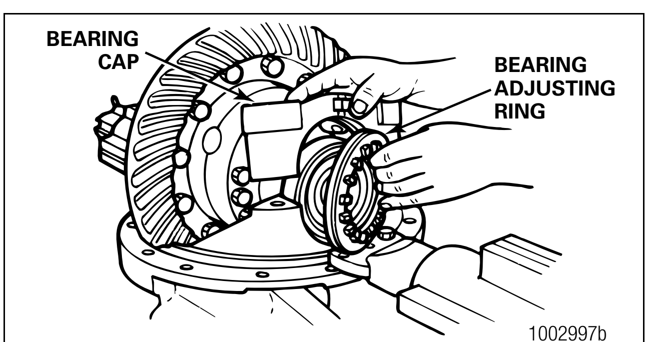


Figure 3.12

8. Safely lift the main differential and ring gear assembly from the carrier. Place the assembly on a workbench. Figure 3.13.

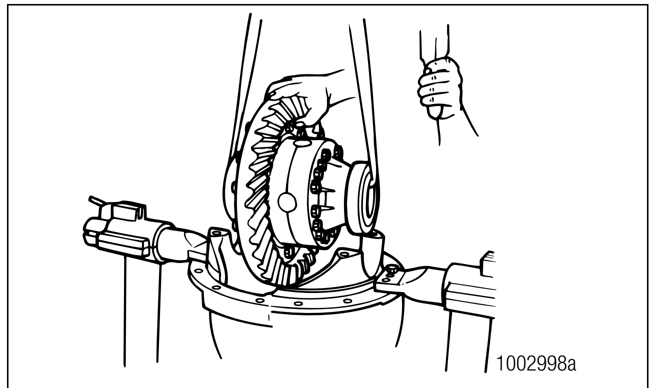


Figure 3.13

Disassembly

Differential and Ring Gear Assembly

1. If the match marks on the case halves of the differential assembly are not visible, mark each case half with a center punch and hammer. Figure 3.14.

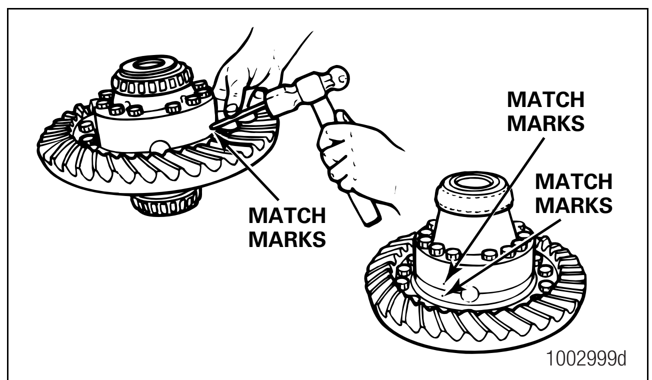


Figure 3.14

2. Remove the capscrews and washers or bolts, nuts and washers, if equipped, that hold the case halves together.

3. Separate the case halves. If necessary, use a brass, plastic or leather mallet to loosen the parts.

4. Remove the differential spider or cross, four pinion gears, two side gears and six thrust washers from inside the case halves. Figure 3.15.

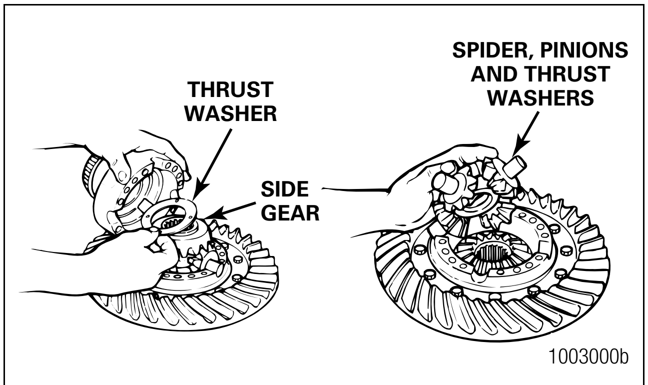


Figure 3.15

5. If the ring gear needs to be replaced, remove the bolts, nuts and washers, if equipped, that hold the gear to the flange case half.

CAUTION

Do not remove the rivets or rivet heads with a chisel and hammer. Using a flat edge tool can cause damage to the flange case.

6. If rivets hold the ring gear to the flange case half, remove the rivets as follows.
   A. Carefully center punch each rivet head in the center, on the ring gear side of the assembly. Do not use a chisel and hammer. Figure 3.16.
   B. Drill each rivet head on the ring gear side of the assembly to a depth equal to the thickness of one rivet head. Use a drill bit that is 0.03125-inch (0.79375 mm) smaller than the body diameter of the rivets. Figure 3.16.
   C. Press the rivets through holes in the ring gear and flange case half. Press from the drilled rivet head.

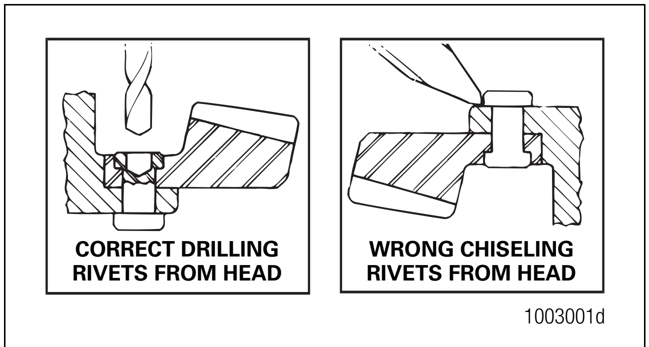


Figure 3.16

7. Use a press to separate the case half and ring gear. Support the assembly under the ring gear with metal or wood blocks. Press the case half through the gear. Figure 3.17.

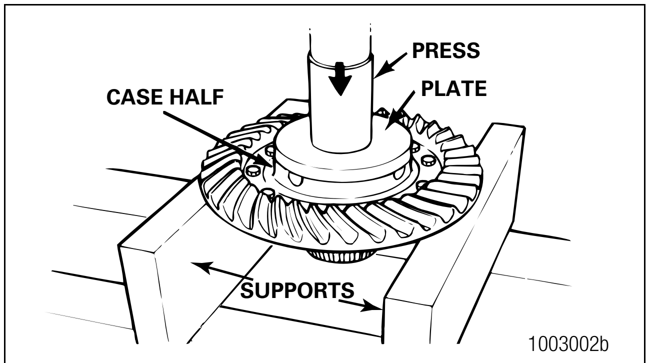


Figure 3.17

8. If the differential bearings need to be replaced, use a bearing puller or press to remove the bearing cones from the case halves. Figure 3.18.

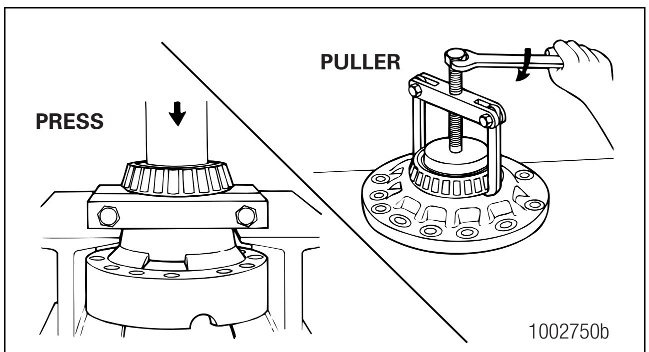


Figure 3.18

Removal

Drive Pinion and Bearing Cage from the Carrier

1. Fasten a flange bar to the input yoke or flange. When the nut is removed, the bar will hold the drive pinion in position. Figure 3.19.

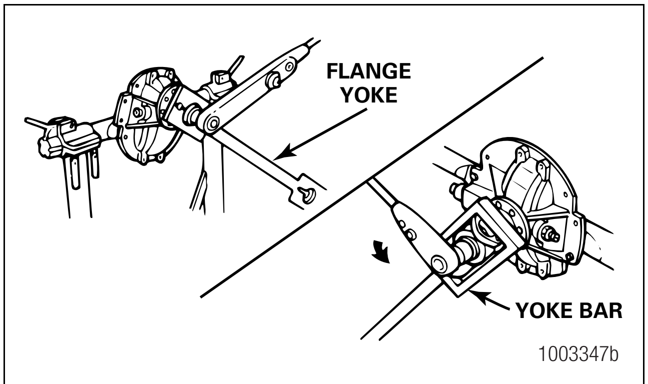


Figure 3.19

2. Remove the nut and washer, if equipped, from the drive pinion. Figure 3.19.
3. Remove the yoke or flange bar.

CAUTION

Do not use a hammer or mallet to loosen and remove the yoke or flange. A hammer or mallet can damage the parts and cause driveline runout or driveline imbalance.

4. Remove the yoke or flange from the drive pinion. Do not use a hammer or mallet.
   - **If the yoke or flange is tight on the pinion:** Use a puller for removal. Figure 3.20.

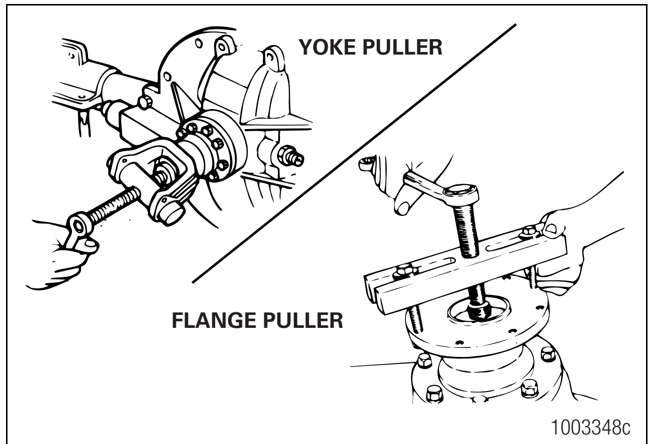


Figure 3.20

5. Remove the capscrews and washers that hold the bearing cage in the carrier. Figure 3.21.

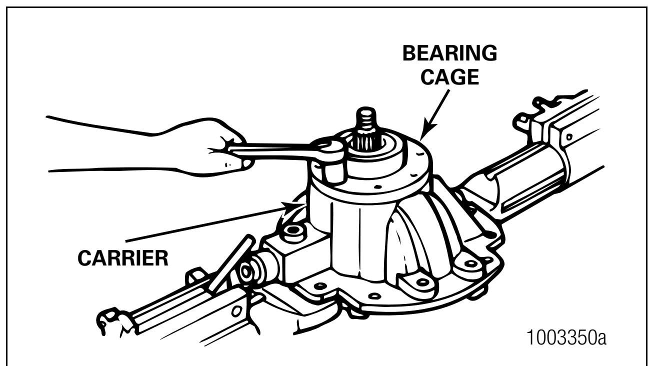


Figure 3.21

CAUTION

Do not use a pry bar to remove the bearing cage from the carrier. A pry bar can damage the bearing case, shims and carrier.

6. Remove the drive pinion, bearing cage and shims from the carrier. Do not use a pry bar.
   - **If the bearing cage is tight in the carrier:** Hit the bearing cage at several points around the flange area with a leather, plastic or rubber mallet. Figure 3.22.

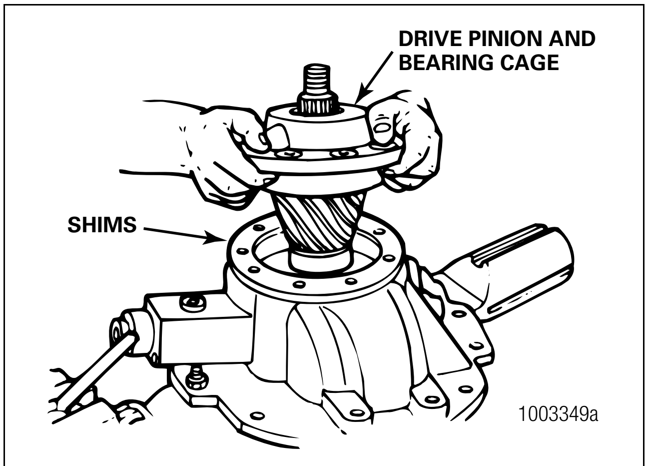


Figure 3.22

7. If the shims are in good condition, keep the shims together to use when the carrier is assembled.
8. If shims are to be discarded because of damage, first measure the total thickness of the pack. Make a note of the dimension. The dimension will be needed to calculate the depth of the drive pinion in the carrier when the gear set is installed.

Disassembly

Drive Pinion and Bearing Cage

1. Place the drive pinion and bearing cage in a press. The pinion shaft must be toward the top of the assembly. Figure 3.23.
2. Support the bearing cage under the flange area with metal or wood blocks. Figure 3.23.

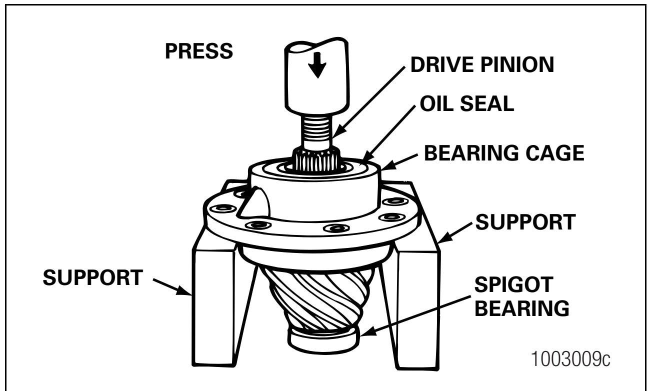


Figure 3.23

3. Press the drive pinion through the bearing cage. The inner bearing cone and bearing spacer will remain on the pinion shaft. Figure 3.23.
   - **If a press is not available:** Use a leather, plastic or rubber mallet to drive the pinion through the bearing cage.

CAUTION

Be careful when you remove the seal. Do not damage the wall of the bore. Damage to the bore wall can result in oil leaks.

4. Use a press and a sleeve to remove the triple-lip or unitized oil seal from the bearing cage.
   - **If a press is not available:** Place a tool with a flat blade under the flange to remove the oil seal from the cage. Figure 3.24.

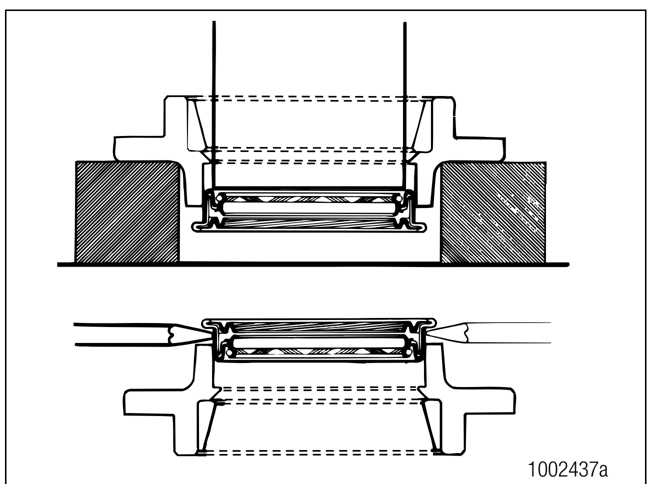


Figure 3.24

5. If the pinion bearings need to be replaced, remove the inner and outer bearing cups from the inside of the cage. Figure 3.25. Use a press and sleeve, bearing puller or a small drift hammer. The type of tool used depends on the design of the bearing cage. Figure 3.26.

   When a press is used, support the bearing cage under the flange area with metal or wood blocks.

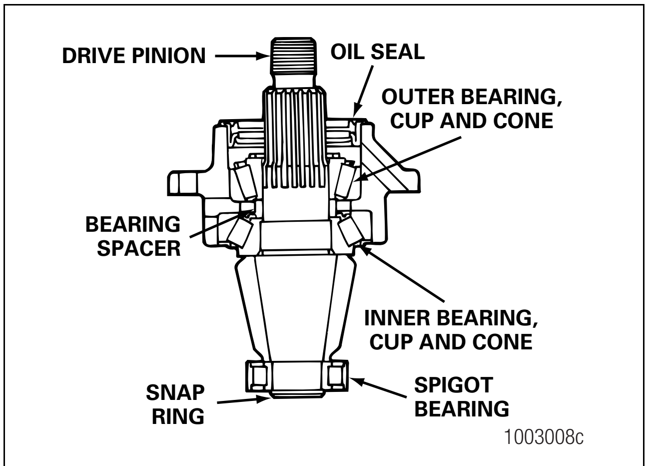


Figure 3.25

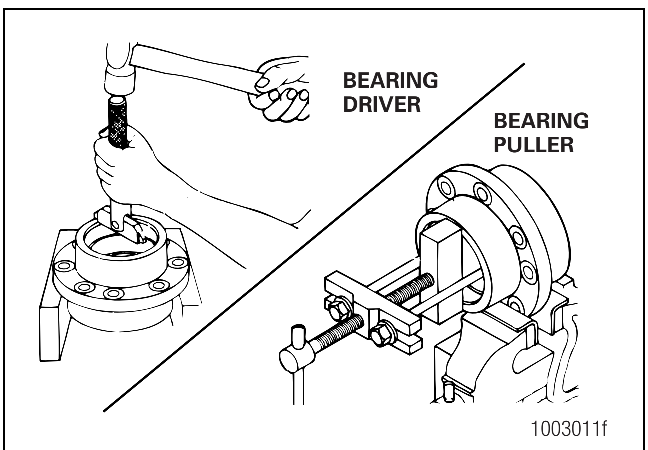


Figure 3.26

6. If the pinion bearings need to be replaced, remove the inner bearing cone from the drive pinion with a press or bearing puller. The puller must fit under the inner race of the cone to remove the cone correctly without damage. Figure 3.27.

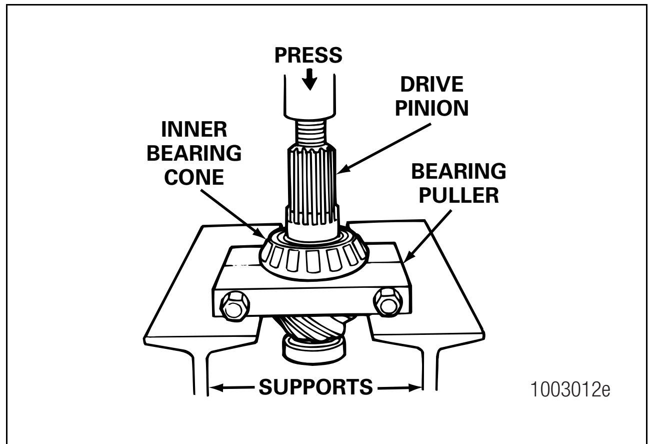


Figure 3.27

7. If the spigot bearing needs to be replaced, place the drive pinion in a vise. Install a soft metal cover over each vise jaw to protect the drive pinion.

8. Remove the snap ring, if equipped, from the end of the drive pinion with snap ring pliers that expand. Figure 3.28.

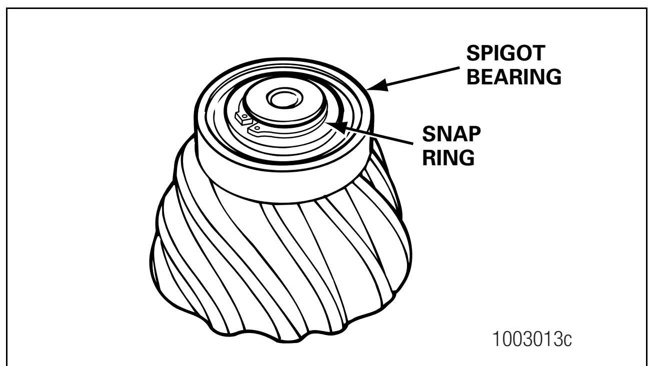


Figure 3.28

9. Remove the spigot bearing from the drive pinion with a bearing puller. Figure 3.29. Some spigot bearings are fastened to the drive pinion with a special peening tool. Figure 3.30.

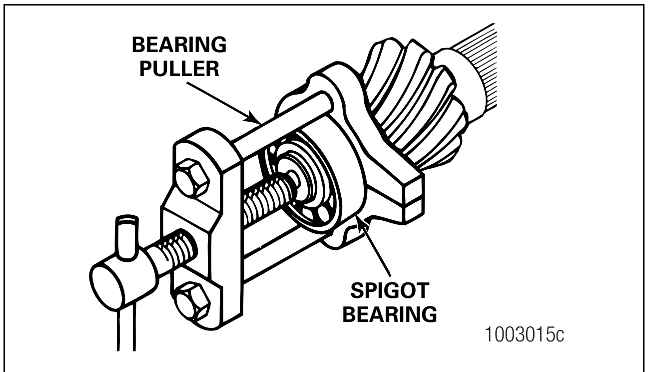


Figure 3.29

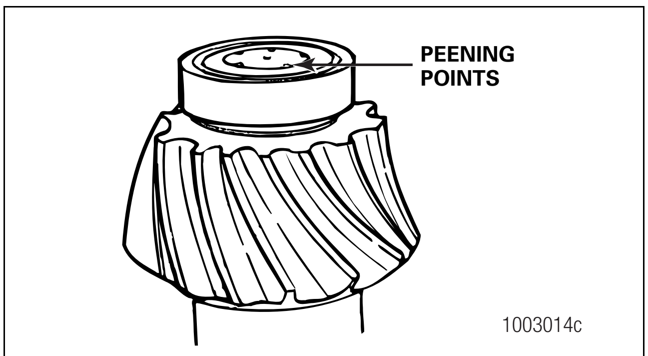


Figure 3.30

10. If the spigot bearings are a two-piece assembly, remove the inner race from the pinion with a bearing puller. Remove the outer race and roller assembly from the carrier with a drift or a press. Figure 3.31.

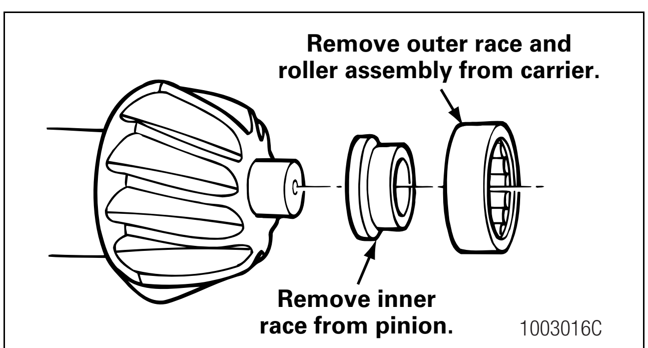


Figure 3.31

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

Take care when you use Loctite, adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin. If Loctite® adhesive material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Clean, Dry and Inspect Parts

Clean and Inspect Yokes

⚠ CAUTION

Do not install a press-on shaft excluder or POSE™ seal after you install a unitized pinion seal. The use of a POSE™ seal will prevent correct seating of the unitized pinion seal on the yoke and will result in lubricant leakage at the seal. POSE™ seal installation is recommended only for triple-lip and other previous design seals.

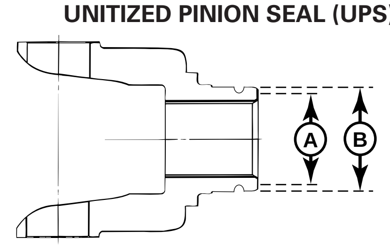
Do not use thin metal wear sleeves to refresh the yoke surface. Wear sleeves pressed onto the yoke will prevent correct seating of the pinion seal and damage the pinion seal assembly. Wear sleeve usage will cause the seal to leak.

1. Clean the ground and polished surface of the yoke journal using a clean shop towel and a safe cleaning solvent. Do not use abrasive cleaners, towels or scrubbers to clean the yoke or flange surface. Do not use gasoline.

NOTE: The unitized seal features a rubber inner sleeve that is designed to seal and rotate with the yoke. This feature allows you to reuse a yoke with minor grooves.

2. Inspect the yoke seal surface for grooves.
   - **If you find grooves on yoke hubs used with single or triple-lip seals:** Replace the yokes.
   - **If you find grooves on the yoke:** Use calipers to measure the groove diameters. If any groove diameter measures less than the dimensions shown in Figure 4.1, replace the yoke.

UNITIZED PINION SEAL (UPS)



Yoke Seal Diameter	Minimum Yoke Diameter at Groove (Inches)
3.000/3.005"	2.990"
3.250/3.255"	3.240"

1003390e

A MINIMUM GROOVE DEPTH — DIAMETER
B YOKE SEAL DIAMETER

Figure 4.1

Clean Ground and Polished Parts

1. Use a cleaning solvent, kerosene or diesel fuel to clean ground or polished parts or surfaces. Do not use gasoline.
2. Use a tool with a flat blade if required, to remove sealant material from parts. Be careful not to damage the polished or smooth surfaces.

CAUTION

Do not use hot solution tanks or water and alkaline solutions to clean ground or polished parts. Damage to parts can result.

3. Do not clean ground or polished parts with water or steam. Do not immerse ground or polished parts in a hot solution tank or use strong alkaline solutions for cleaning, or the smooth sealing surface may be damaged.

Clean Rough Parts

1. Clean rough parts with the same method as cleaning ground and polished parts.
2. Rough parts can be cleaned in hot solution tanks with a weak or diluted alkaline solution.
3. Parts must remain in hot solution tanks until heated and completely cleaned.
4. Parts must be washed with water until all traces of the alkaline solution are removed.

Clean Axle Assemblies

1. A complete axle assembly can be steam cleaned on the outside to remove dirt.
2. Before the axle is steam cleaned, close or place a cover over all openings in the axle assembly. Examples of openings are breathers or vents in air chambers.

Drying Parts After Cleaning

1. Parts must be dried immediately after cleaning and washing.
2. Dry the parts using soft, clean paper or cloth rags.

CAUTION

Damage to bearings can result when they are rotated and dried with compressed air.

3. Except for bearings, parts can be dried with compressed air.

Prevent Corrosion on Cleaned Parts

1. Apply axle lubricant to cleaned and dried parts that are not damaged and are to be assembled.
2. To store parts, apply a special material that prevents corrosion to all surfaces. Wrap cleaned parts in a special paper that will protect the parts from moisture and prevent corrosion.

Inspect Parts

It is very important to inspect all parts carefully and completely before the axle or carrier is assembled. Check all parts for wear and replace damaged parts.

1. Inspect the cup, cone, rollers and cage of all tapered roller bearings in the assembly. If any of the following conditions exist, replace the bearing.
   - The center of the large-diameter end of the rollers is worn level with or below the outer surface. Figure 4.2.
   - The radius at the large-diameter end of the rollers is worn to a sharp edge. Figure 4.2.
   - There is a visible roller groove in the cup or cone inner race surfaces. The groove can be seen at the small- or large-diameter end of both parts. Figure 4.3.
   - There are deep cracks or breaks in the cup, cone inner race or roller surfaces. Figure 4.3.
   - There are bright wear marks on the outer surface of the roller cage. Figure 4.4.
   - There is damage on the rollers and on the surfaces of the cup and cone inner race that touch the rollers. Figure 4.5.
   - There is damage on the cup and cone inner race surfaces that touch the rollers. Figure 4.6.

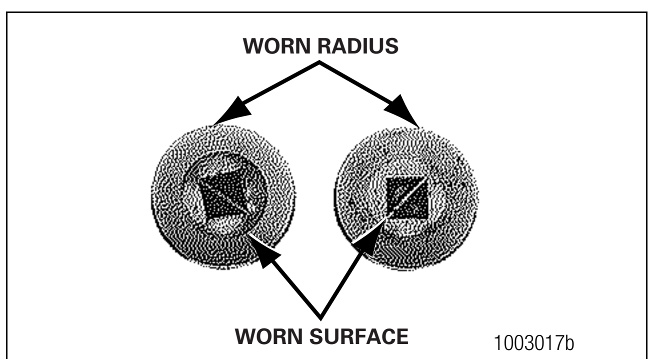


Figure 4.2

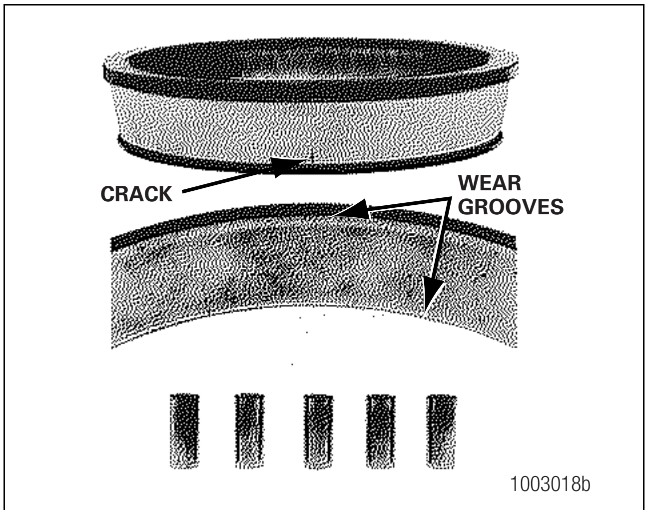


Figure 4.3

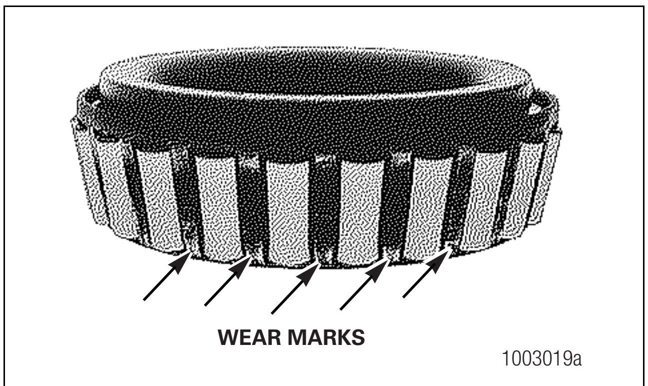


Figure 4.4

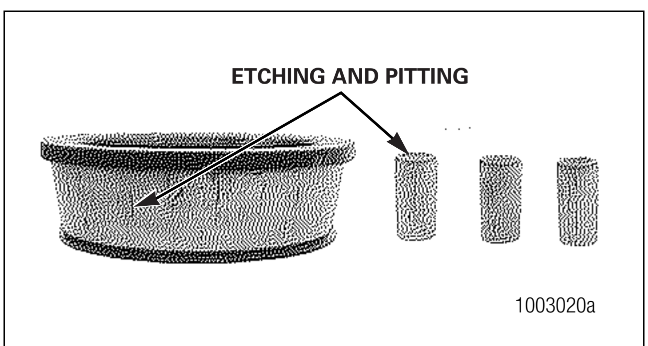


Figure 4.5

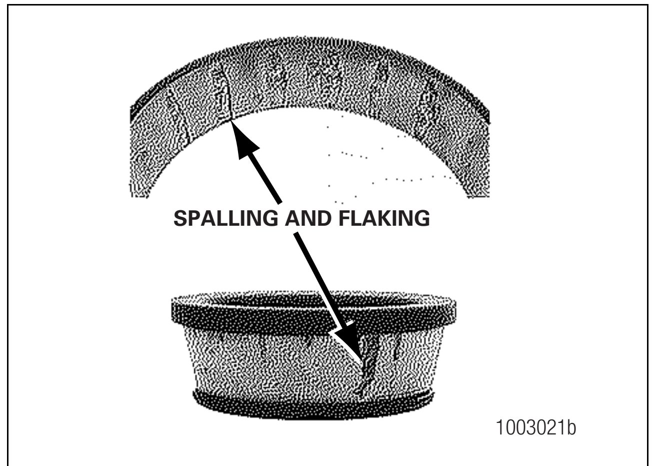


Figure 4.6

⚠ CAUTION

A drive pinion and ring gear are machined as a matched set. When you replace either a drive pinion or a ring gear, you must replace both parts as a matched set. Do not mix old and new parts. Damage to components can result.

2. Inspect hypoid pinions and gears for wear and damage. Replace gears that are worn or damaged.

⚠ CAUTION

A thrust washer, differential side gear and pinion gear are machined as a matched set. When you replace any of these parts, you must install a new matched set. Do not mix old and new parts. Damage to components can result.

3. Inspect the following main differential assembly parts for wear or stress. Replace parts that are damaged. Figure 4.7.
   - Inside surfaces of both case halves
   - Both surfaces of all thrust washers
   - The four trunnion ends of the spider or cross
   - Teeth and splines of both differential side gears
   - Teeth and bore of all differential pinions

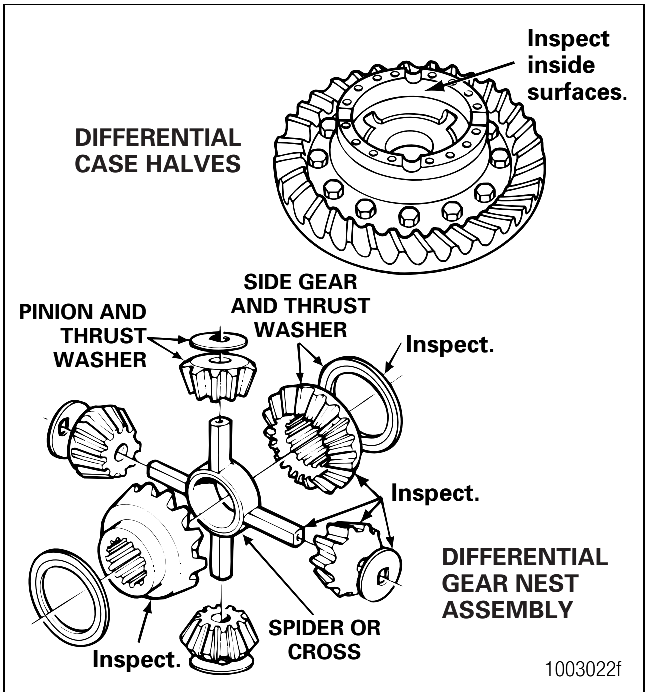


Figure 4.7

4. Inspect the axle shafts for wear and cracks at the flange, shaft and splines. Replace the axle shafts, if required.
5. Inspect the breather.
   A. Remove the breather from the axle housing.
   B. Clean the breather.
      - **If the breather remains dirty after cleaning:** Replace the breather.
   C. Apply compressed air to the breather.
      - **If compressed air does not pass through the breather:** Replace the breather.
   D. Install the breather in the axle housing.

Repair or Replace Parts

Threads must be without damage and clean so that accurate adjustments and correct torque values can be applied to fasteners and parts.

1. Replace any fastener if the corners of the head are worn.
2. Replace the washers if damaged.
3. Replace the gaskets, oil seals or grease seals at the time of axle or carrier repair.
4. Clean the parts and apply new silicone gasket material where required when the axle or carrier is assembled. Figure 4.8.

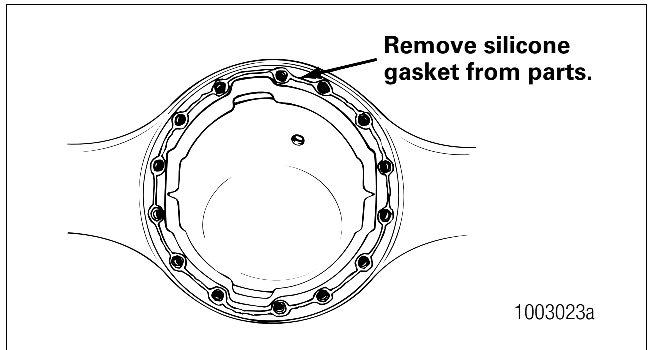


Figure 4.8

5. Remove nicks, mars and burrs from parts with machined or ground surfaces. Use a fine file, india stone, emery cloth or crocus cloth.
6. Clean and repair the threads of fasteners and holes. Use a die or tap of the correct size or a fine file.

Welding on Axle Housings

WARNING

Wear safe clothing and eye protection when you use welding equipment. Welding equipment can burn you and cause serious personal injury. Follow the operating instructions and safety procedures recommended by the welding equipment manufacturer.

Axle weld locations and welding procedures must adhere to Meritor standards. Welding at locations other than those authorized by Meritor will void the warranty and can reduce axle beam fatigue life. Serious personal injury and damage to components can result.

Refer to Maintenance Manual 8, Drive Axle Housings. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Meritor permits drive axle housing assembly repair welding in the following locations only.

- Housing-to-cover weld joints
- Snorkel welds
- Housing seam welds between the suspension attaching brackets
- Bracket welding to the drive axle housing

Prepare the Axle

⚠ WARNING

The high temperature caused by the open flame from the cutting torch can ignite the oil in the axle housing and can cause serious personal injury.

1. Remove the oil drain plug from the bottom of the axle housing and drain the lubricant from the assembly.

⚠ CAUTION

Remove the differential carrier from the axle housing before you weld onto an axle. Do not weld onto an axle with the differential carrier installed. Electrical arcing and damage to components can result.

2. Remove the differential carrier from the axle housing. Refer to the correct Meritor carrier maintenance manual or the vehicle manufacturer's instructions.

⚠ CAUTION

Remove the brake air chambers before you weld onto an axle. Do not expose a brake air chamber to more than 250° F (121° C). Damage to the air chamber can result.

3. Remove the wheel-end components and brake air chambers from the axle. Refer to the correct Meritor brake maintenance manual or the vehicle manufacturer's instructions.
4. For housing-to-cover welds, clean the outside housing-to-cover weld area two-three-inches (50.8-76.2 mm) past each end or side of the crack. Clean the inside area where the cover mates with the housing. Clean the area completely around the cover. Use a wire brush and a cleaning solvent that will remove dirt and grease from these areas. Figure 4.9.

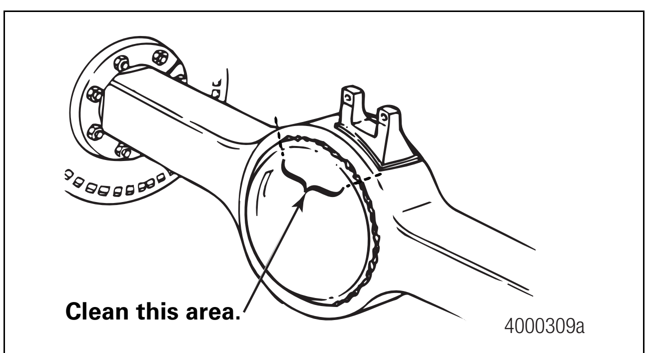


Figure 4.9

5. For suspension bracket welds, clean both lower and upper suspension brackets and the areas of the axle housing around each bracket. Use a wire brush and a cleaning solvent that will remove dirt and grease from these areas. Figure 4.10 and Figure 4.11.

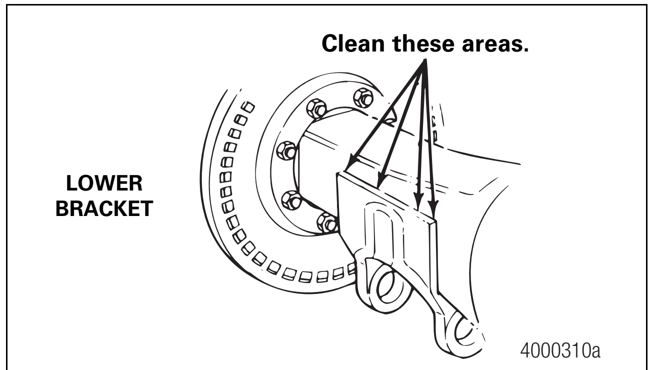


Figure 4.10

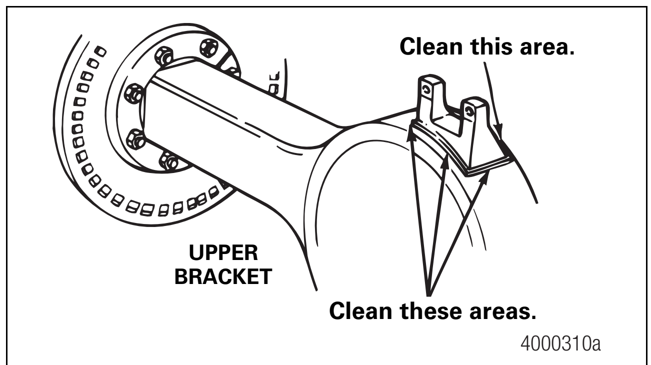


Figure 4.11

⚠ WARNING

The axle housing must be 70° F (21° C) or warmer before you weld onto the axle. Do not weld onto a cold axle or weld cold parts onto an axle. Cracks in the weld area, damage to components and serious personal injury can result.

6. Ensure that the axle housing temperature measures 70° F (21° C) or warmer.
   - **If the axle housing temperature measures less than 70° F (21° C):** Store the axle in a heated room until the housing reaches the correct temperature.

7. Heat the damaged area to approximately 300° F (149° C) before you begin welding.
8. Use suitable weld wire electrodes when you weld. Suitable weld wire electrodes include either BS EN 499 – E 42 2 B 32 H5 or BS EN 440 – G 42 2 M GSi (American Welding Society equivalents E7018 and ER70S3, respectively).
9. For complete welding instructions, refer to Maintenance Manual 8, Drive Axle Housings. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Do Not Bend or Straighten a Damaged Drive Axle Housing

WARNING

Replace damaged or out-of-specification axle components. Do not bend, repair or recondition axle components by welding or heat-treating. A bent axle beam reduces axle strength, affects vehicle operation and voids Meritor's warranty. Serious personal injury and damage to components can result.

Always replace a damaged drive axle housing. Do not bend or straighten a damaged housing, which can misalign or weaken it, and void Meritor's warranty.

Removing Fasteners Secured with Adhesive

If it is difficult to remove fasteners secured with Dri-Loc®, Meritor adhesive or Loctite® 277 adhesive, use the following procedure.

When you remove fasteners secured with adhesive, slowly heat the fastener to 350° F (177° C). Do not exceed this temperature, or heat fasteners quickly. Damage to components can result.

1. Heat the fastener for three to five seconds. Try to loosen the fastener with a wrench. Do not use an impact wrench or hit the fastener with a hammer.
2. Repeat Step 1 until you can remove the fastener.

New Fasteners with Pre-Applied Adhesive

1. Use a wire brush to clean the oil and dirt from threaded holes.
2. Install new fasteners with pre-applied adhesive to assemble parts. Do not apply adhesives or sealants to fasteners with pre-applied adhesive, or to fastener holes.
3. Tighten the fasteners to the required torque value for that size fastener. No drying time is required for fasteners with pre-applied adhesive.

Original or Used Fasteners

1. Use a wire brush to clean the oil, dirt and old adhesive from all threads and threaded holes.
2. Apply four or five drops of Meritor liquid adhesive 2297-C-7049, Loctite® 638 or 680 liquid adhesive or equivalent inside each threaded hole or bore. Do not apply adhesive directly to the fastener threads. Figure 4.12.

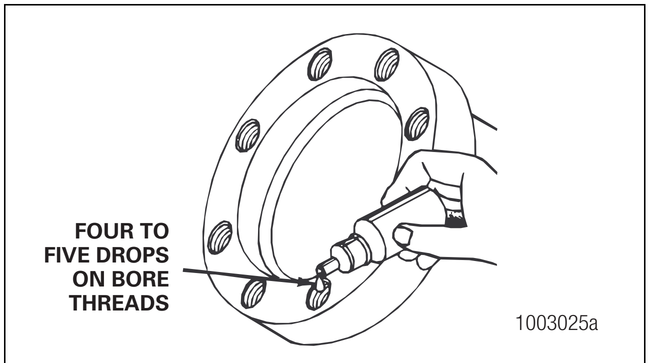


Figure 4.12

3. Tighten the fasteners to the required torque value for that size fastener. There is no drying time required for Meritor liquid adhesive 2297-C-7049, Loctite® 638 or 680 liquid adhesive or equivalent.

Meritor Specification 2297-T-4180 Adhesive in the Differential Bearing Bores

NOTE: Use Meritor specification 2297-T-4180 adhesive for all axles.

1. Clean the oil and dirt from the outer diameters of the bearing cups and bearing bores in the carrier and bearing caps. There is no special cleaning required.
2. Apply axle lubricant to the bearing cones and the inner diameters of the bearing cups of the main differential. Do not get oil on the outer diameter of the bearing cup and do not permit oil to drip onto the bearing bores.

NOTE: Meritor specification 2297-T-4180 adhesive will dry in approximately two hours. You must complete the procedure within two hours from the time you apply the adhesive. If two hours have passed since application, clean the adhesive from the parts and apply new adhesive.

3. Apply a single continuous bead of the adhesive to the bearing bores in the carrier and bearing caps. Apply the adhesive around the circumference of the smooth, ground surfaces only. Do not place the adhesive on the threaded areas. Figure 4.13.

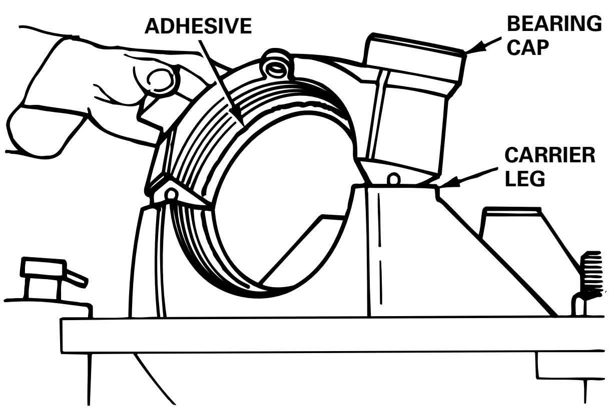


Figure 4.13

4. Install the main differential assembly, bearing cups and bearing caps into the carrier. Refer to Section 5.
5. Adjust the preload of the differential bearings, backlash and tooth contact patterns of the gear set as required. Refer to Section 5.

Carrier-to-Housing Joint Sealing Procedure

1. Remove the carrier from the housing. Refer to Section 3.
2. Remove all debris from inside the housing.
3. Use a rotary tool with a scour pad to clean all silicone residue from the housing and carrier faces. Figure 4.14. Surfaces must be clean, dry and free of foreign matter. The surfaces must not be oily to the touch.

Cleaning the housing face with a rotary tool and a scour pad.

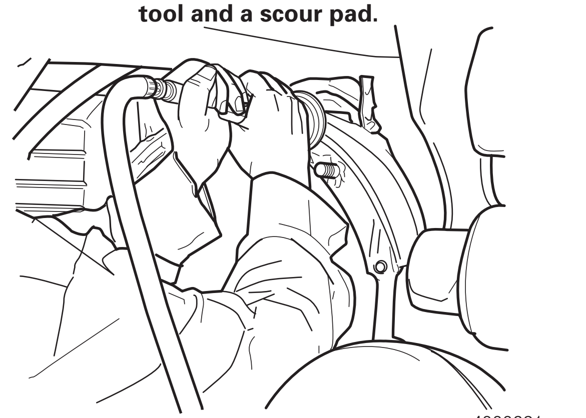


Figure 4.14

4. Remove metal filings from the magnets inside the housing.
5. Use solvent to clean the inside of the housing.
6. Use Loctite® ODC Free cleaner or brake cleaner to clean the housing and carrier faces.
7. Dry the housing and carrier faces.

⚠ CAUTION

New capscrew kits have blue Dri-Loc® STS threadlocker, an equivalent to Loctite® 242 threadlocker, applied to the capscrews. Do not remove the blue Dri-Loc® STS threadlocker from the capscrews. Damage to components can result.

8. If you reuse the carrier-to-housing capscrews, use a rotary wire brush to remove any threadlocker material and clean the capscrew threads. Use a clean cloth to wipe the threads.
9. Use a tap to clean the internal threads in the housing.

⚠ CAUTION
Apply silicone gasket material in a continuous 0.25-inch (6 mm) bead. If you use more than this amount, gasket material can break off and plug lubrication passages. Damage to components can result.

10. Apply a 0.25-inch (6 mm) bead of Loctite® 5699 silicone gasket material to the housing face. Do not use ThreeBond 1216E silicone products. Figure 4.15.

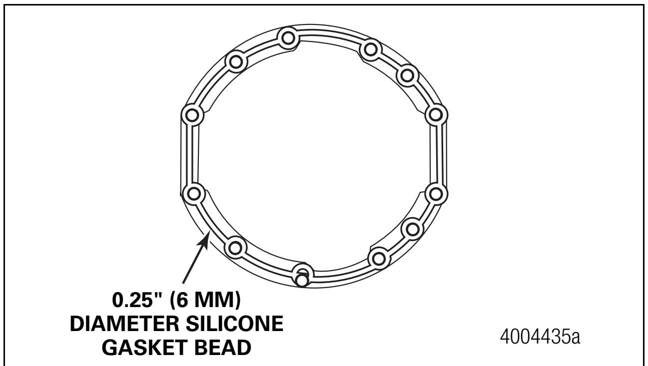


Figure 4.15

11. Install two long studs in the carrier to guide the carrier into the housing.
12. Immediately install the carrier into the housing to permit the silicone gasket material to compress evenly between the faces. If using a new capscrew kit with blue Dri-Loc® STS pre-applied threadlocker, skip the next step.
13. Apply a 0.125-inch (3 mm) bead of Loctite® 242 threadlocker around the capscrew threads approximately 0.25-inch (6 mm) from the end. Apply a 0.125-inch (3 mm) bead of Loctite® 242 threadlocker across the length of the threads. Figure 4.16.

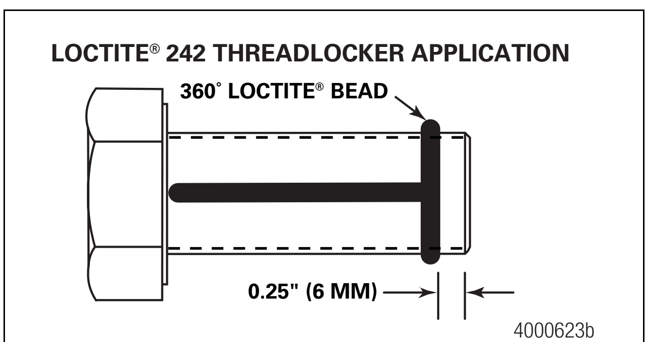


Figure 4.16

14. Install the capscrews. Use a crossing pattern to tighten the capscrews evenly. The capscrews must be tightened within 10 minutes of initial application of Loctite® 242 threadlocker.
    - Tighten the 1/2-inch capscrews to 140 lb-ft (190 N•m). ⓣ
    - Tighten the 5/8-inch capscrews to 225 lb-ft (306 N•m). ⓣ
15. Wait a minimum of 60 minutes before filling the assembly with lubricant. Refer to Section 7.

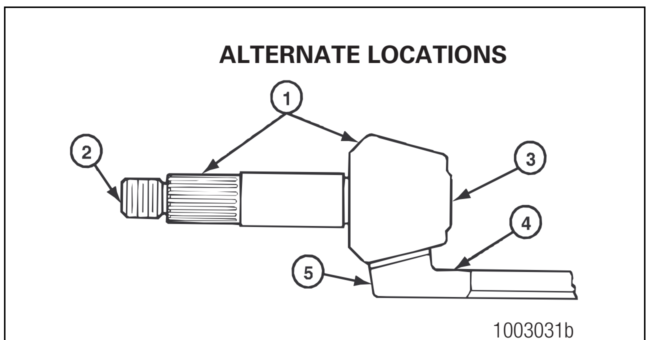
General Yoke and U-Joint Reassembly

Install the end yoke hub capscrews by hand after seating the U-joint. Tighten the capscrews according to the manufacturer's torque specifications.

Identification

Gear Sets

Refer to Table E, Table F, Table G and Table H for information on identifying gear sets with matched parts. Always check match numbers to verify that the gear set you will install has matched parts. Figure 4.17.



1. PART NUMBER, TOOTH COMBINATION NUMBER, GEAR SET MATCH NUMBER, PINION CONE VARIATION NUMBER
2. PART NUMBER, TOOTH COMBINATION NUMBER
3. GEAR SET MATCH NUMBER, PINION CONE VARIATION NUMBER
4. PART NUMBER, TOOTH COMBINATION NUMBER, GEAR SET MATCH NUMBER
5. PART NUMBER, TOOTH COMBINATION NUMBER, GEAR SET MATCH NUMBER

Figure 4.17

Examples

Table E: Gear Set Part Numbers

Part	Number	Location
Conventional ring gear	36786	On the front face or outer diameter
Conventional drive pinion	36787	At the end at threads
Generoid ring gear	36786 K or 36786 K2	On the front face or outer diameter
Generoid drive pinion	36787 K or 36787 K2	At the end at threads

Table F: Gear Set Tooth Combination Number

Gear Set Teeth	Drive Pinion Location	Ring Gear Location
5-37 = gear set has a five-tooth drive pinion and a 37-tooth ring gear	At the end at threads	On the front face or outer diameter

NOTE: Meritor drive pinions and ring gears are only available as matched sets. Each gear in a set has an alphanumeric match number.

Table G: Gear Set Match Number

Match Number	Drive Pinion Location	Ring Gear Location
M29	At the end of the gear head	On the front face or outer diameter

NOTE: Don't use the pinion cone variation number when you check for a matched gear set. Use this number when you adjust the pinion depth of the carrier. Refer to Section 5.

Table H: Pinion Cone Variation Number

Pinion Cone (PC) Variation Number	Drive Pinion Location	Ring Gear Location
PC+3 +2 +0.01 mm PC–5 –1 –0.02 mm	At the end of the pinion gear head	On the outer diameter

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin. If Loctite® adhesive material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Use a brass or synthetic mallet for assembly and disassembly procedures. Do not hit steel parts with a steel hammer. Pieces of a part can break off. Serious personal injury and damage to components can result.

Observe all warnings and cautions provided by the press manufacturer to avoid damage to components and serious personal injury.

Assembly

Drive Pinion, Bearings and Bearing Cage

1. Place the bearing cage in a press. Figure 5.1.
2. Support the bearing cage with metal or wood blocks.
3. Press the bearing cup into the bore of the bearing cage until the cup is flat against the bottom of the bore. Use a sleeve of the correct size to install the bearing cup. Use the same procedure for both bearing cups. Figure 5.1.

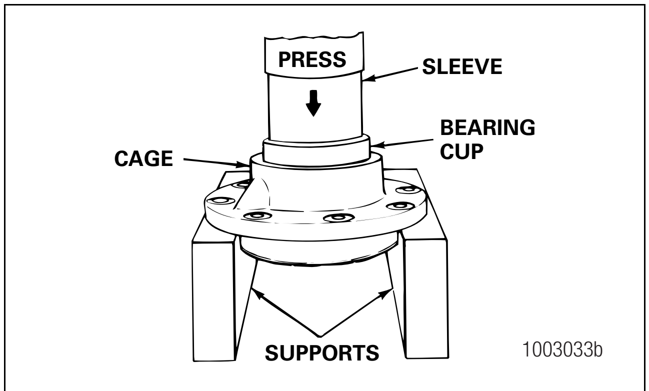


Figure 5.1

4. Place the drive pinion in a press with the gear head or teeth toward the bottom. Figure 5.2.

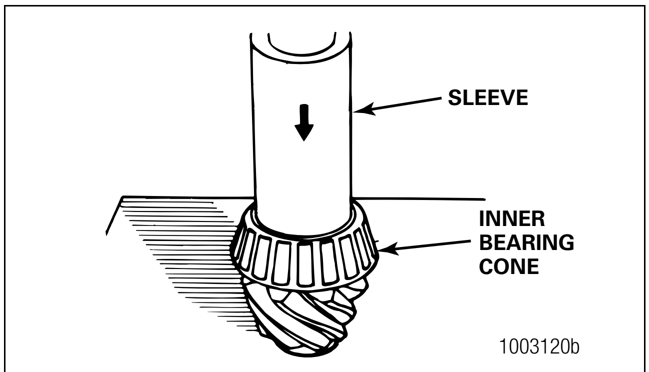


Figure 5.2

5. Press the inner bearing cone on the shaft of the drive pinion until the cone is flat against the gear head. Use a sleeve of the correct size against the bearing inner race.

NOTE: Spigot bearings are usually fastened to the drive pinion with a snap ring. Some are fastened with a peening tool, and some are a two-piece bearing assembly with the inner race pressed on the nose of the pinion and the outer race pressed into its bore in the carrier.

6. Install the spigot bearing using one of the following three procedures.

Installation

One-Piece Spigot Bearing on the Drive Pinion with a Snap Ring

NOTE: The following procedure applies to all axles except:

- Some 160 Series single axles may use snap rings.
- Some 160 and 180 Series rear-rear tandem axles may use snap rings.

1. Place the drive pinion in a press with the gear head or the teeth toward the top. Figure 5.3.

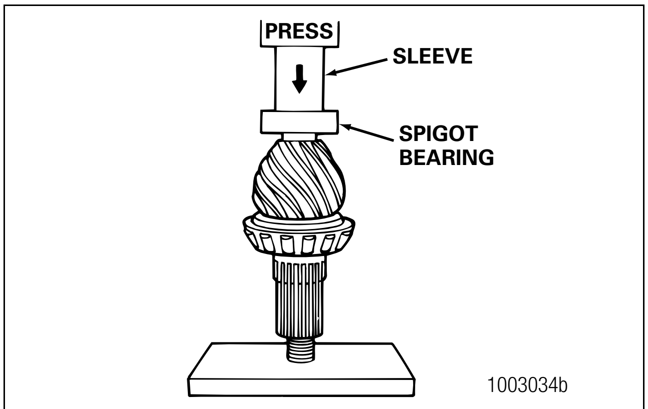


Figure 5.3

2. Press the spigot bearing on the end of the drive pinion. The bearing must be flat against the gear head. Use a sleeve of the correct size against the bearing inner race. Figure 5.3.
3. Use snap ring pliers to install the snap ring, if equipped, into the groove in the end of the drive pinion. Figure 5.4.

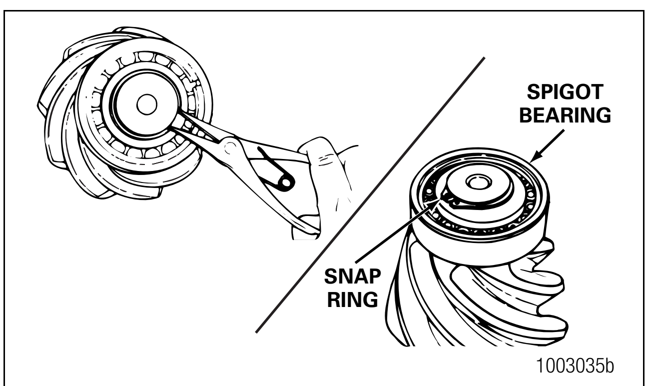


Figure 5.4

One-Piece Spigot Bearing on the Drive Pinion Without a Snap Ring

NOTE: The following procedure applies to some 180 Series rear-rear tandem axles with existing snap ring components.

To obtain the staking tool, refer to the Service Notes page on the front inside cover of this manual. Figure 5.5.

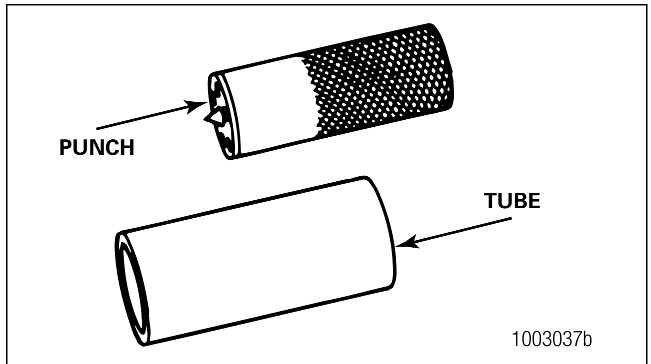


Figure 5.5

1. Place the drive pinion and the tube of the staking tool into a press with the spigot bearing toward the top. Figure 5.6.

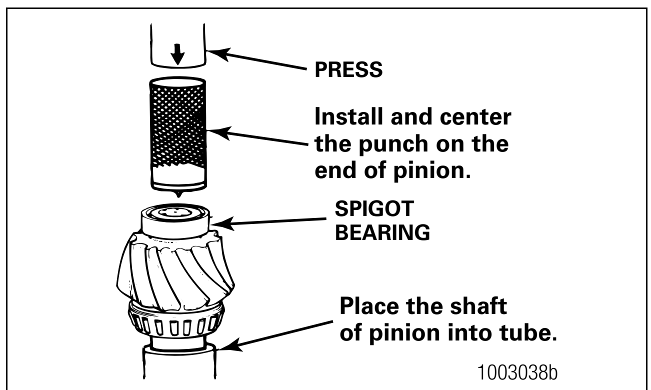


Figure 5.6

2. When you use a staking tool and press, apply 6,614 lb (3 000 kg) force on a 0.375-inch (10 mm) ball. Calculate the force required on the tool as follows.
   - 6,614 lb (3000 kg) x amount of balls in tool = pounds or kilograms
   - **Example:** 6,614 lb (3000 kg) x three balls = 19,842 pounds (9000 kg)

3. Place the punch of the staking tool over the end of the pinion and spigot bearing. Apply the required amount of force on the punch. Figure 5.6.

⚠ CAUTION

Do not align new points with the grooves in the end of the drive pinion or in old points. If the new staked points are placed in the wrong areas, the spigot bearing will not be held correctly on the pinion shaft.

NOTE: If a three-ball stake tool is used, rotate the tool 180 degrees.

4. Stake the end of the drive pinion at a minimum of five points. Figure 5.7. Rotate the punch as many times as required for a minimum of five points. Repeat Step 3 for each point.

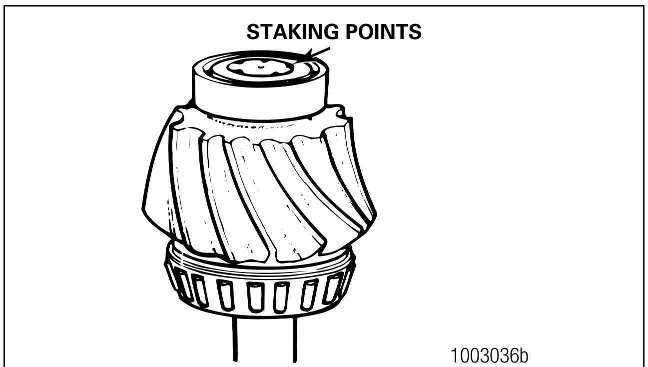


Figure 5.7

Two-Piece Spigot Bearing on the Drive Pinion

NOTE: This procedure applies to some 160 Series single rear axles and rear-rear tandem axles. These axles may also use a one-piece spigot bearing with a snap ring retainer.

NOTE: The inner race of the two-piece spigot bearings must be staked in place on RS and RR-160 Series rear axles. Before you stake the pinion, you must heat the pinion stem to soften it.

NOTE: SPX Kent-Moore kit number J-39039 includes the staking tool, temperature indicating liquid, heat shield and plastigage needed for this procedure. To obtain this kit, refer to the Service Notes page on the front inside cover of this manual.

1. Apply two stripes of temperature indicating liquid on the pinion stem from the top to the bottom. Figure 5.8. Apply a green stripe to indicate 400° F (205° C) and a blue stripe to indicate 500° F (260° C).

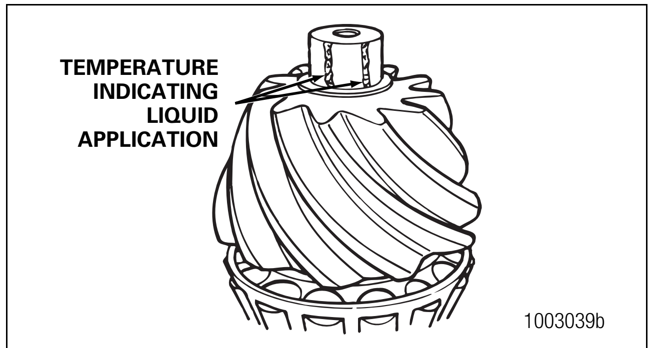


Figure 5.8

⚠ CAUTION

You must use the heat shield when you heat the pinion stem. Do not heat the pinion stem without the heat shield in place. Damage to components can result.

2. Place the heat shield over the pinion stem so that you can see the temperature indicating liquid through the hole in the shield. Figure 5.9.

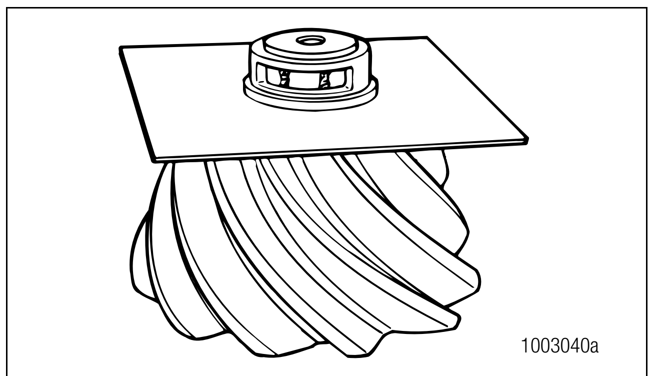


Figure 5.9

⚠ WARNING

Read the manufacturer's instructions before using a torch. Always wear safe clothing, gloves and eye protection when working with a torch for heating parts to prevent serious personal injury during assembly.

3. Put on safe clothing, gloves and eye protection.

⚠ CAUTION

Do not overheat the pinion stem or you will weaken the metal. Damage to components can result.

NOTE: Correct heating will take approximately 25-35 seconds, depending on how hot the torch is.

4. Light and adjust the torch until the white part of the flame is approximately 0.25-inch (6 mm) long. Keep the white part of the flame approximately 0.125-inch (3 mm) from the top of the stem. Figure 5.10. Move the flame around the outer diameter of the top of the pinion stem. The green temperature indicating liquid will turn black before the blue liquid does. Heat the stem until the blue liquid turns black at a point in the middle of the window.

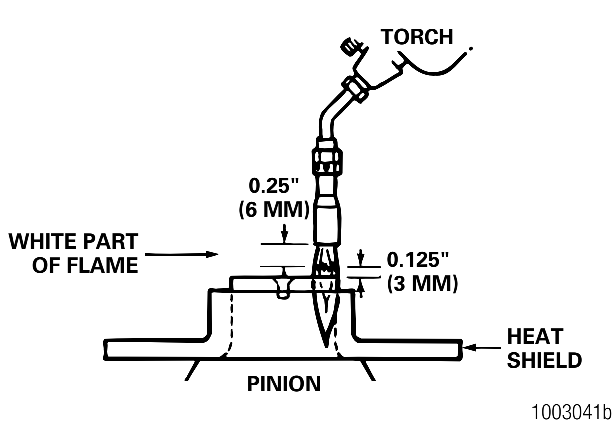


Figure 5.10

5. Remove the flame and the heat shield from the pinion. Let the pinion air cool for 10 minutes. Use a razor blade to remove the temperature indicating liquid.

⚠ CAUTION

Do not press or directly strike the new inner race. Damage to the bearing will result.

6. Use a press, if available, or a brass hammer to install the new inner race. Use the old inner race as a sleeve. The face is completely seated when you cannot fit a 0.002-inch (0.0508 mm) feeler gauge between the race and the pinion shoulder.

NOTE: To hold the races in place, use a staking tool, not the old race, to start the new race on the stem. The old race can be used to completely seat the new race.

7. Place the staking tool over the bearing race. Cut a one-inch (25 mm) piece from the green plastigage strip and place in between the punch and the staking tool. You do not need to use the plastigage for every stake. Use the plastigage until you are sure that you are hitting the punch with the correct amount of force. Figure 5.11.

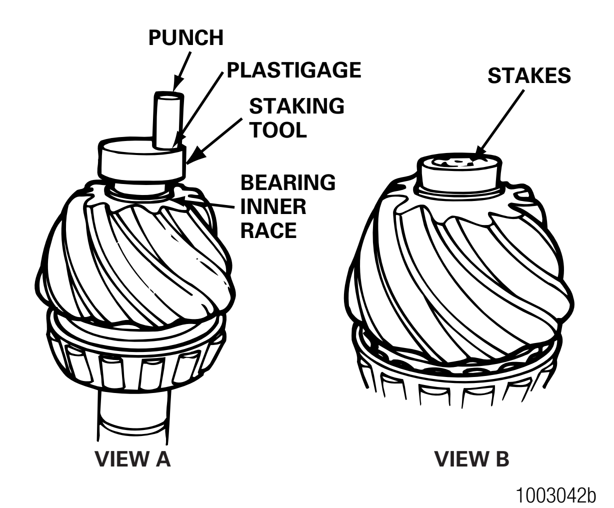


Figure 5.11

8. Strike the punch with a two-three pound (0.9-1.4 kg) brass hammer to upset the end of the pinion stem. Remove the strip and measure its thickness against the gauge on the strip's wrapper. The strip must not be less than 0.003-inch (0.0762 mm) thick. This thickness indicates that you are using enough force when you hit the punch. If the strip is too thin, then you must hit the punch harder so the stake will hold the race in place. Rotate the tool and repeat this procedure until there are six evenly spaced stake marks around the stem. Figure 5.11.

9. With a press or a soft mallet and sleeve, install the outer race and roller assembly into its bore in the carrier. Use a sleeve that is the same size as the outer race. Press the bearing until it is squarely seated against the shoulder in the bottom of its bore.

Drive Pinion

1. Apply axle lubricant to the bearing cups and to the bearing cones in the cage.
2. Install the drive pinion into the bearing cage.
3. Install the bearing spacer or spacers onto the pinion shaft against the inner bearing cone. Figure 5.12. The spacer or spacers control the preload adjustment of the drive pinion bearings.

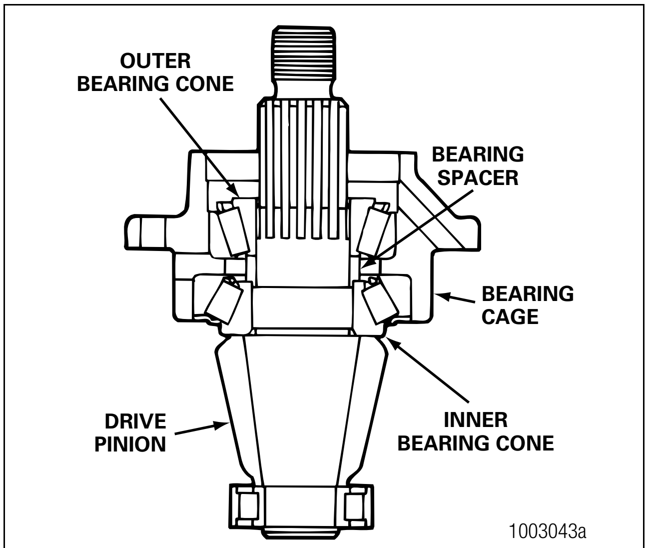


Figure 5.12

4. Install the outer bearing cone onto the pinion shaft against the spacer. Do not install the pinion seal into the bearing cage. Figure 5.12.

Adjustment

Pinion Bearing Preload

Press Method

If a press is not available, or the press does not have a pressure gauge, use the yoke or flange method to adjust the pinion bearing preload.

NOTE: Do not read the starting torque. Read only the torque value after the cage starts to rotate. The starting torque will give an incorrect reading.

1. Place the drive pinion and cage assembly into a press with the gear head or teeth toward the bottom.
2. Install a sleeve of the correct size against the inner race of the outer bearing. Figure 5.13.

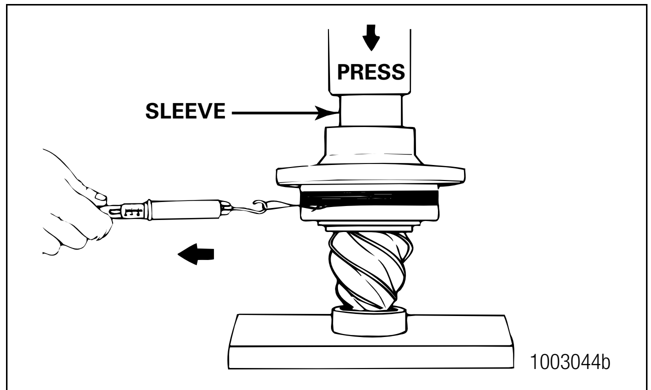


Figure 5.13

3. Apply and hold the correct amount of pressure to the pinion bearings. Refer to Table I. As pressure is applied, rotate the bearing cage several times so that the bearings make normal contact.

Table I

Thread Size of Pinion Shaft	Press Pressure Needed on Bearings for Correct Preload		Torque Value Needed on Pinion Nut for Correct Bearing Preload	
	pounds/ tons	kg/metric tons	lb-ft	N•m
7/8″-20	22,000/1	9979/10	200-275	271-373
1″-20	30,000/15	13 608/13.6	300-400	407-542
1-1/4″-12	54,000/27	24 494/24.5	700-900	949-1220
1-1/4″-18	54,000/27	24 494/24.5	700-900	949-1220
1-1/2″-12	54,000/27	24 494/24.5	800-1100	1085-1491
1-1/2″-18	54,000/27	24 494/24.5	800-1100	1085-1491
1-3/4″-12	50,000/25	22 680/22.7	900-1200	1220-1627
2″-12	50,000/25	22 680/22.7	1200-1500	1627-2034

4. While pressure is held against the assembly, wind a cord around the bearing cage several times.
5. Attach a spring scale to the end of the cord.
6. Pull the cord on a horizontal line. As the bearing cage rotates, read the value indicated on the scale. Record the reading. Figure 5.13.

7. Measure the diameter of the bearing cage where the cord was wound. Measure in inches or centimeters. Figure 5.14.

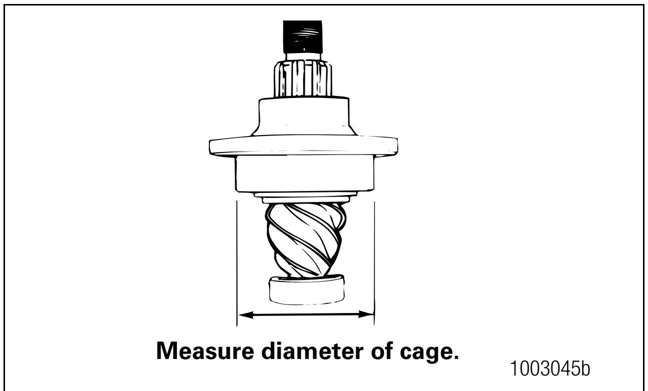


Figure 5.14

8. Divide the dimension in half to get the radius. Record the radius dimension.
9. Use the following procedure to calculate the bearing preload or torque.
   - Pounds Pulled x Radius (inches) = lb-in Preload
     — Preload x 0.113 = N•m Preload
   - Kilograms Pulled x Radius (cm) = kg-cm lb-in Preload
     — Preload x 0.098 = N•m Preload
   - Reading from spring scale = 7.5 pounds (3.4 kg)
   - Diameter of bearing cage = 6.62-inches (16.8 cm)
   - Radius of bearing cage = 3.31-inches (8.4 cm)
     — 7.5 lb x 3.31-inches = 24.8 in-lb Preload
       Preload x 0.113 = 2.8 N•m Preload
     — 3.4 kg x 8.4 cm = 28.6 kg-cm Preload
       Preload x 0.098 = 2.8 N•m Preload
10. If the preload or torque of the pinion bearings is not within 5-45 lb-in (0.56-5.08 N•m) for new pinion bearings or 10-30 lb-in (1.13-3.39 N•m) for used pinion bearings in good condition, adjust the spacer and repeat Step 1 through Step 9.
    - **To increase preload:** Install a thinner bearing spacer.
    - **To decrease preload:** Install a thicker bearing spacer.
11. Check the bearing preload with the drive pinion and cage assembly installed in the carrier. Follow the procedures to adjust the pinion bearing preload using the yoke or flange method.

Yoke or Flange Method

CAUTION

Do not install tight-fitting yokes or flanges onto shafts using a hammer or mallet. A hammer or mallet will damage the yoke or flange.

1. Use a press to install the input yoke or flange, nut and washer, if equipped, onto the drive pinion. The yoke or flange must be seated against the outer bearing. Figure 5.15.

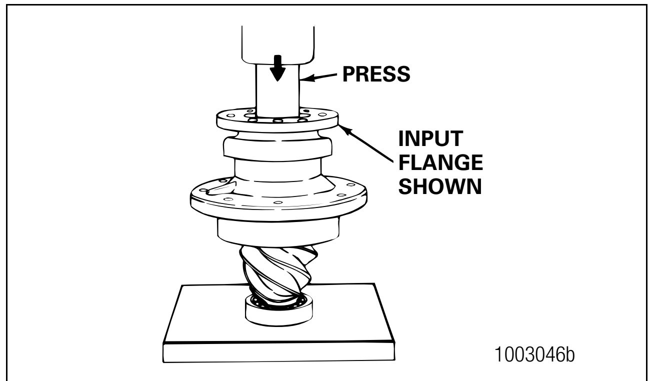


Figure 5.15

2. Install the drive pinion and cage assembly into the carrier. Do not install shims under the bearing cage. Figure 5.16.

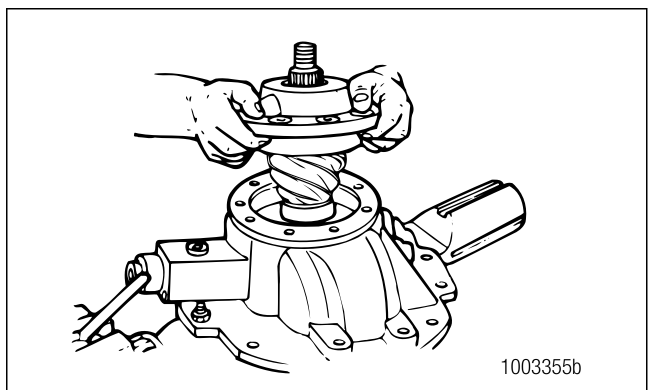


Figure 5.16

3. Install the bearing cage-to-carrier capscrews. Washers are not required at this time. Hand-tighten the capscrews.

4. Fasten a yoke or flange bar to the input yoke or flange. The bar will hold the drive pinion in position when the nut is tightened. Figure 5.17.

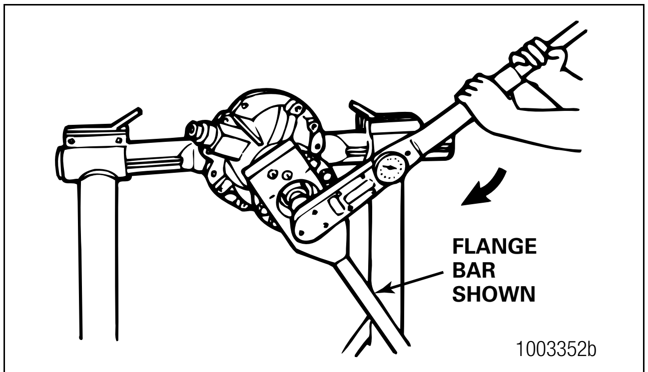


Figure 5.17

5. Tighten the drive pinion nut to the correct torque value. Figure 5.17. Refer to Table I.
6. Remove the yoke or flange bar.
7. Attach a torque wrench onto the drive pinion nut. Rotate the drive pinion and read the value indicated on the torque wrench. Figure 5.18.

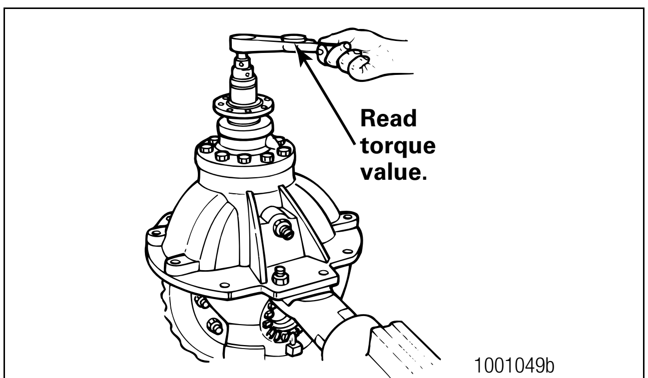


Figure 5.18

8. If the pinion bearing preload or torque is not within 5-45 lb-in (0.56-5.08 N•m) for new pinion bearings or 10-30 lb-in (1.13-3.39 N•m) for used pinion bearings in good condition, remove the pinion and cage assembly from the carrier. Adjust the spacer and repeat Step 1 through Step 7.
   - **To increase preload:** Install a thinner bearing spacer.
   - **To decrease preload:** Install a thicker bearing spacer.
9. After adjusting the pinion bearing preload, remove the drive pinion and bearing cage from the carrier. Refer to Section 3.

Shim Pack Thickness for a New Drive Pinion

Use this procedure if you'll install a new drive pinion and ring gear set, or if you have to adjust the depth of the drive pinion. If the pinion depth shims are misplaced during carrier repair, use 0.045-inch (1.14 mm) for the initial pinion position. Figure 5.19.

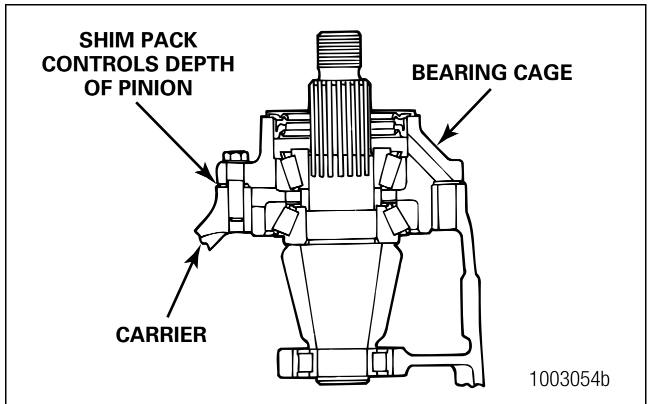


Figure 5.19

1. Use a micrometer to measure the thickness of the shim pack that was removed from under the pinion cage. Record the measurement. Figure 5.20.

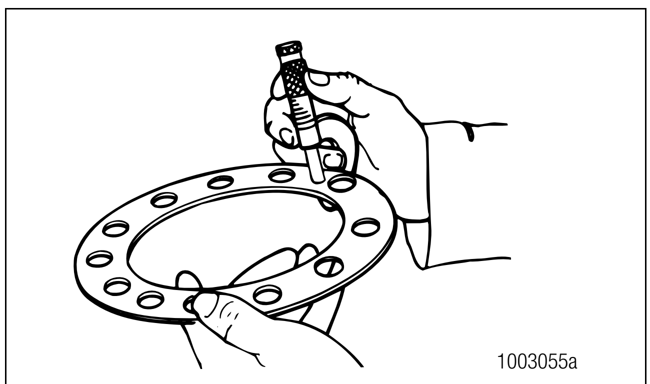


Figure 5.20

2. Find the pinion cone (PC) variation number on the drive pinion you'll replace. Figure 5.21. Record the number. The pinion cone number can be one of the following values.
   - PC +3, PC –3, +3 or –3 = 0.003-inch
   - PC +0.03, PC 0.03 mm, +0.03 mm or –0.03 = 0.03 mm

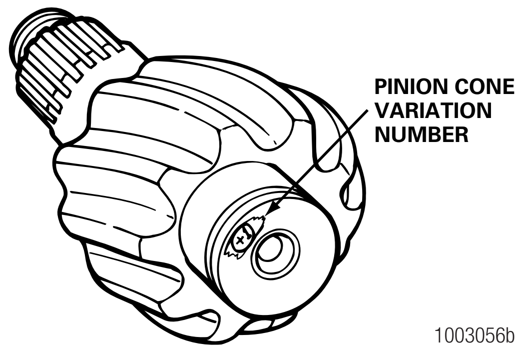


Figure 5.21

3. If you can't find the PC number or it's unreadable, install a new shim pack of the same thickness that you measured in Step 1.
4. If the old pinion cone number is a plus (+) number, subtract the number from the old shim pack thickness that was measured in Step 2.
5. If the old pinion cone number is a minus (–) number, add the number to the old shim pack thickness that was measured in Step 2.
6. Find the pinion cone (PC) variation number on the new drive pinion that will be installed. Record the number.
7. If the new pinion cone number is a plus (+) number, add the number to the standard shim pack thickness that was calculated in Step 4 or Step 5. Use new shims to make a shim pack to the correct thickness. Refer to Table J.

Table J

Examples	Inches	mm
1. Old Shim Pack Thickness.	0.030 – 0.002	0.760 – 0.050
Old PC Number, PC +2-inches (+0.05 mm)	= 0.028	= 0.710
	+ 0.005	+ 0.130
Standard Shim Pack Thickness. New PC Number, PC +5-inches (+0.13 mm)	= 0.033	= 0.840
New Shim Pack Thickness		
2. Old Shim Pack Thickness.	0.030 + 0.002	0.760 + 0.050
Old PC Number, PC –2-inches (–0.05 mm)	= 0.032	= 0.810
	+ 0.005	+ 0.130
Standard Shim Pack Thickness. New PC Number, PC +5-inches (+0.13 mm)	= 0.037	= 0.940
New Shim Pack Thickness		
3. Old Shim Pack Thickness.	0.030 – 0.002	0.760 – 0.050
Old PC Number, PC +2-inches (+0.05 mm)	= 0.028	= 0.710
	– 0.005	– 0.130
Standard Shim Pack Thickness. New PC Number, PC –5-inches (–0.13 mm)	= 0.023	= 0.580
New Shim Pack Thickness		
4. Old Shim Pack Thickness.	0.030 + 0.002	0.760 + 0.050
Old PC Number, PC –2-inches (–0.05 mm)	= 0.032	= 0.810
	– 0.005	– 0.130
Standard Shim Pack Thickness. New PC Number, PC –5-inches (–0.13 mm)	= 0.027	= 0.680
New Shim Pack Thickness		

8. If the new pinion cone number is a minus (–) number, subtract the number from the standard shim pack thickness that was calculated in Step 4 or Step 5. Use new shims to make a shim pack to the correct thickness. Refer to Table J.

Installation

Drive Pinion, Bearing Cage and Shim Pack into the Carrier

NOTE: If a new drive pinion and ring gear set is installed, or if the depth of the drive pinion has to be adjusted, calculate the thickness of the shim pack. Refer to the procedure in this section.

1. Select the correct shim pack and install it between the bearing cage and carrier. Figure 5.22.

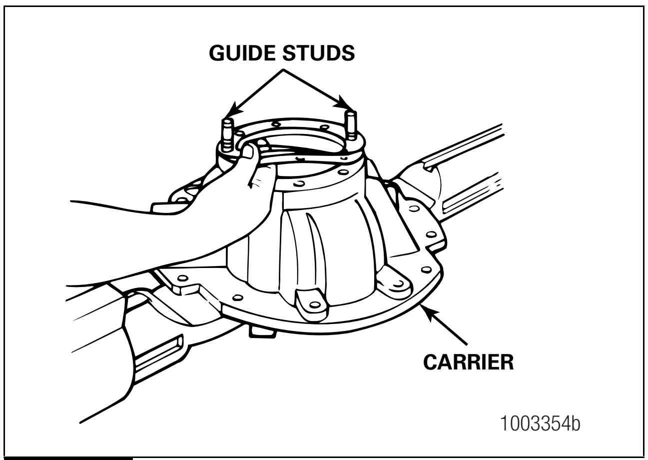


Figure 5.22

2. Apply Loctite® 518 Gasket Eliminator to the carrier face.
3. Align the oil slots in the shims with the oil slots in the bearing cage and carrier. Use guide studs to help align the shims. Figure 5.22.
4. Apply Loctite® 518 Gasket Eliminator to the top of the shim pack.
5. Install the drive pinion and bearing cage into the carrier. If necessary, use a rubber, plastic or leather mallet to hit the assembly into position. Figure 5.23.

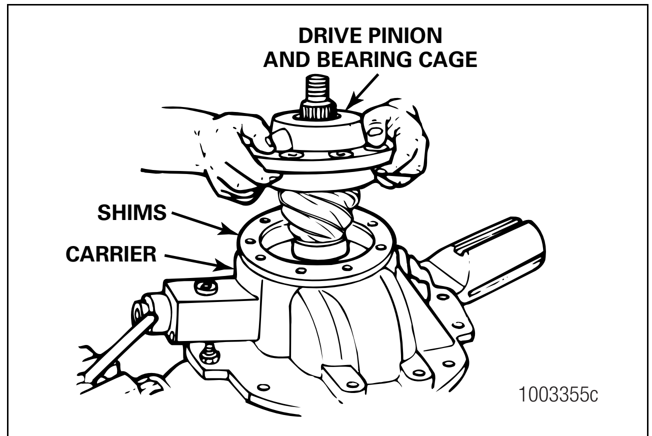


Figure 5.23

6. Install the bearing cage-to-carrier capscrews and washers. Tighten the capscrews to the correct torque value. Figure 5.24. Refer to Section 8.

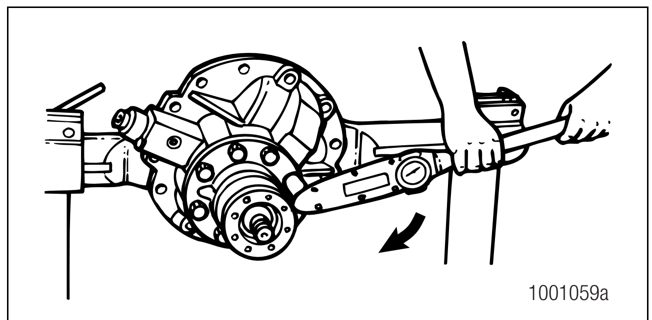


Figure 5.24

Tight Fit Yokes and POSE™ Seal

⚠ CAUTION

Do not use a hammer or mallet to install tight fit yokes onto shafts. A hammer or mallet can damage the yoke.

The seal lips must be clean. Dirt and particles may cause a leak between the yoke and the POSE™ seal.

NOTE: Do not install a POSE™ seal all the way against the yoke shoulder. This seal is designed to position itself as the yoke is installed.

1. Apply axle lubricant on the yoke seal.
2. Inspect all surfaces of the yoke hub for damage.

3. If the carrier uses a POSE™ seal element, install a new POSE™ seal.
   A. Lightly lubricate the yoke journal with the same lubricant used in the axle housing.
   B. Partially install the POSE™ seal onto the yoke 0.25-0.50-inch (6.4-12.7 mm). Figure 5.25.
   C. Before you install the yoke onto the drive pinion, lubricate the yoke with the same lubricant used in the axle housing.

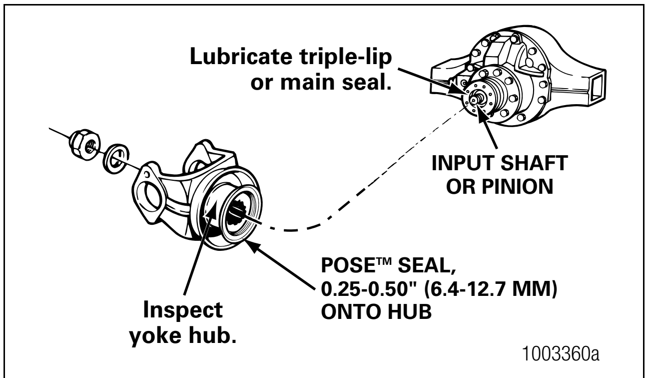


Figure 5.25

4. Slide the yoke over the input shaft pinion. Align the yoke splines with the shaft splines.

⚠ CAUTION
Do not use a hammer or mallet to install the yoke to the input pinion shaft. A hammer or mallet can damage the yoke or flange.

5. Install the input yoke flange onto the drive pinion shaft. The yoke or flange must be fully seated against the outer differential bearing before the nut is tightened to specifications.
6. Install the drive pinion nut and washer onto the input pinion shaft and against the yoke collar. Tighten the nut against yoke collar to torque specifications. Figure 5.26. Refer to Section 8.

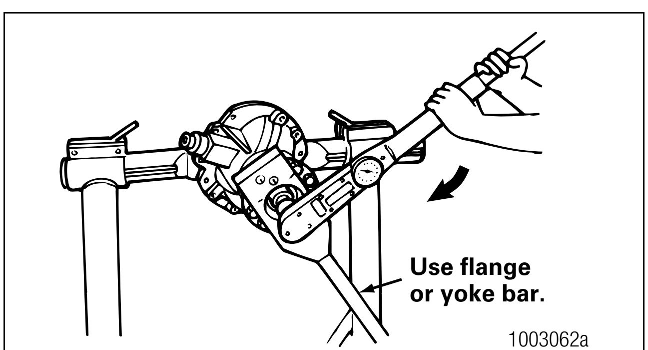


Figure 5.26

⚠ CAUTION
The seal lips must be clean. Dirt and particles may cause a leak between the yoke and the seal.

7. Install a new triple-lip seal.
   A. Apply the same lubricant used in the axle housing to the outer surface of the seal and the seal bore in the bearing cage. Figure 5.27.
   B. Place the drive pinion and cage assembly into a press with the seal bore toward the top.
   C. Press the seal into the bearing cage. The seal flange must be flat against the top of the bearing cage. Use a sleeve or seal driver of the correct size that fits against the metal seal flange. The diameter of the sleeve or driver must be larger than the flange diameter. Figure 5.28.
      - **If a press is not available:** Use a mallet and the sleeve or driver to install the seal. Figure 5.29.
   D. After the triple-lip seal is installed, a gap of approximately 0.015-0.030-inch (0.38-0.76 mm) between the flange and bearing cage is normal. Figure 5.30.
   E. Check the gap with a feeler gauge at several points around the seal. The gap must be within 0.015-0.030-inch (0.38-0.76 mm). The difference between the largest and smallest gap measurement must not exceed 0.010-inch (0.0254 mm).

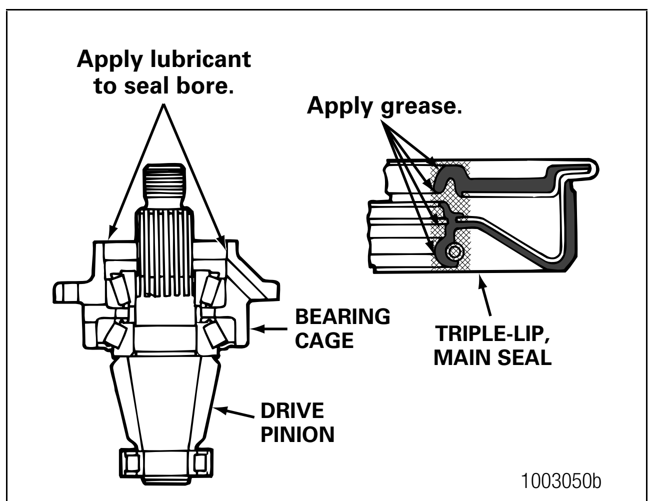


Figure 5.27

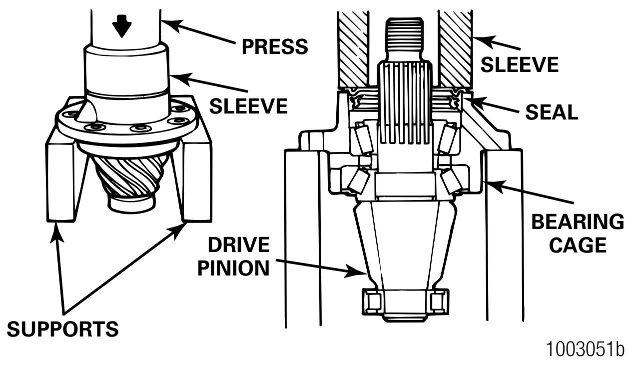


Figure 5.28

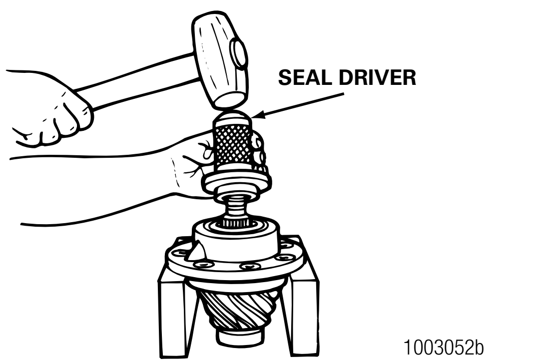


Figure 5.29

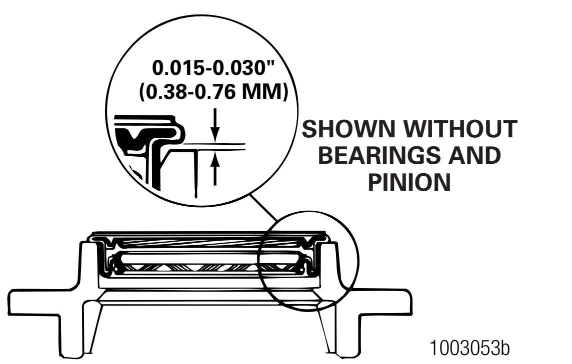


Figure 5.30

Any Type Yoke with a Unitized Pinion Seal (UPS)

1. Remove the replacement unitized seal from the package. Figure 5.31.

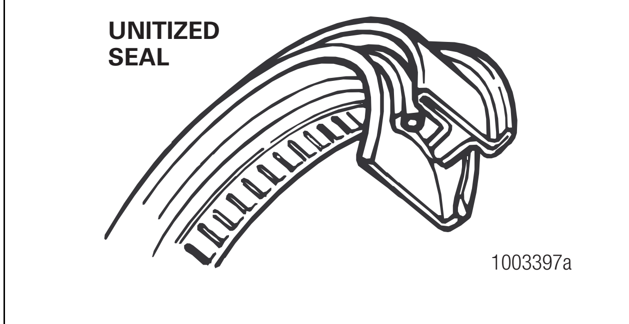


Figure 5.31

⚠ CAUTION

If a yoke is removed after it has been partially or fully installed, the unitized pinion seal will be damaged. Remove and discard the original unitized pinion seal and replace it with a new one.

If a yoke has been installed into the unitized pinion seal and then removed, the inner sleeve of the seal will be damaged. Install a new seal.

2. Select the correct seal driver from Table K. Each seal driver is designed to correctly install a specific diameter seal. To determine the yoke seal diameter, measure the yoke journal. To obtain the Meritor seal driver KIT 4454, refer to the Service Notes page on the front inside cover of this manual.
3. Position the seal on the driver.

⚠ CAUTION

Use a rubber mallet to install the seal. Do not use a steel, brass or plastic hammer. Using a steel, brass or plastic hammer can damage the seal and driver tool.

4. Use a rubber mallet to drive the seal into or against the bearing cage. The seal must fully seat into or against the bearing cage. Figure 5.32.

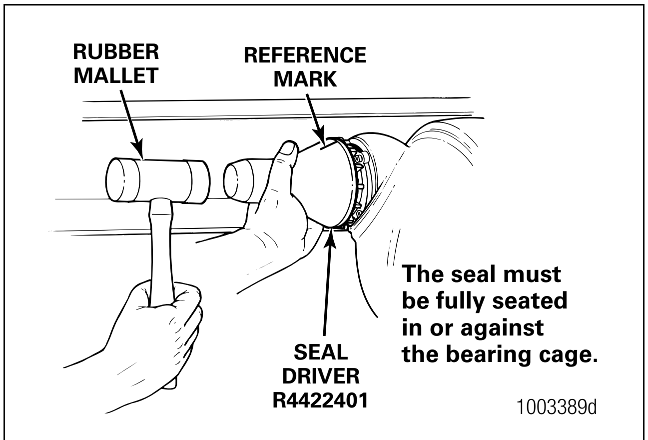


Figure 5.32

5. Visually inspect the seal to verify that it is seated correctly.

Table K: Unitized Pinion Seals and Seal Drivers

Single Models	Tandem Models	Meritor Unitized Pinion Seal	Seal Installation Location	Meritor Seal Driver	Yoke Seal Diameter Inches
RS-17-145	RT-34-144 /P	A-1205-R-2592	Tandem Forward Input — 145 models from November 1993 to present	R4422402	3.250
RS-19-145	RT-34-145 /P				3.255
RS-21-145	RT-40-145 /A /P				
RS-21-160	RT-40-149 /A /P	A-1205-P-2590	Tandem Forward Output — Tandem Forward Input 145 models before November 1993 with seal A-1205-F-2424	R4422401	3.000
RS-23-160 /A	RT-44-145 /P				3.005
RS-23-161 /A	RT-40-160 /A /P				
RS-25-160 /A	RT-40-169 /A /P	A-1205-N-2588	Tandem and Single Rear Input — 145 models	R4422401	3.000
RS-23-186	RT-46-160 /A /P				3.005
RS-26-185	RT-46-169 /A /P	A-1205-Q-2591	Tandem and Single Rear Input — 160/164/185 models	R4422402	3.250
RS-30-185	RT-46-164EH /P				3.255
	RT-46-16HEH /P				
	RT-50-160 /P				
	RT-52-185*				
	RT-58-185*				

* Forward and rear input only.

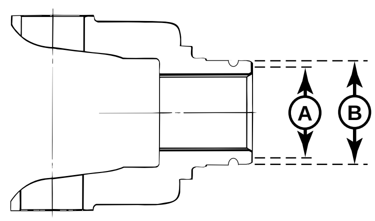
Clean, Inspect and Install the Yoke After Installing a Unitized Pinion Seal

1. Use a clean shop towel and a safe cleaning solvent to clean the ground and polished surface of the yoke journal. Do not use gasoline, abrasive cleaners, towels or scrubbers to clean the yoke. Do not attempt to polish the yoke.

NOTE: The unitized seal features a rubber inner sleeve that is designed to seal and rotate with the yoke. This feature allows you to reuse a yoke with minor grooves.

2. Inspect the yoke seal surface for grooves.
   - **If you find grooves on the yoke:** Use calipers to measure the groove diameters. If any groove diameter measures less than the dimensions shown in Figure 5.33, replace the yoke.

UNITIZED PINION SEAL (UPS)



Yoke Seal Diameter	Minimum Yoke Diameter at Groove (Inches)
3.000/3.005" 3.250/3.255"	2.990" 3.240"

1003390e

A MINIMUM GROOVE DEPTH — DIAMETER
B YOKE SEAL DIAMETER

Figure 5.33

⚠ CAUTION

Do not install a POSE™ seal after you install a unitized pinion seal. The use of a POSE™ seal will prevent correct seating of the unitized pinion seal on the yoke and can result in lubricant leakage at the seal. POSE™ seal installation is recommended only for triple-lip and other previous design seals.

Do not use thin metal wear sleeves to refresh the yoke surface. Wear sleeves pressed onto the yoke can prevent correct seating of the pinion seal, damage the pinion seal assembly and cause the seal to leak.

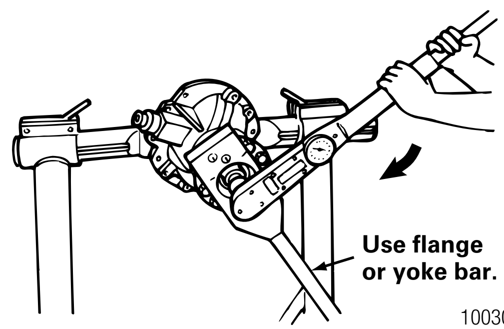
3. Before you install the yoke, lightly lubricate or coat the yoke seal journal with axle oil.

4. Align the yoke splines with the shaft splines. Slide the yoke over the shaft spline.

⚠ CAUTION

Do not use a hammer or mallet to install the yoke to the input pinion shaft. A hammer or mallet can damage the yoke or flange.

5. Install the input yoke flange onto the drive pinion shaft. The yoke or flange must be fully seated against the outer differential bearing before the nut is torqued to specifications.
6. Apply a single bead of Loctite® 277 adhesive (part number 1199Y3795) or Loctite® 270 adhesive (part number 2297M5213) at the top of the input shaft threads from inboard to outboard. The bead should be 0.120-inch wide.
7. Install the drive pinion nut, and washer if required, onto the input pinion shaft and against the yoke collar. Tighten the nut against the yoke collar to torque specifications. Figure 5.34. Refer to Section 8.

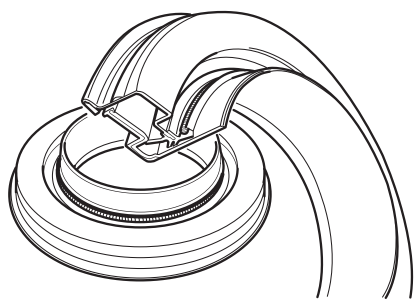


1003062a

Figure 5.34

Any Type Yoke with a Multiple Lip Seal (MLS)

1. Remove the replacement multiple lip seal from the package. Figure 5.35.



4005523a

Figure 5.35

⚠ CAUTION

If a yoke is removed after it has been partially or fully installed, the multiple lip seal will be damaged. Remove and discard the original multiple lip seal and replace it with a new one.

If a yoke has been installed into the multiple lip seal and then removed, the inner sleeve of the seal will be damaged. Install a new seal.

2. Select the correct seal driver from Table L. Each seal driver is designed to correctly install a specific diameter seal. To determine the yoke seal diameter, measure the yoke journal. To obtain the Meritor seal driver KIT 4454, refer to the Service Notes page on the front inside cover of this manual.
3. Position the seal on the driver.
4. Install the rear-rear axle input seal. Hold the seal only on the outer diameter. Position the seal into the seal driver and align it with the rear-rear axle input bearing cage. Use a dead-blow hammer and the appropriate driver to install the seal into the bearing cage. Figure 5.36.

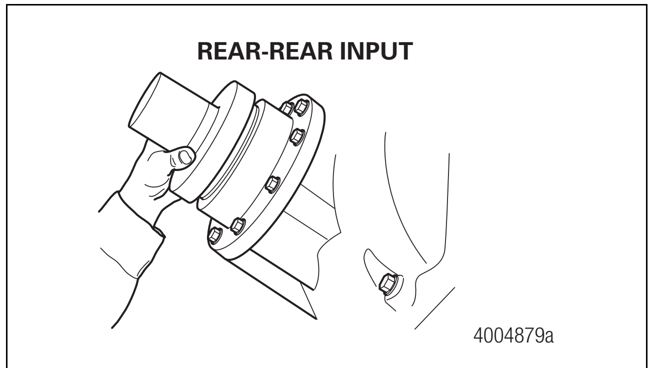


Figure 5.36

5. Use a feeler gauge to check the seal gap at all three axle positions. The seal is correctly installed if the gap is less than 0.005-inch (0.127 mm) around the circumference of the seal flange.
   - **If the gap is more than 0.005-inch (0.127 mm):** Use a dead-blow hammer and the appropriate driver to completely install the seal.

Table L: Multiple Lip Seals and Seal Drivers*

Single Models	Tandem Models
MX-21-160	RT-34-144 /P
MX-23-160R	RT-34-145 /P
RF-16-145	MT-40-143
RF-21-160	RT-40-145 /A /P
RF-22-166	RT-40-149 /A /P
RF-23-185	RT-44-145 /P
RS-17-145	RT-40-160 /A /P
RS-19-145	RT-40-169 /A /P
RS-21-145	RT-46-160 /A /P
RS-21-160	RT-46-169 /A /P
RS-23-160 /A	RT-46-164EH /P
RS-23-161 /A	RT-46-16HEH /P
RS-25-160 /A	RT-50-160 /P
RS-23-186	RT-52-185*
RS-26-185	RT-58-185*
RS-30-185	

Axle Model and Position	Seal Service Part Number	Previous Seal Part Number	Seal Drivers	Sleeve Drivers
14X/16X/18X/38X Forward-Rear Unit Input (FUI)	A1-1205X2728	A-1205R2592	2728T1	2728T2
14X/16X Forward-Rear Unit Output (FUO)	A1-1205Y2729	A-1205P2590	2729T1	2729T2
14X Rear-Rear Unit Input (RUI)	A1-1205Z2730	A-1205N2588	2730T1	Not Required — Sleeve is unitized
16X/18X Rear-Rear Unit Input (RUI)	A1-1205A2731	A-1205Q2591	2731T1	Not Required — Sleeve is unitized

* Forward and rear input only.

Forward input and output seals must be serviced with the seal and sleeve. The service part number provides both when required.

If the Yoke or Inner Sleeve of the Multiple Lip Seal was Removed at Any Time During Installation

1. The original multiple lip seal will be damaged. Remove and discard the seal to prevent damage to components.
2. Install a new multiple lip seal.

Yoke

1. Before you install the yoke, lightly lubricate or coat the yoke seal journal with axle oil.
2. Align the yoke splines with the shaft splines. Slide the yoke over the shaft spline.

CAUTION

Do not use a hammer or mallet to install the yoke onto the input pinion shaft, which can damage the yoke or flange.

3. Install the input yoke flange onto the drive pinion shaft. The yoke or flange must be fully seated against the outer differential bearing before you tighten the nut.
4. Install the drive pinion nut, and washer if required onto the input pinion shaft and against the yoke collar. Use a flange or yoke bar to tighten the nut against the yoke collar to torque specifications. Figure 5.37. Refer to Section 8.

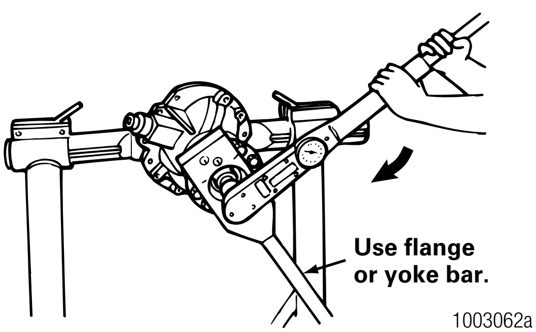


Figure 5.37

Assembly

Main Differential and Ring Gear Assembly

CAUTION

Heat the ring gear before seating it onto the differential case. Do not press a cold ring gear on the flange case half. A cold ring gear will damage the case half because of the tight fit.

1. Heat the ring gear in a tank of water to a temperature of 160-180° F (71-82° C) for 10 to 15 minutes.

WARNING

Wear safe clothing and gloves when working with the hot ring gear to prevent serious personal injury.

2. Use a lifting tool to safely lift the ring gear from the tank of water.
3. Install the ring gear onto the flange case half immediately after the gear is heated.
   - **If the ring gear does not fit easily onto the case half:** Heat the gear again.
4. Align the ring gear and the flange case half fastener holes. Rotate the ring gear as necessary.
5. Install the bolts, nuts and washers that hold the ring gear to the flange case half. Install the bolts from the gear side of the assembly. The bolt heads must be against the ring gear. Figure 5.38.
   - **If rivets were used to hold the ring gear to the flange case half:** Replace them with bolts, nuts and washers.

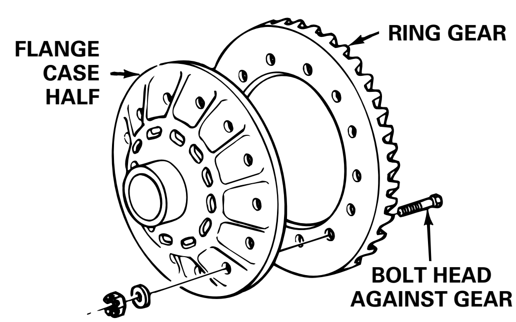


Figure 5.38

6. Tighten the bolts and nuts to the correct torque value. Refer to Section 8.
   - **For 59000 Series carriers:** Apply four to six drops of red Loctite® 277 threadlocker to the threaded holes in the ring gear. Install the capscrews. Tighten the capscrews to 360-470 lb-ft (490-639 N•m).
7. Use a 0.003-inch (0.08 mm) feeler gauge to check for gaps between the back surface of the ring gear and the case flange. Check for gaps at four points around the assembly. Figure 5.39.
   - **If the gaps exceed specifications:** Check the flange case half and ring gear for the problem that causes the gap. Repair or replace parts. Assemble the ring gear onto the flange case half.

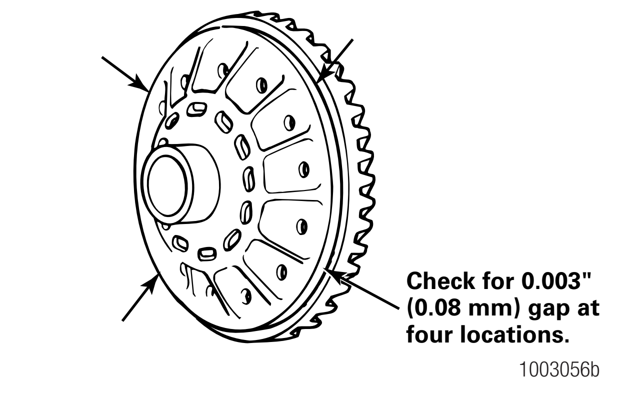


Figure 5.39

8. Use a press and the correct size sleeve to install the bearing cones on both of the case halves. Figure 5.40.

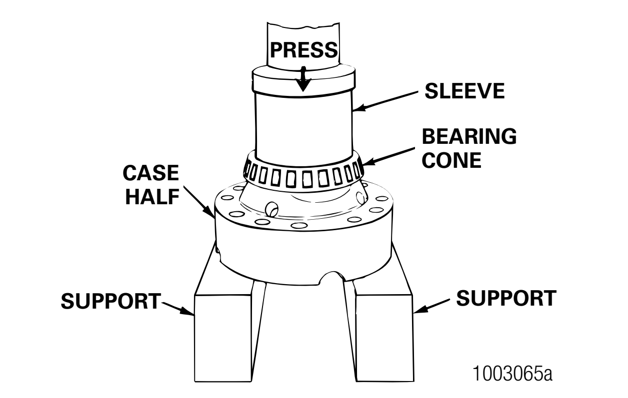


Figure 5.40

9. Apply axle lubricant on the inside surfaces of both case halves, spider or cross, thrust washers, side gears and differential pinions.
10. Place the flange case half on a bench with the ring gear teeth toward the top.
11. Install one thrust washer and side gear into the flange case half. Figure 5.41.

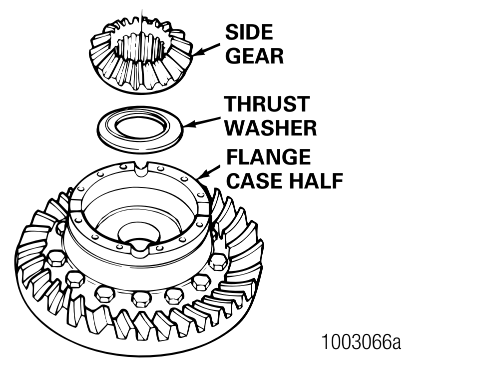


Figure 5.41

⚠ CAUTION

The side gears in some carrier models have hubs of different lengths. Install the correct length side gear into the flange case half. Damage to components can result.

12. Install the spider or cross, differential pinions and thrust washers into the flange case half. Figure 5.42.

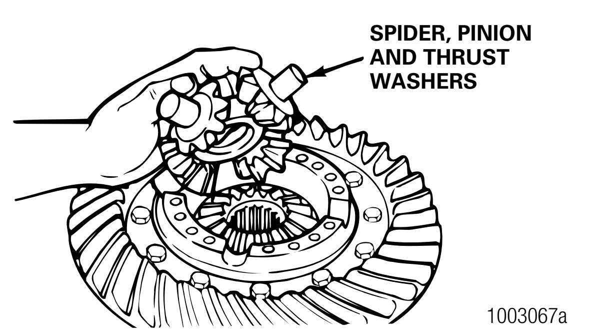


Figure 5.42

13. Install the second side gear and thrust washer over the spider and differential pinions. Figure 5.43.

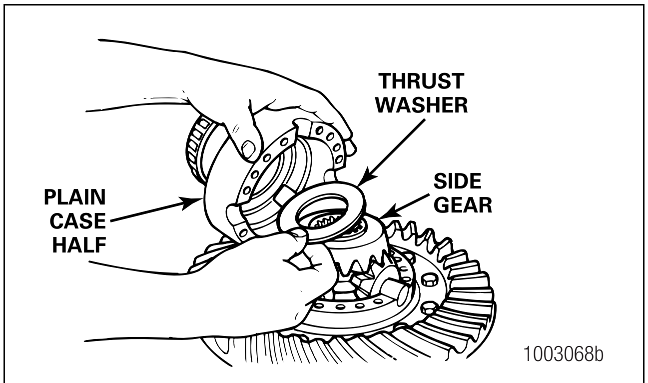


Figure 5.43

14. Place the plain half of the differential case over the flange half and gears. Rotate the plain half to align the match marks. Figure 5.43 and Figure 5.44.

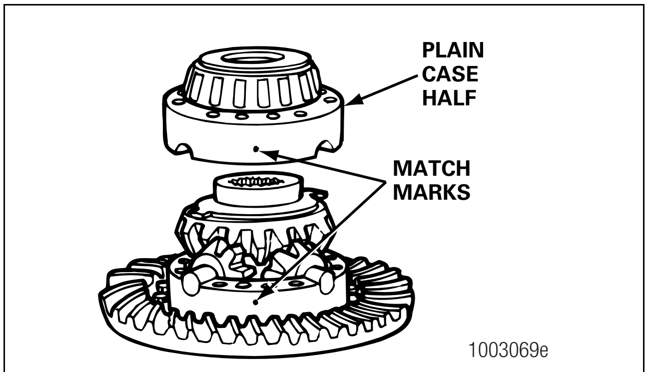


Figure 5.44

15. Install Dri-Loc® fasteners into the case halves. Refer to Section 6.
    A. Install four capscrews and washers or bolts, nuts and washers, if equipped, into the case halves. The distance between the fasteners must be equal. Tighten the fasteners to the correct torque value in a progressive crisscross pattern opposite each other. Refer to Section 8. Figure 5.45.
    B. Install the other fasteners into the case halves. Tighten the fasteners to the correct torque value. Refer to Section 8.
16. Check the differential gears rotating resistance.

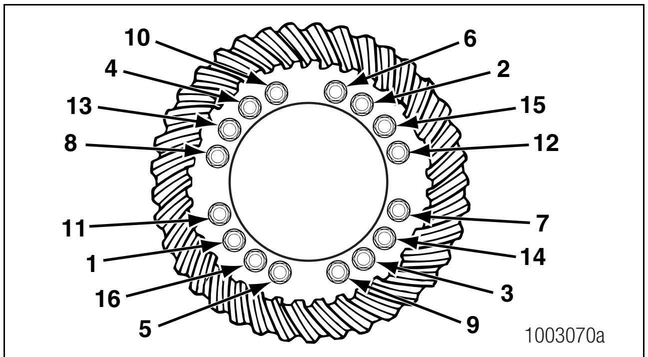


Figure 5.45

Inspection

Differential Gears Rotating Resistance

1. Make an inspection tool using an axle shaft that matches the spline size of the differential side gear. Cut the shaft to approximately 12-inches (304.8 mm). Weld a nut onto the end of the shaft. Figure 5.46.

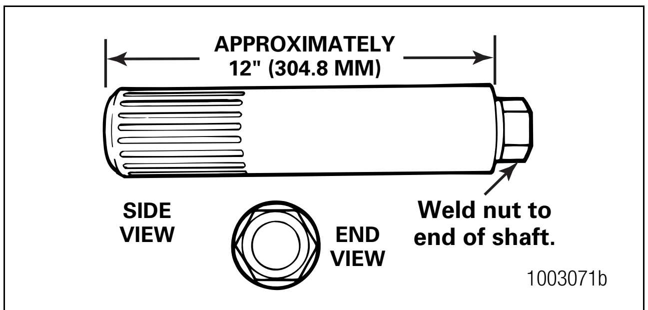


Figure 5.46

2. Place the differential and ring gear assembly in a vise. Install soft metal covers over the vise jaws to protect the ring gear. Figure 5.47.

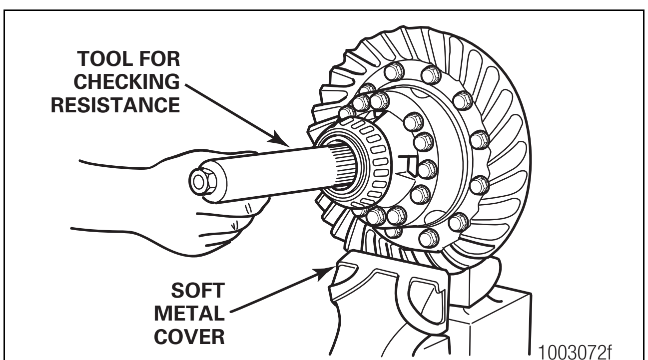


Figure 5.47

3. Install the tool into the differential until the splines of the tool are engaged with one side gear. Figure 5.47.

4. Place a torque wrench onto the nut of the tool and rotate the differential gears. As the differential gears rotate, read the value indicated on the torque wrench. Figure 5.48.

   - **If the torque value exceeds 50 lb-ft (67.8 N•m):** Disassemble the differential gears from the case halves. Inspect the case halves, spider, gears and thrust washers. Repair or replace parts. Assemble the parts and repeat Step 2 through Step 4.

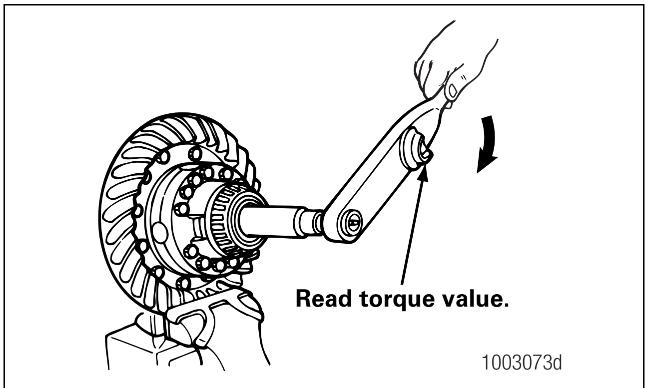


Figure 5.48

Installation

Differential and Ring Gear Assembly

1. Clean and dry the bearing cups and bores of the carrier legs and bearing caps.

2. Apply axle lubricant on the inner diameter of the bearing cups and on both bearing cones that are assembled on the case halves.

3. Apply green Loctite® 635 or 680 adhesive into the bearing bores of the carrier legs and bearing caps so that the Loctite® adhesive is spread out 360 degrees. Adhesive must not contact the adjusting ring threads. Refer to Section 6. Figure 5.49.

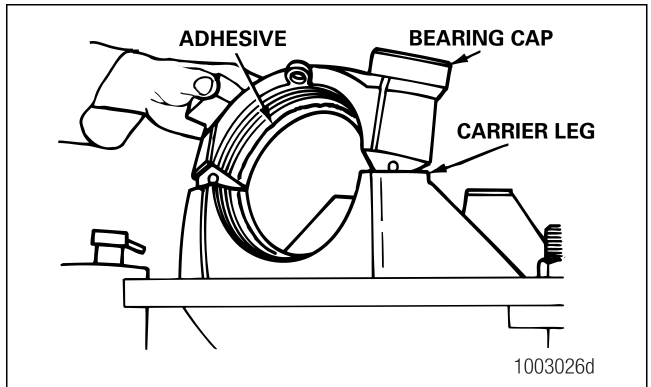


Figure 5.49

4. Install the bearing cups over the bearing cones that are assembled on the case halves. Figure 5.50.

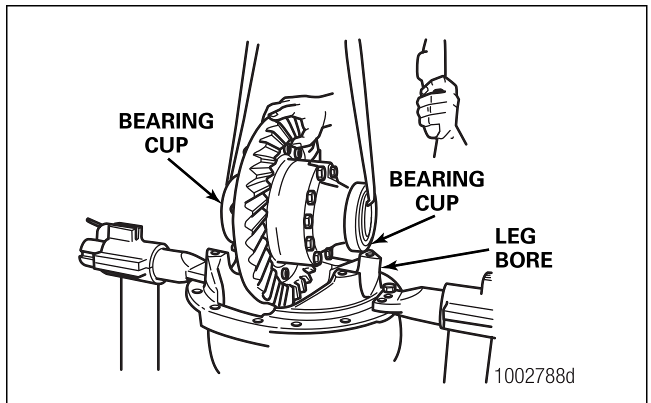


Figure 5.50

5. Safely lift the differential and ring gear assembly and install it into the carrier. The bearing cups must be flat against the bores between the carrier legs. Figure 5.50.

6. Install both of the bearing adjusting rings into position between the carrier legs. Turn each adjusting ring hand-tight against the bearing cup. Figure 5.51.

   - **For 59000 Series carriers:** Apply green Loctite® 635 or 680 adhesive to the adjusting ring threads on the carrier legs and bearing caps so that the Loctite® adhesive is spread out 360 degrees. Do not apply Loctite® adhesive between the bearing cup and adjusting ring. You must adjust the preload within the "set-time" of the Loctite® adhesive used. Refer to the manufacturer's instructions for these set-times. Also, during and after setting the bearings, verify that no Loctite® adhesive gets into the interface between the bearing cup and the adjusting ring.

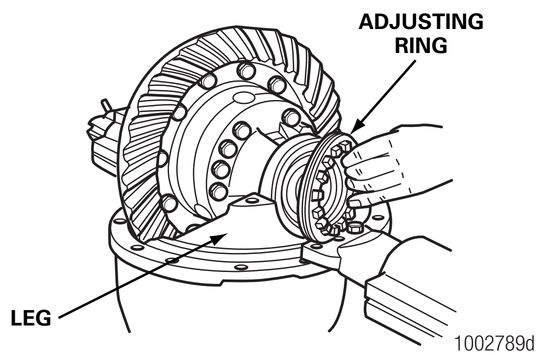


Figure 5.51

7. Install the bearing caps over the bearings and adjusting rings. Align the match marks you made when you removed the caps. Figure 5.52.

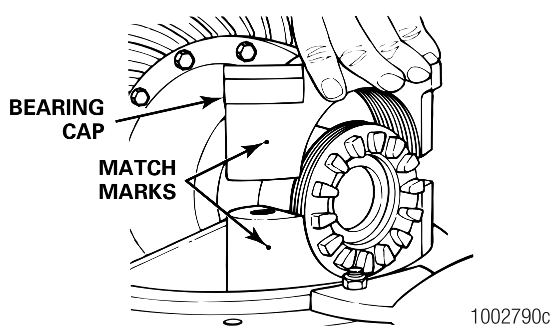


Figure 5.52

CAUTION

If the bearing caps are not installed in the correct locations, the bores and threads in the caps will not match the carrier. You will have problems assembling the caps on the carrier and damage to parts can occur. Do not force the bearing caps into position.

8. Seat each bearing cap with a light leather, plastic or rubber mallet. The caps must fit easily against the bearings, adjusting rings and carrier. Do not force the bearing caps into position.
   - **If the bearing caps do not correctly fit into position:** Check the alignment of the match marks between the caps and carrier. Remove the caps and repeat Step 6 through Step 8.

9. Install the capscrews and washers that hold the bearing caps to the carrier. Hand-tighten the capscrews four to six turns. Tighten the capscrews to the correct torque value. Refer to Section 8.

   Do not install the capscrews, cotter pins, roll pins or lock plates, if equipped, that hold the bearing adjusting rings in position.

10. Adjust the differential bearing preload and hypoid gear backlash. Check the tooth contact patterns.

Adjustment

Differential Bearing Preload

Method 1

1. Attach a dial indicator onto the carrier mounting flange so that the plunger or pointer is against the ring gear back surface. Figure 5.53.

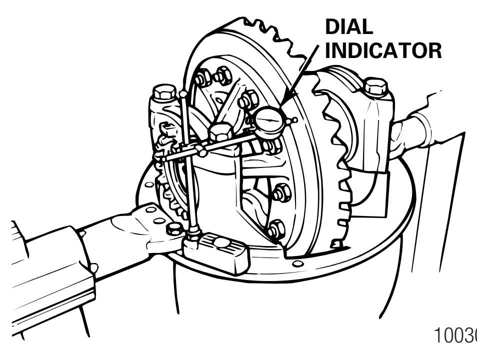


Figure 5.53

CAUTION

When you turn the adjusting rings, always use a tool that engages two or more opposite notches in the ring. A "T" bar wrench can be used for this purpose. If the tool does not correctly fit into the notches, damage to the lugs will occur.

2. Use a "T" bar wrench to loosen the bearing adjusting ring that is opposite the ring gear. A small amount of end play will show on the dial indicator. Figure 5.54.

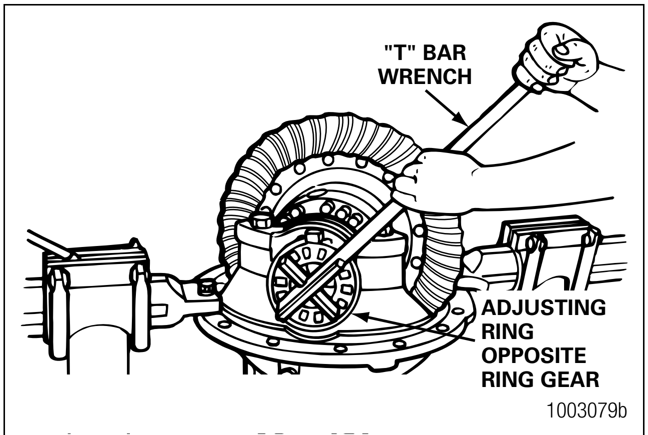


Figure 5.54

3. Use one of the following methods to move the differential and ring gear to the left and right while you read the dial indicator.
   A. Insert two pry bars between the bearing adjusting rings and ends of the differential case. The pry bars must not touch the differential bearings. Figure 5.55.
   B. Insert two pry bars between the differential case or ring gear and the carrier at locations other than described in Step A. The pry bars must not touch the differential bearings. Figure 5.56.

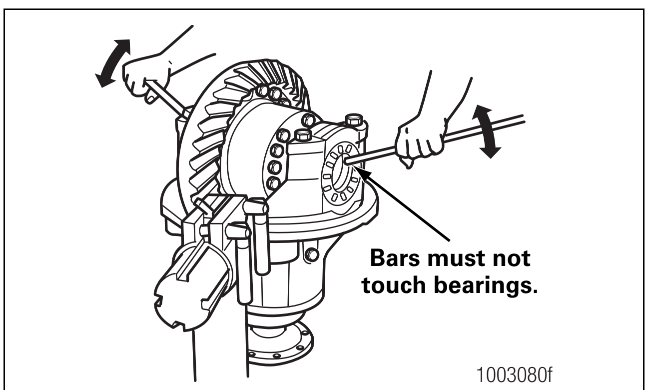


Figure 5.55

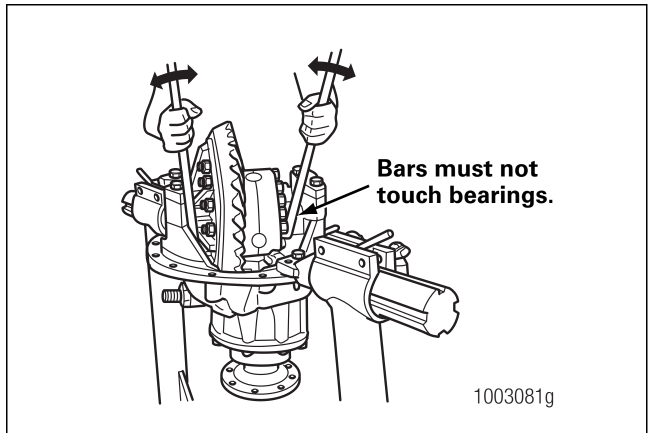


Figure 5.56

4. Tighten the bearing adjusting ring until the dial indicator reads ZERO end play. Move the differential and ring gear to the left and right as needed. If necessary, repeat Step A or Step B.
5. Tighten each bearing adjusting ring one notch from ZERO.
6. Proceed to check ring gear runout.

Method 2

1. Hand-tighten both adjusting rings against the differential bearings.
2. Use a micrometer to measure distance X or Y between the opposite surfaces of the bearing caps. Figure 5.57 and Figure 5.58. Record the measurement.

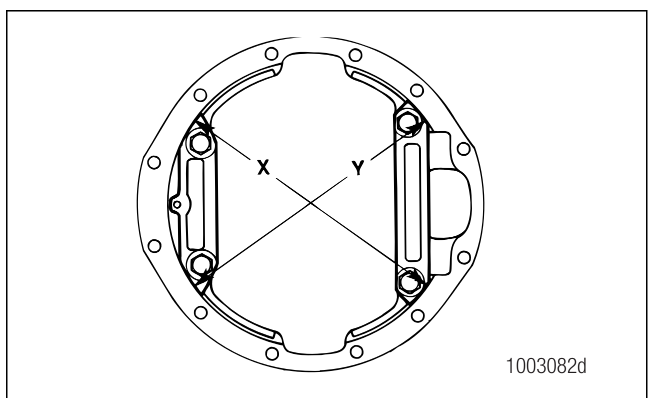


Figure 5.57

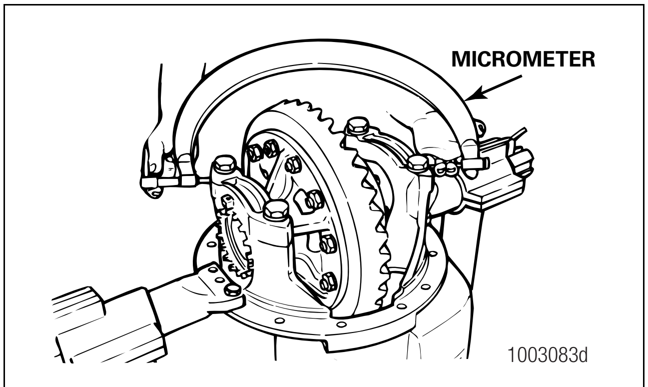


Figure 5.58

3. Tighten each bearing adjusting ring one notch.
4. Measure distance X or Y again. Compare the measurement with the one you obtained in Step 2. The difference between the two dimensions is the amount the bearing caps have expanded. Refer to the example in Table M.
   - **If the dimension is within the specification in Table N:** Continue by checking ring gear runout.
   - **If the dimension is less than the specification in Table N:** Repeat Step 3 and Step 4 as needed.

Table M: Example

RS-145 Carrier Measurements
Distance X or Y before tightening the adjusting rings = 13.927-inches (353.74 mm)
Distance X or Y after tightening the adjusting rings = 13.936-inches (353.97 mm)
13.936-inches – 13.927-inches = 0.009-inch (0.23 mm) difference

Table N: Specification

Differential Bearing Preload	Expansion Between Bearing Caps	
15-35 lb-in (1.7-3.9 N•m)	RS-140, RS-145 and RS-160 carrier models	RS-120 and all other carrier models
	0.002-0.009-inch (0.05-0.229 mm)	0.006-0.013-inch (0.15-0.33 mm)

Ring Gear Runout

1. Attach a dial indicator onto the carrier mounting flange. Figure 5.59.

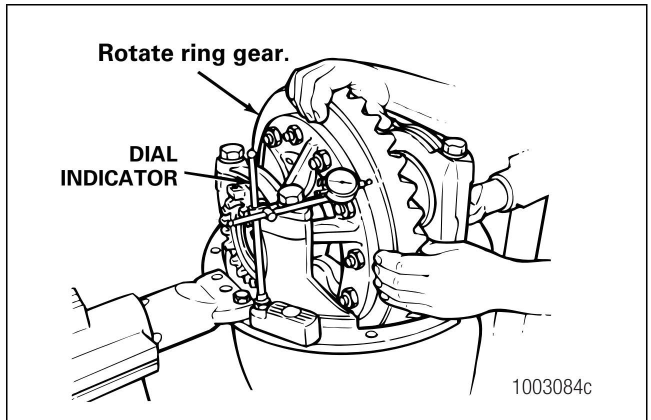


Figure 5.59

2. Adjust the dial indicator so that the plunger or pointer is against the back surface of the ring gear. Figure 5.59. Set the dial indicator to ZERO.
3. Rotate the differential and ring gear. Read the dial indicator. The ring gear runout must not exceed 0.008-inch (0.200 mm).
   - **If the ring gear runout is within the specification:** Proceed to Ring Gear Backlash.
   - **If the ring gear runout exceeds the specification:** Remove the differential and ring gear assembly from the carrier. Refer to Section 3.

   A. Inspect the differential parts, including the carrier, for wear and damage. Repair or replace parts as necessary.

   B. Install the main differential case and ring gear assembly into the carrier. Refer to the procedure in this section.

   C. Repeat the procedure for preload adjustment of the differential side bearings.

Ring Gear Backlash

Table O: Specifications

Ring Gear Pitch Diameter	Range of Backlash Setting	Backlash Setting for New Gear Sets
Less than 17-inches (431.8 mm)	0.008-0.018-inch (0.20-0.46 mm)	0.012-inch (0.30 mm)
Greater than 17-inches (431.8 mm)	0.010-0.020-inch (0.25-0.51 mm)	0.015-inch (0.38 mm)

Measure the outer diameter of the ring gear for the approximate pitch diameter. Figure 5.60.

- **If the old gear set is installed:** Adjust the backlash to the setting that was measured before the carrier was disassembled.
- **If a new gear set is installed:** Adjust the backlash to the correct specification for new gear sets.

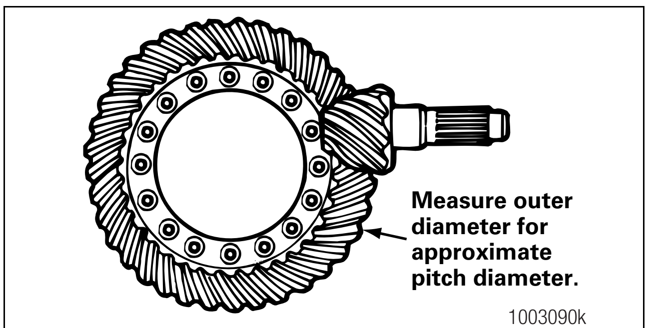


Figure 5.60

After checking the tooth contact patterns, the backlash can be adjusted within the specification limits, if needed. To change the location of the pattern, use the following procedures.

1. Attach a dial indicator onto the carrier mounting flange. Figure 5.61.
2. Adjust the dial indicator so that the plunger is against the tooth surface.
3. Adjust the dial indicator to ZERO. Hold the drive pinion in position.
4. After reading the dial indicator, rotate the differential and ring gear a small amount in both directions against the drive pinion teeth.
   - **If the backlash reading is within the specification:** Check the tooth contact patterns.
   - **If the backlash reading is not within the specification:** Adjust the backlash as needed.

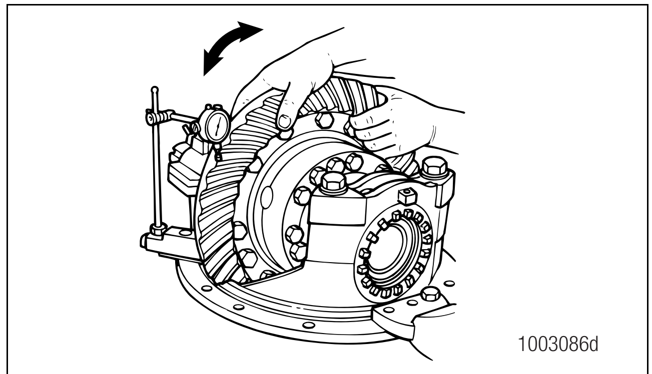


Figure 5.61

5. Loosen one bearing adjusting ring one notch. Tighten the opposite ring by the same amount.
   - **To increase the backlash:** Move the ring gear away from the drive pinion. Figure 5.62.
   - **To decrease the backlash:** Move the ring gear toward the drive pinion. Figure 5.63.

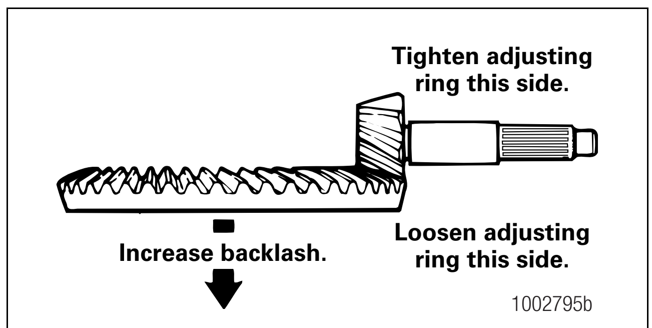


Figure 5.62

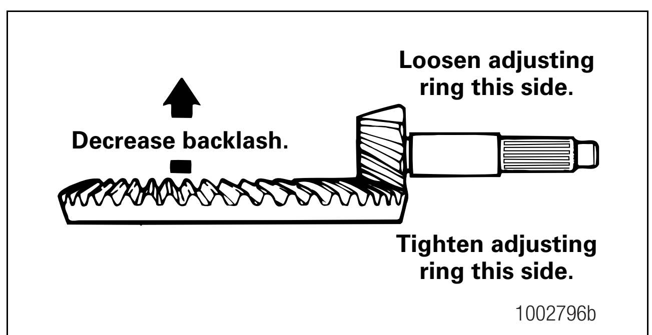


Figure 5.63

NOTE: When you adjust the backlash, only move the ring gear. Do not move the drive pinion.

6. Repeat Step 2 through Step 5 until the backlash is within specification. Record the setting for use when you adjust the pinion bearing preload.

Gear Set Tooth Contact Patterns (Backlash)

Some Meritor carriers have a generoid hypoid gear set. The tooth contact patterns for each type of gear set are different. Check the part numbers to determine what type of gear set is in the carrier. Refer to Figure 5.64 for the location of part numbers. Refer to Section 4.

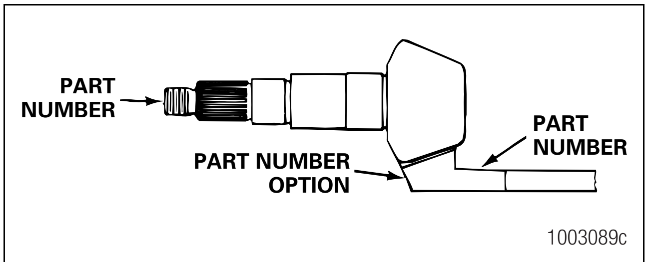


Figure 5.64

The following are examples of part numbers for generoid gear sets.

- 36786 K or 36786 K2 for the ring gear
- 36787 K or 36787 K2 for the drive pinion

In the following procedures, movement of the contact pattern in the length of the tooth is indicated as toward the heel or toe of the ring gear. Figure 5.65.

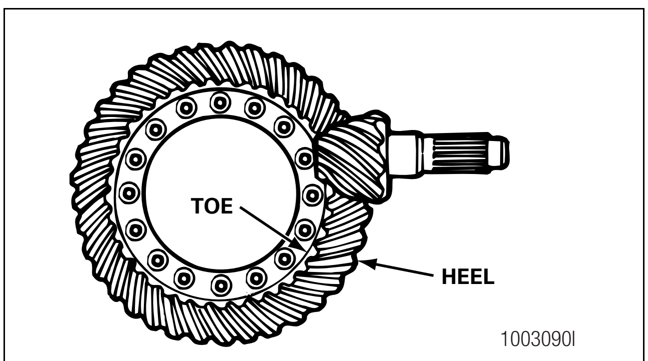


Figure 5.65

Always check the tooth contact patterns on the drive side of the gear teeth. Figure 5.66.

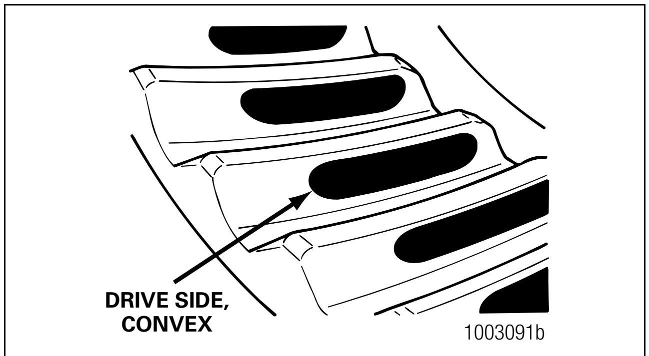


Figure 5.66

1. Adjust the backlash of a new gear set to either 0.012-inch (0.305 mm) or 0.015-inch (0.380 mm) depending on the size of the ring gear. Adjust the backlash of an old gear set to the setting that you measured before the carrier was disassembled. Refer to the procedure in this section.
2. Apply a marking compound onto approximately 12 gear teeth of the ring gear. Rotate the ring gear so that the 12 gear teeth are next to the drive pinion. Figure 5.67.

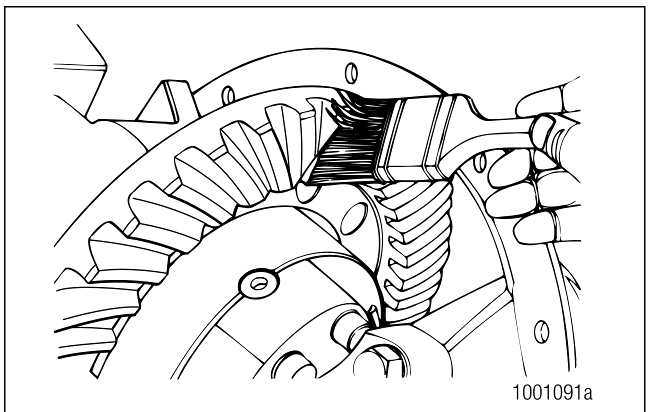


Figure 5.67

3. Rotate the ring gear forward and backward so that the 12 gear teeth go past the drive pinion six times to get the contact patterns. Repeat if needed to get a clearer pattern.

4. Look at the contact patterns on the ring gear teeth. Compare the patterns to Figure 5.68, Figure 5.69 and Figure 5.70.

   The location of good hand-rolled contact patterns for new conventional and generoid gear sets is toward the toe of the gear tooth and in the center between the top and bottom of the tooth. Figure 5.68.

   When the carrier is operated, a good pattern will extend approximately the full length of the gear tooth. The top of the pattern will be near the top of the gear tooth. Figure 5.71.

   The location of a good hand-rolled contact pattern for an old gear set must match the wear pattern in the ring gear. The new contact pattern will be smaller in area than the old wear pattern.

   A high contact pattern indicates that the drive pinion was not installed deep enough into the carrier. A low contact pattern indicates that the drive pinion was installed too deep in the carrier.

   - **If the contact patterns require adjustment:** Continue by following Step 5 to move the contact patterns between the top and bottom of the gear teeth.
   - **If the contact patterns are in the center of the gear teeth:** Continue by following Step 6.

GOOD HAND-ROLLED PATTERN, HYPOID GENEROID GEARS

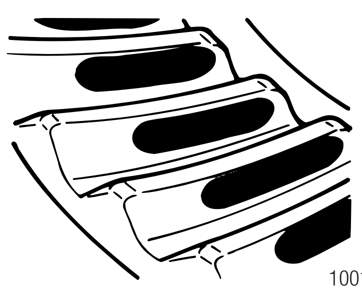


Figure 5.68

HIGH PATTERN, HYPOID GENEROID GEARS

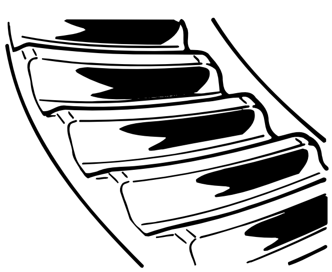


Figure 5.69

LOW PATTERN, HYPOID GENEROID GEARS

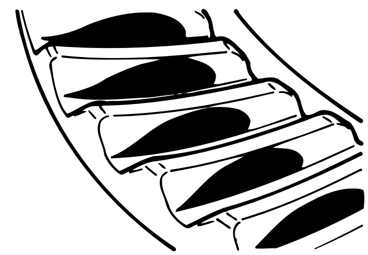


Figure 5.70

GOOD PATTERN IN OPERATION, GENEROID GEARS

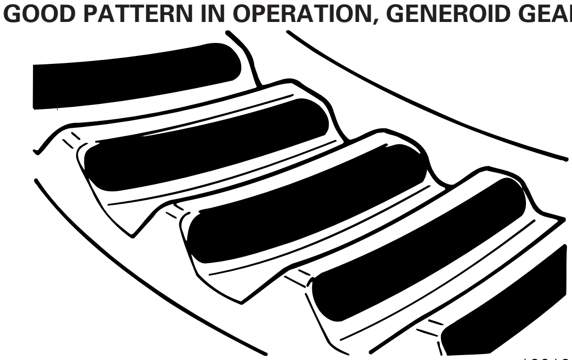


Figure 5.71

5. Change the thickness of the shim pack under the bearing cage to move the contact patterns between the top and bottom of the gear teeth. Use the following procedure.

   A. Remove the drive pinion and bearing cage from the carrier. Refer to Section 3.

      - **To correct a high contact pattern:** Decrease the thickness of the shim pack under the bearing cage. When decreasing the thickness of the shim pack, the drive pinion will move toward the ring gear. Figure 5.72.
      - **To correct a low contact pattern:** Increase the thickness of the shim pack under the bearing cage. When increasing the thickness of the shim pack, the drive pinion will move away from the ring gear. Figure 5.73.

   B. Install the drive pinion, bearing cage and shims into the carrier. Refer to the procedure in this section.

   C. Repeat Step 2 through Step 5 until the contact patterns are in the center between the top and bottom of the gear teeth.

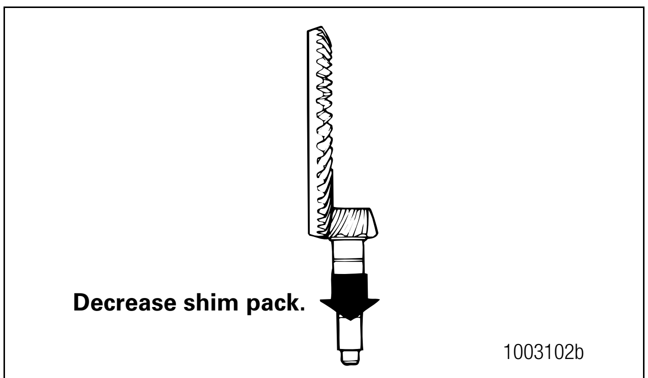


Figure 5.72

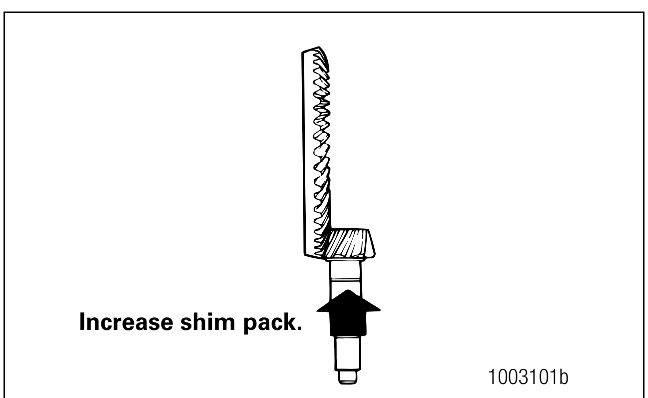


Figure 5.73

6. Adjust the backlash of the ring gear within the specification range to move the contact patterns to the correct location in the length of the gear teeth. Refer to the procedure in this section.

   A. Decrease the backlash to move the contact patterns toward the toe of the ring gear teeth. Figure 5.74.

   B. Increase the backlash to move the contact patterns toward the heel of the ring gear teeth. Figure 5.75.

   C. Repeat Step 2 through Step 4 and Step 6 until the contact patterns are at the correct location in the length of the gear teeth.

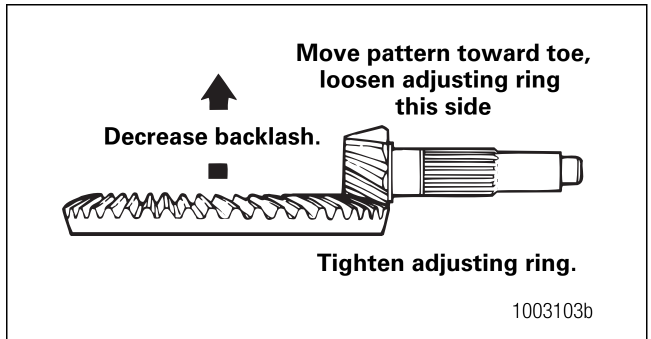


Figure 5.74

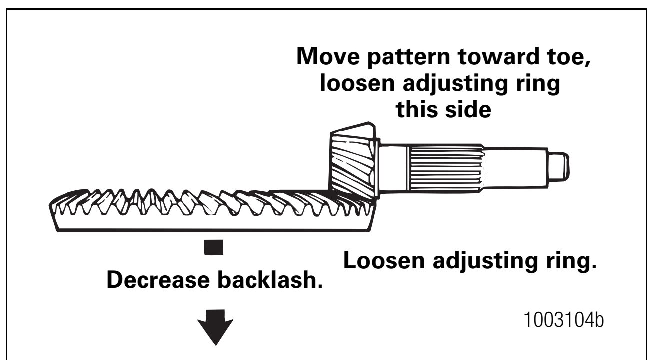


Figure 5.75

CAUTION

If the carrier has cotter pins or capscrews, lock the adjusting rings only with cotter pins or capscrews. If the carrier has roll pins, reuse the roll pins. Do not force a roll pin into a cotter pin hole. Damage to components can result.

7. Install the capscrews, cotter pins, roll pins or lock plates, if equipped, that hold the two bearing adjusting rings in position. Use the following procedures.
   A. Install capscrews between the lugs of the adjusting ring and through the boss of the bearing cap. New capscrews include a locking patch, which can only be used once. If you are installing used capscrews, apply Loctite® threadlocker to the capscrew threads before you install the capscrews. Figure 5.76.
   B. Install cotter pins between the lugs of the adjusting ring and through the boss of the bearing cap. Bend the two ends of the cotter pin around the boss. Figure 5.76.
   C. Use a drift and hammer to install the roll pin through the boss of the bearing cap until the roll pin is between the lugs of the adjusting ring. Figure 5.76.
   D. Install the lock plate onto the bearing cap so that the tab is between the lugs of the adjusting ring. Install the two capscrews and washers that hold the lock plate to the bearing cap. Tighten the capscrews to the correct torque value. Refer to Section 8. Figure 5.76.
      - **For 59000 Series carriers:** Apply two to three drops of red Loctite® 277 threadlocker to the sides of the locking tab threaded holes. Apply Loctite® 277 threadlocker even if the capscrews have a locking patch.

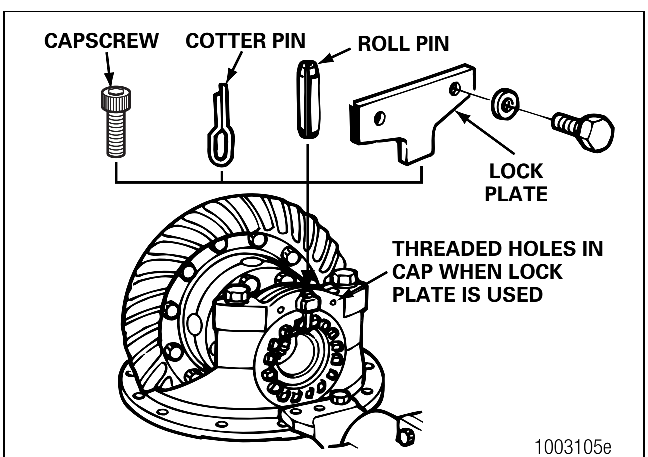


Figure 5.76

Installation

Thrust Screw (If Equipped)

1. Rotate the carrier in the repair stand until the back surface of the ring gear is toward the TOP.
2. Install the jam nut onto the thrust screw. Thread the jam nut to the middle of the thrust screw. Figure 5.77.

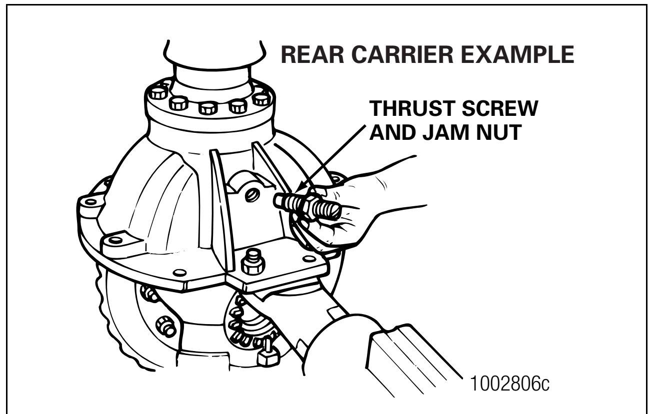


Figure 5.77

3. Install the thrust screw into the carrier. Use a feeler gauge to verify that the clearance between the thrust screw and the ring gear is 0.025-0.045-inch (0.65-1.14 mm).
4. Loosen the thrust screw one-half turn or 180 degrees. Figure 5.78.

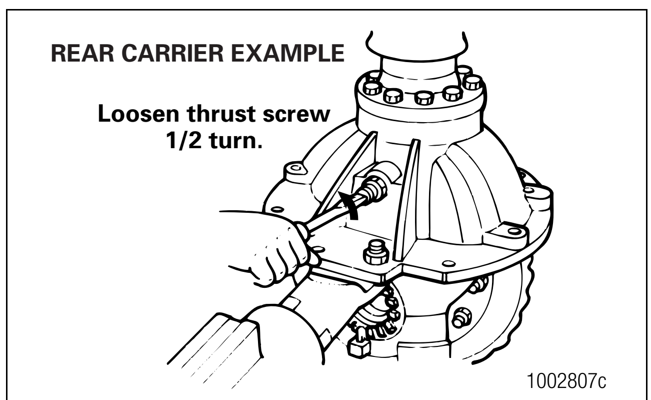


Figure 5.78

5. Tighten the jam nut, if equipped, to the correct torque value against the carrier. Refer to Section 8. Figure 5.79.

   To complete the assembly of axles equipped with driver-controlled main differential locks, refer to Section 6.

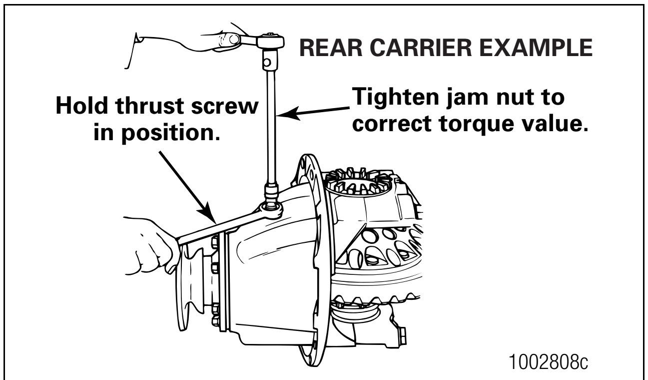


Figure 5.79

Differential Carrier into the Axle Housing

WARNING

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

1. Use a cleaning solvent and rags to clean the inside of the axle housing and the carrier mounting surface.
2. Inspect the axle housing for damage. Repair or replace the axle housing.
3. Check for loose studs, if equipped, in the mounting surface of the housing where the carrier fastens. Remove and clean the studs that are loose.
4. Apply liquid adhesive to the threaded holes. Install the studs into the axle housing. Tighten the studs to the correct torque value. Refer to Section 8.

CAUTION

Apply silicone gasket material in a continuous 0.25-inch (6 mm) bead. If you use more than this amount, gasket material can break off and plug lubrication passages. Damage to components can result.

5. Apply a 0.25-inch (6 mm) continuous bead of silicone gasket material to the mounting surface of the housing where the carrier fastens. Figure 5.80.

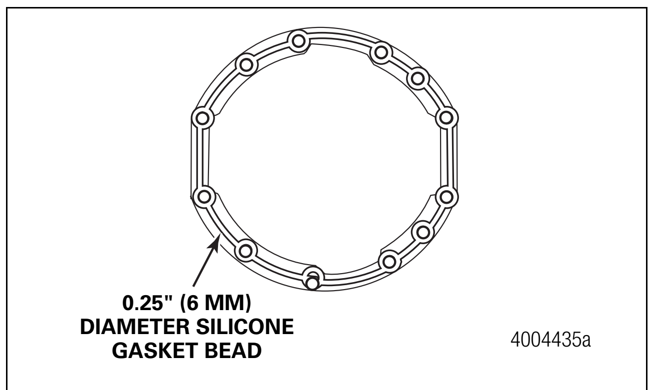


Figure 5.80

CAUTION

Do not use a hammer or mallet to install the carriers.
A hammer or mallet will damage the mounting flange of the carrier and cause oil leaks.

6. Use a hydraulic roller jack or a lifting tool to install the carrier into the axle housing.
7. Install nuts and washers or capscrews and washers, if equipped, into the four corner locations around the carrier and axle housing. Hand-tighten the fasteners. Figure 5.81.

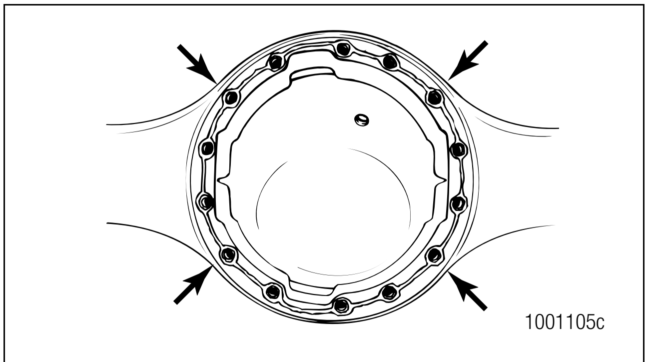


Figure 5.81

8. Carefully push the carrier into position. Tighten the four fasteners two or three turns each in a pattern opposite each other. Figure 5.81.
9. Repeat Step 8 until the four fasteners are tightened to the correct torque value. Refer to Section 8.
10. Install the other fasteners and washers that hold the carrier in the axle housing. Tighten fasteners to the correct torque value. Refer to Section 8.
11. Connect the driveline universal joint to the pinion input yoke or flange on the carrier.
12. Install the gaskets and axle shafts into the axle housing and carrier. The gasket and flange of the axle shafts must fit flat against the wheel hub. Figure 5.82.

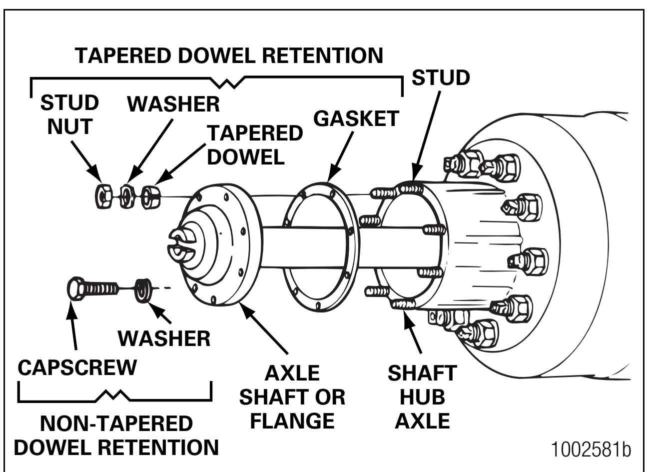


Figure 5.82

Straight Holes, Nuts and Hardened Washers

1. Clean the mating surfaces of the axle shaft and the wheel hub.
2. If silicone gasket material is used, apply a 0.125-inch (3 mm) diameter bead of the gasket material around the mating surface of the hub and around the edge of each fastener hole.
3. Install the gasket and the axle shaft into the housing. The gasket and the flange of the axle shaft must fit flat against the wheel hub. Figure 5.82.
4. Install the Grade 8 nuts and hardened washers onto the stud. Lock washers are an acceptable alternative. Tighten the stud nuts to the torque specified in Table P.

Table P: Shaft-to-Hub Torque Fastener Chart — Non-Tapered Dowel Applications

		Torque Value — Grade 8 Nuts lb-ft (N•m)	
Fastener	**Thread Size**	**Plain Nut**	**Locknut**
Stud Nut, Axle Shaft	0.62-18	150-230 (244-312)	130-190 (203-258)
	0.75-16	310-400 (420-542)	270-350 (366-475)
Studs	All	Install the coarse thread end of the stud into the hub and tighten to the last thread.	

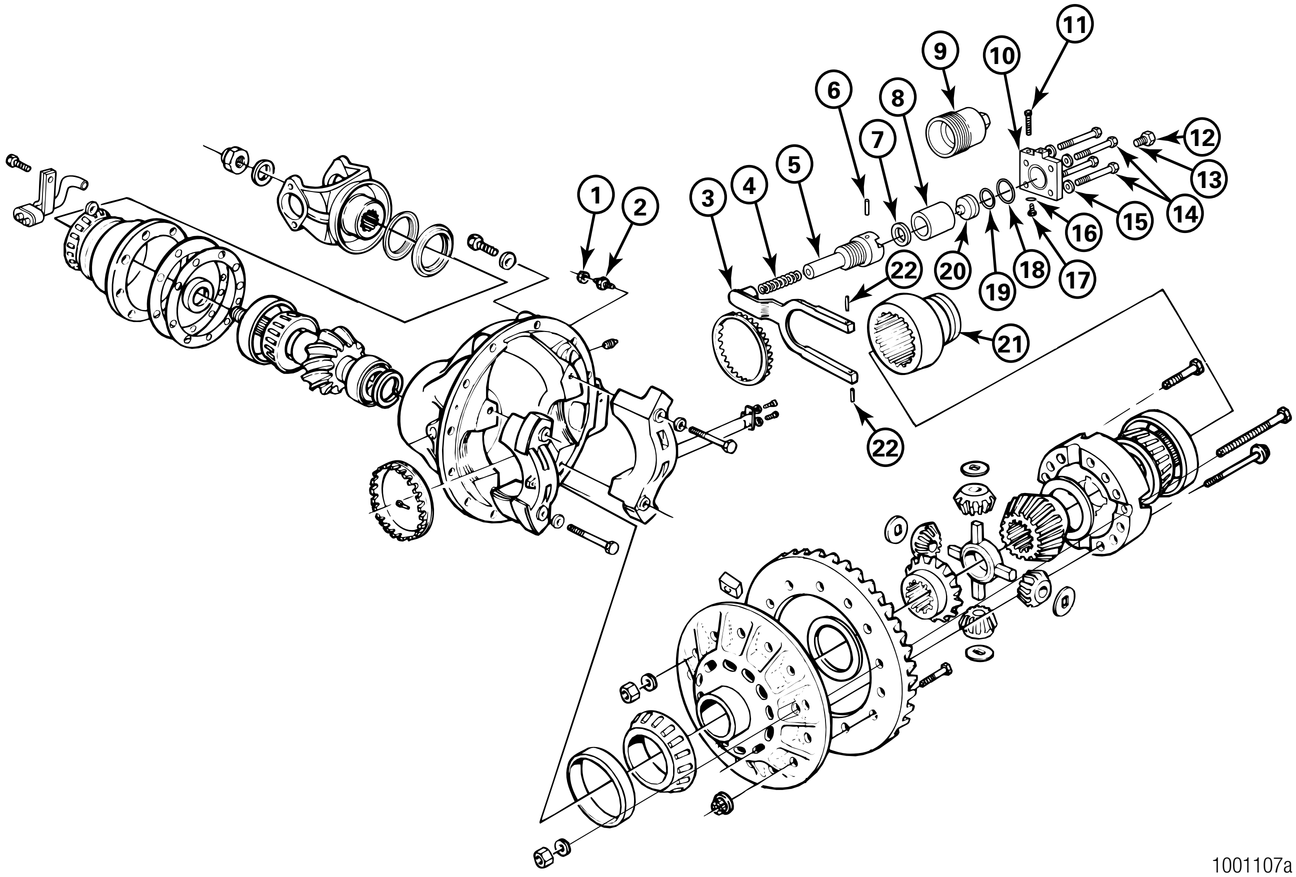
Tapered Dowel, Hardened Washer and Hardened Nut

1. Clean the mating surfaces of the axle shaft and the wheel hub.
2. If silicone gasket material is used, apply a 0.125-inch (3 mm) diameter bead of the gasket material around the mating surface of the hub and around the edge of each fastener hole.
3. Install the gasket and the axle shaft into the housing. The gasket and the flange of the axle shaft must fit flat against the wheel hub. Figure 5.82.
4. Install solid tapered dowels over each stud and into the flange of the axle shaft. Use a punch or a drift and hammer, if necessary.

5. Install the Grade 8 nuts and hardened washers onto the stud. Lock washers are an acceptable alternative. Tighten the stud nuts to the torque specified in Table Q.

Table Q: Shaft-to-Hub Torque Fastener Chart — Tapered Dowel Applications

		Torque Value — Grade 8 Nuts lb-ft (N•m)	
Fastener	**Thread Size**	**Plain Nut**	**Locknut**
Stud Nut, Axle Shaft	0.44-20	50-75 (81-102)	40-65 (67-88)
	0.50-20	75-115 (115-156)	65-100 (102-136)
	0.56-18	110-165 (176-224)	100-145 (149-197)
	0.62-18	150-230 (244-312)	130-190 (203-258)
Studs	All	Install the coarse thread end of the stud into the hub and tighten to the last thread.	



1 SENSOR SWITCH LOCKNUT
2 SENSOR SWITCH
3 SHIFT FORK
4 SHIFT SHAFT SPRING
5 SHIFT SHAFT
6 SPRING RETAINING PIN
7 FLAT WASHER, OR SILASTIC AS REQUIRED
8 AIR CYLINDER TUBE
9 SCREW-IN DIFFERENTIAL LOCK
10 CYLINDER COVER
11 MANUAL ACTUATION CAPSCREW, STORAGE POSITION
12 WASHER, OPERATING POSITION
13 PLUG GASKET, OPERATING POSITION
14 COVER CAPSCREWS
15 WASHERS
16 PLUG GASKET, STORAGE POSITION
17 COVER PLUG, STORAGE POSITION
18 COVER COPPER GASKET
19 PISTON O-RING
20 PISTON
21 SHIFT COLLAR
22 SHIFT FORK ROLL PINS

Figure 6.1

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

When you apply some silicone gasket materials, a small amount of acid vapor is present. To prevent serious personal injury, ensure that the work area is well-ventilated. Read the manufacturer's instructions before using a silicone gasket material, then carefully follow the instructions. If a silicone gasket material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Take care when you use Loctite® adhesive to avoid serious personal injury. Read the manufacturer's instructions before using this product. Follow the instructions carefully to prevent irritation to the eyes and skin. If Loctite® adhesive material gets into your eyes, follow the manufacturer's emergency procedures. Have your eyes checked by a physician as soon as possible.

Description

Some Meritor drive axle models have a driver-controlled main differential lock (DCDL). This differential lock is operated by a carrier-mounted, air-actuated shift unit. When activated, the shift unit moves a sliding collar that is installed on the splines of the axle shaft. When engaged, the collar locks the axle shafts together with a second set of splines on the differential case. When the DCDL is engaged, there is no differential action. Figure 6.1.

NOTE: The Meritor carrier models with driver-controlled differential lock equipment are manufactured in metric dimensions and sizes. When these carriers are serviced, it is important to use the correct metric size tools on the fasteners. Refer to Section 8.

Vehicle Towing

CAUTION

If the vehicle must be towed to a service facility with the drive axle wheels on the ground, remove the axle shafts before the vehicle is towed. Damage to components can result.

1. Remove the axle shafts before the vehicle is towed. Refer to Section 11.
2. Install the axle shafts after the vehicle is towed. Refer to Section 11.
3. If the differential carrier must be removed from the axle housing, use the following procedures.

Removal

Differential Carrier from the Axle Housing

Before the differential carrier can be removed or installed, the differential lock must be shifted into and held in the locked or engaged position. The locked position gives enough clearance between the shift collar and the axle housing to permit the removal or installation of the carrier.

NOTE: If the axle shafts were removed for towing with the differential in the unlocked or disengaged position, install the right-hand axle shaft into the housing before removing the differential carrier. Refer to Section 11.

To shift into the locked position, refer to the procedure in this section.

Axle Setup for DCDL Disassembly

WARNING

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Remove the drain plug from the bottom of the housing and drain the lubricant.

WARNING

During DCDL disassembly, when the DCDL is in the locked or engaged position and the vehicle's wheels are raised from the floor, do not start the engine and engage the transmission. The vehicle can move and cause serious personal injury. Damage to components can result.

3. Use a jack to raise the vehicle so that the wheels to be serviced are off the ground. Place safety stands under the spring seats to hold the vehicle in the raised position.

4. Disconnect the driveline from the pinion input yoke.
5. Disconnect the vehicle air line from the differential lock actuator assembly.

DCDL Assembly Manual Engaging Methods

Bolt-On Style Differential Lock Cylinder

Use the following manual engaging method to lock out the bolt-on DCDL assembly. Figure 6.2.

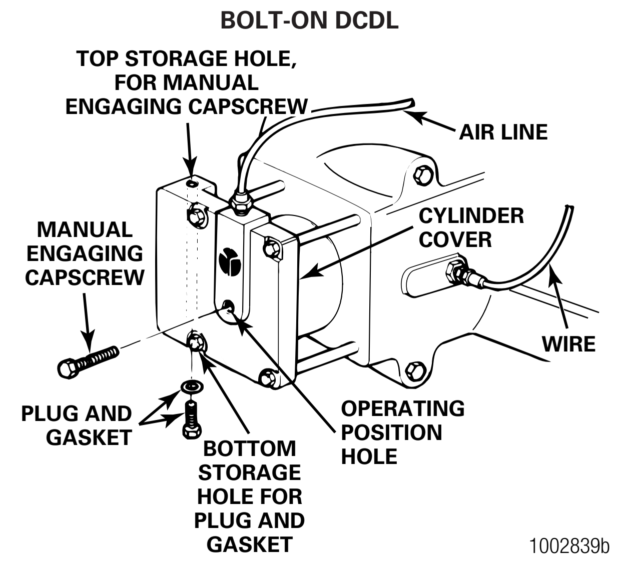


Figure 6.2

1. Follow Step 2 through Step 5 of Axle Setup for DCDL Disassembly in this section.
2. Remove the plug and gasket from the hole in the center of the cylinder cover.

NOTE: The storage hole for the plug and gasket is located on the opposite side of the cylinder cover where the storage hole for the manual engaging capscrew is located.

3. Remove the manual engaging capscrew from the top storage hole in the cylinder cover.
4. Install the plug and gasket into the bottom storage hole in the cylinder cover.
5. Install the manual engaging capscrew into the threaded hole in the center of the cylinder cover.

⚠ CAUTION

There will be a small amount of spring resistance felt when you turn in the manual engaging capscrew. If a high resistance is felt before reaching the locked or engaged position, stop turning the capscrew, or the cover and capscrew threads will be damaged.

6. Turn the manual adjusting capscrew to the right until the head is approximately 0.25-0.5-inch (6-13 mm) from the cylinder cover. Do not turn the capscrew beyond its normal stop. If the 0.25-10.5-inch (6-13 mm) service position of the capscrew is achieved, the main differential lock is completely engaged.

   A high resistance on the capscrew indicates that the splines of the shift collar and the differential case half are not aligned or engaged. To align the splines, use the following procedure.

   A. Rotate the drive pinion or right-hand wheel to align the splines of the shift collar and case half while you turn in the manual engaging capscrew.

   B. When a normal amount of spring resistance is felt on the capscrew, the splines are engaged. Continue to turn in the manual engaging capscrew until the head is approximately 0.25-inch (6 mm) from the cylinder cover.

7. Remove the carrier from the axle housing. Refer to Section 3.

Screw-In Style Differential Lock Cylinder

Use the following manual engaging method to lock out the screw-in DCDL assembly.

1. Follow Step 2 through Step 5 of Axle Setup for DCDL Disassembly in this section.
2. Remove the manual engaging capscrew from the storage hole in the carrier casting, next to the cylinder. Figure 6.3.

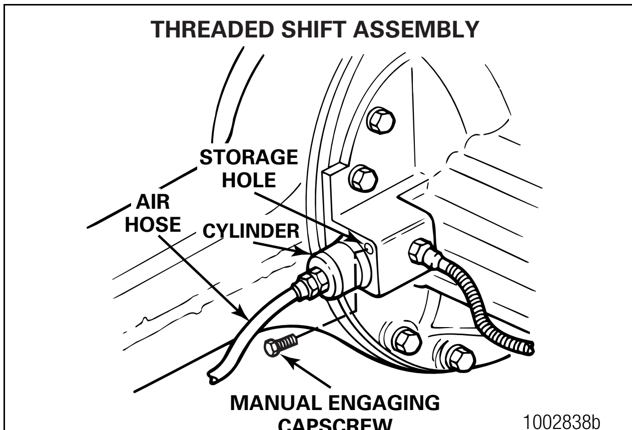


Figure 6.3

3. Remove the air line and fitting. Install the manual engaging capscrew into the threaded hole in the center of the cylinder cover.
4. Turn the manual adjusting capscrew to the right until the head is approximately 0.25-inch (6 mm) from the cylinder cover. Do not turn the capscrew beyond its normal stop. The capscrew is now in the service position and the main differential lock is completely engaged.
5. Remove the carrier from the axle housing. Refer to Section 3.

Differential and Gear Assembly

Differential Lock Sliding Collar

1. For carriers with roll pins, tap out the two retainer roll pins, if equipped, until they are level with the inner face of the shift fork. Release the differential lock if it is manually engaged. Figure 6.4.

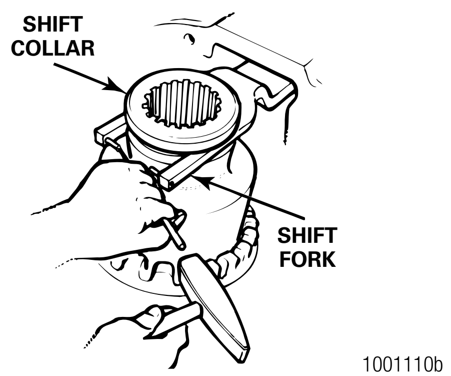


Figure 6.4

2. For carriers without roll pins, snap out the collar from the fork.
3. If required, remove the DCDL assembly at this time.

NOTE: On some bolt-on assemblies, a roll pin is installed in the shift shaft and is used as a stop for the shift shaft spring. It is not necessary to remove this roll pin during a normal disassembly.

A. **Bolt-on style differential lock cylinder:** Remove the sensor switch and locknut.

B. Remove the four capscrews and washers that hold the cylinder cover to the carrier. Remove the cylinder cover and copper gasket. Figure 6.5.

C. Remove the shift unit cylinder and piston. Remove the O-ring from the piston.

D. Remove the shift shaft from the shift fork. The shaft may be secured with liquid adhesive or pre-applied adhesive material.

E. Remove the shift shaft spring and flat washer. Some models use silastic seal instead of the flat washer.

F. Remove the shift fork.

A. **Screw-in style differential lock cylinder:** Remove the sensor switch.

B. Remove the cylinder by turning the hex nut at the top of the cylinder with a wrench. The cylinder may be secured to the carrier casting with Loctite® adhesive or equivalent pre-applied liquid adhesive.

C. Remove the shift shaft, spring and shift fork.

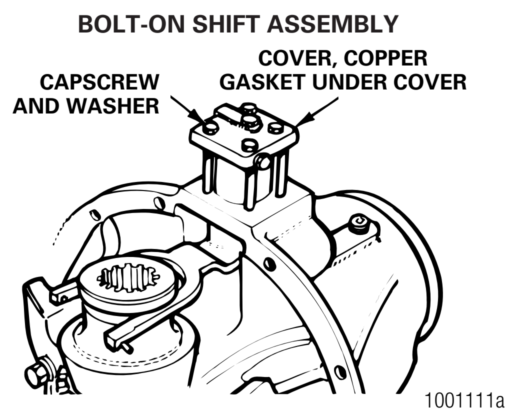


Figure 6.5

4. Remove the capscrews, cotter pins, roll pins or lock plates, if equipped, that hold the two bearing adjusting rings in position. Use a small drift and hammer to remove the pins. Each lock plate is held in position by two capscrews.

5. Mark one bearing cap and one carrier leg so that these parts will be assembled in the correct positions. Remove the bearing cap capscrews and washers, the bearing caps and the adjusting rings.
6. Lift the differential and gear assembly from the carrier. Tilt the assembly as required to permit the ring gear to clear the support for the pinion spigot bearing. Figure 6.6.

   Further disassembly of these carriers is the same as axles without the driver-controlled main differential lock. To continue disassembly, follow the procedures in Section 3.

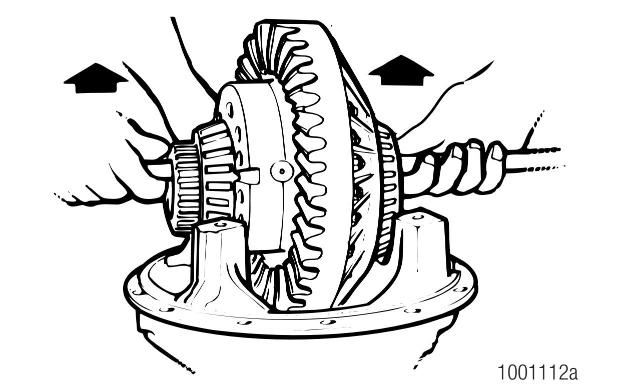


Figure 6.6

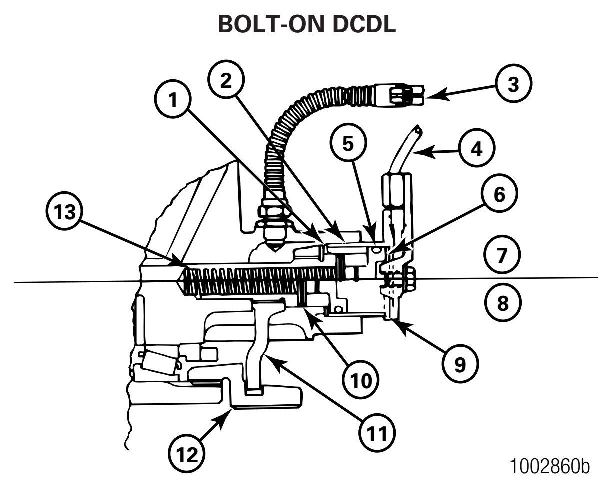
Installation

DCDL Assembly into the Carrier

Bolt-On Style Differential Lock Assembly

Install the differential shift assembly after the differential carrier is assembled and the gear and bearing adjustments are completed. Figure 6.7.

1. On carrier models with shift fork roll pins, install the two roll pins into the ends of the shift fork. Tap the pins into position until they are level with the inner yoke face. Figure 6.8. Do not install the pins completely at this time.
2. On models without roll pins, snap the fork into position.
3. Apply Loctite® 222 threadlocker, Meritor part number 2297-B-6112, to the threads of the shift shaft.
4. Install the shift fork into its correct position in the carrier case. Figure 6.9.



1 FLAT WASHER OR SILASTIC AS REQUIRED
2 CYLINDER
3 ELECTRIC CONNECTION FOR SENSOR
4 AIR LINE
5 O-RING
6 PISTON
7 DISENGAGED
8 ENGAGED
9 COPPER GASKET
10 PIN
11 SHIFT FORK
12 COLLAR
13 SHIFT SHAFT AND SPRING

Figure 6.7

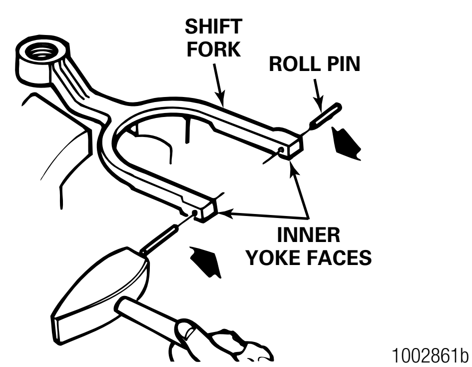


Figure 6.8

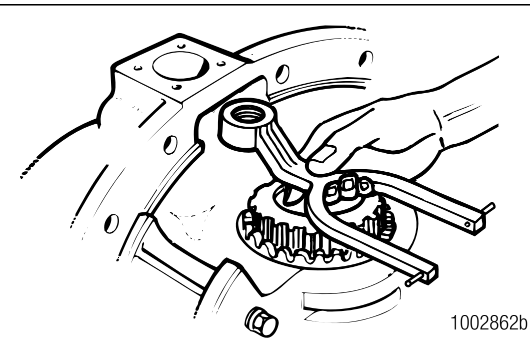


Figure 6.9

5. Hold the shift fork in position. Install the shift shaft spring into the shift shaft opening in the carrier, through the shift fork bore and into the bore for the shift shaft spring. Figure 6.10.

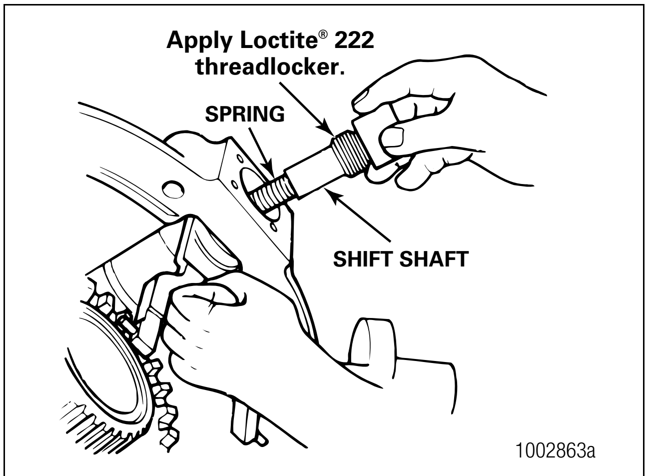


Figure 6.10

6. Slide the shift shaft over the spring. Install the shaft into the shift fork. Tighten to 20-25 lb-ft (27-34 N•m).

7. Install the flat washer, when used, or apply silastic sealant, Meritor part number 1199-Q-2981, to the bottom of the cylinder bore. Figure 6.11.

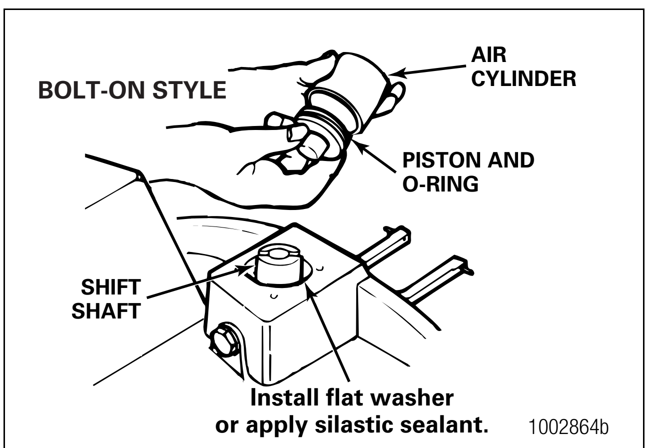


Figure 6.11

8. Install the O-ring into its groove on the piston. Lubricate the O-ring with axle lubricant. Install the piston into the air cylinder. Figure 6.11.

9. Install the cylinder into the housing bore. Verify that the pilot journal on the piston is against its bore on the shift shaft. Figure 6.12.

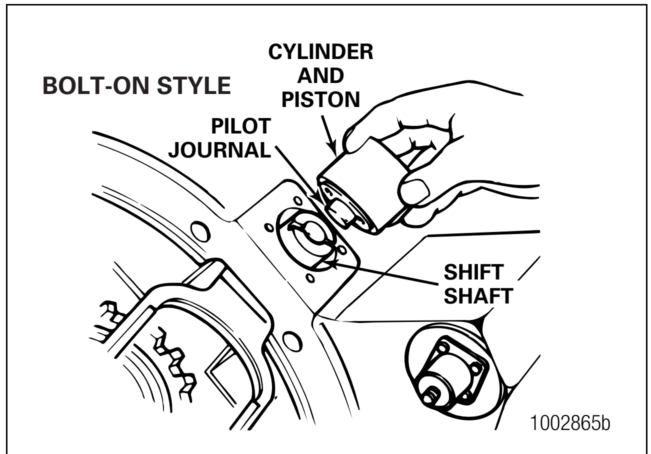


Figure 6.12

10. Install the copper gasket into its bore on the inside of the cylinder cover. Place the cover in position over the cylinder so that the air intake port will point UP when the carrier is installed into the housing. Install the cover with the four attaching capscrews and washers. Tighten the capscrews to 7.4-8.9 lb-ft (10-12 N•m). Figure 6.7 and Figure 6.13.

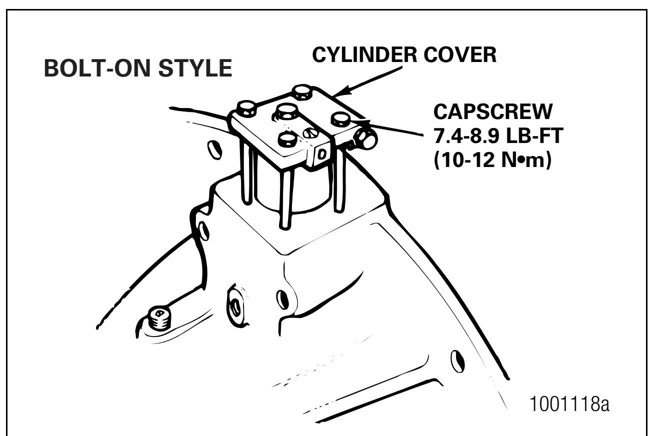


Figure 6.13

11. Slide the shift collar into the fork. Engage the shift collar splines with the splines of the differential case. Use the manual actuation capscrew to move the shift collar splines into the differential case splines. Refer to the procedure in this section.

12. Hold the shift collar in the locked or engaged position. If employed, tap the two roll pins into the shift fork ends until they are level with the outer yoke faces. Figure 6.14.

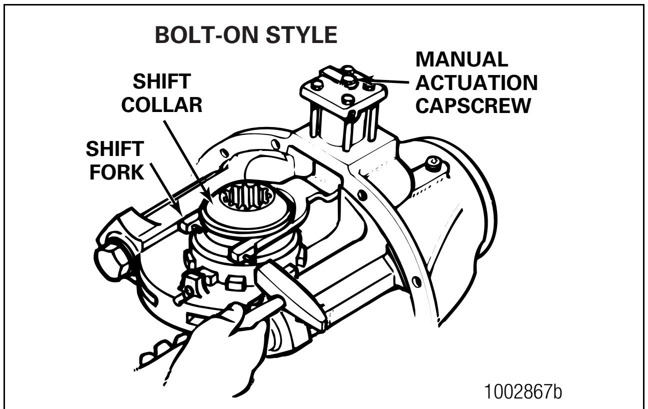


Figure 6.14

13. While the shift collar is still in the locked position, place the sensor switch, with the jam nut loosely attached into its hole.
14. Connect a volt-ohm meter to the sensor switch. Select ohms on the meter. Rotate the switch CLOCKWISE until the meter reading changes from infinity to less than one ohm. Turn the switch one additional revolution. Tighten the jam nut to 26-33 lb-ft (34-45 N•m).

Screw-In Style Differential Lock Assembly with O-Ring

Install the differential shift assembly after the differential carrier is assembled and the gear and bearing adjustments are completed. Figure 6.15.

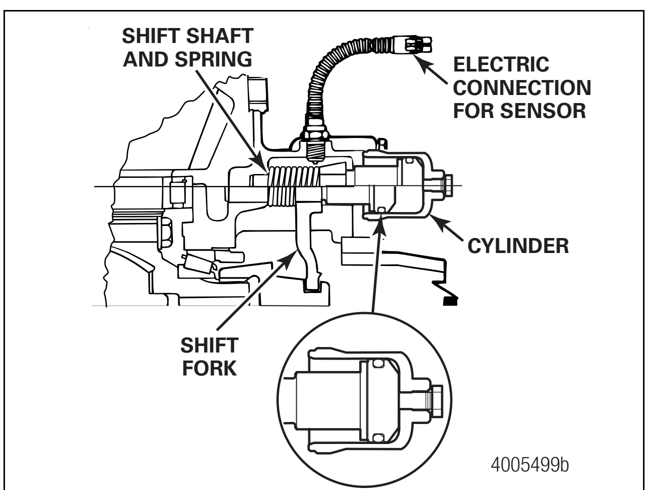


Figure 6.15

1. Install the shift spring and fork into the correct position in the carrier case. Compress the spring slightly while installing the fork.
2. Install the shift shaft into the shaft bore of the carrier. Slide the shaft through the shift fork bore and shift spring inside diameter.
3. Inspect the piston O-ring. Replace the O-ring if there is any evidence of cuts, cracks, abrasion or wear.
4. Lightly lubricate the O-ring and DCDL cylinder bore with the same lubricant used in the axle housing.
5. Install the piston and O-ring assembly into the DCDL cylinder. Slide the piston to the port end of the cylinder.
6. Apply a continuous 0.06-inch (1.5 mm) bead of Loctite® flange sealant, Meritor part number 2297-D-7076, around the DCDL cylinder threads.
7. Screw the DCDL cylinder in place. Tighten the cylinder to 80-100 lb-ft (109-136 N•m). Figure 6.16.

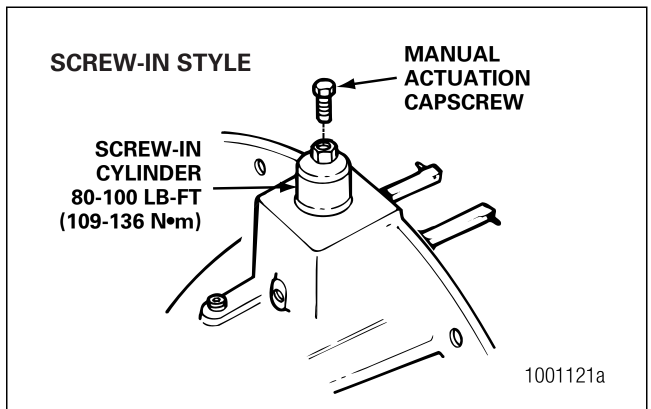


Figure 6.16

8. Snap the shift collar into the fork. Engage the shift collar splines with the splines of the differential case. Use the manual actuation capscrew to move the shift collar splines into the differential case splines. Refer to the procedure in this section.
9. Install the sensor switch into its hole. Tighten the switch to 25-35 lb-ft (35-45 N•m).

10. Connect a volt-ohm meter to the sensor switch. Select ohms on the meter. With the DCDL engaged, the circuit should be closed, showing less than one ohm resistance.
    - **If the resistance value is over one ohm:** Check the sensor.

    A. Verify that the fork is aligned with the sensor switch when it is in the engaged position.

    B. Check for a loose wiring connection. The connector must be tightly seated.

    C. Verify that the sensor switch is fully seated against the carrier.
      - **If the resistance is greater than one ohm after these checks:** Replace the sensor switch.

Screw-In Style Differential Lock Assembly with Bonded Lip Seal Piston

Install the differential shift assembly after the differential carrier is assembled and the gear and bearing adjustments are completed. Figure 6.17.

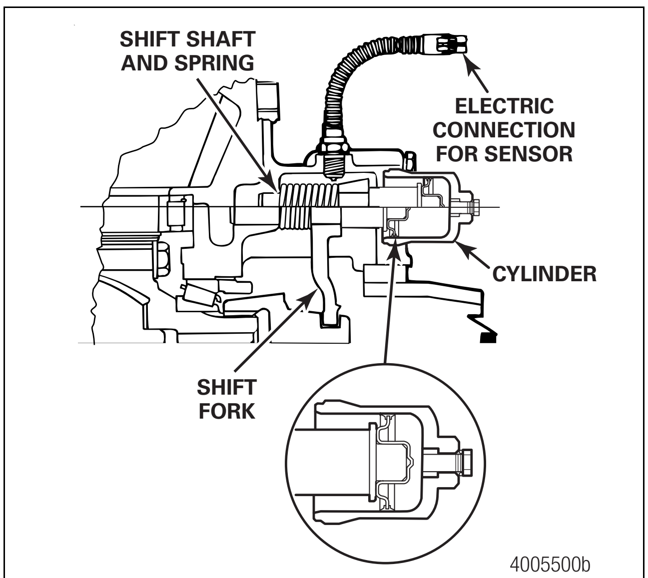


Figure 6.17

1. Install the shift spring and fork into the correct position in the carrier case. Compress the spring slightly while installing the fork.
2. Install the shift shaft into the shaft bore of the carrier. Slide the shaft through the shift fork bore and shift spring inside diameter.
3. Inspect the bonded lip seal piston. Replace the piston if there is any evidence of cuts, cracks, abrasion or wear.
4. Lightly lubricate the bonded lip seal piston and DCDL cylinder bore with the same lubricant used in the axle housing.
5. Install the bonded lip seal piston assembly into the DCDL cylinder. Slide the piston to the port end of the cylinder.
6. Apply a continuous 0.06-inch (1.5 mm) bead of Loctite® flange sealant, Meritor part number 2297-D-7076, around the DCDL cylinder threads.
7. Screw the DCDL cylinder in place. Tighten the cylinder to 80-100 lb-ft (109-136 N•m). Figure 6.18.

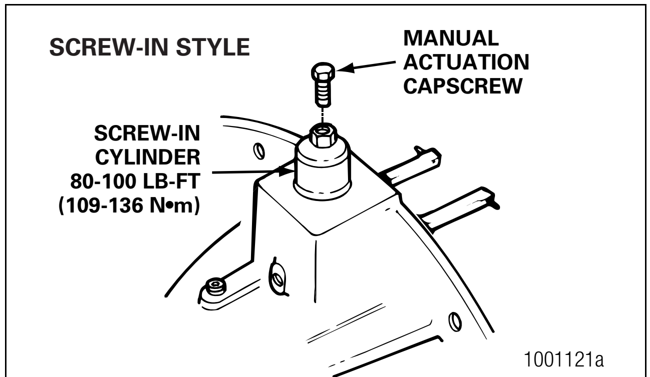


Figure 6.18

8. Snap the shift collar into the fork. Engage the shift collar splines with the splines of the differential case. Use the manual actuation capscrew to move the shift collar splines into the differential case splines. Refer to the procedure in this section.
9. Install the sensor switch into its hole. Tighten the switch to 25-35 lb-ft (35-45 N•m).
10. Connect a volt-ohm meter to the sensor switch. Select ohms on the meter. With the DCDL engaged, the circuit should be closed, showing less than one ohm resistance.
    - **If the resistance value is over one ohm:** Check the sensor.

    A. Verify that the fork is aligned with the sensor switch when it is in the engaged position.

    B. Check for a loose wiring connection. The connector must be tightly seated.

    C. Verify that the sensor switch is fully seated against the carrier.
      - **If the resistance is greater than one ohm after these checks:** Replace the sensor switch.

Differential Lock Assembly Cover Plates

For carriers without the differential lock or air shift, assemble the sensor switch plug and cover plate as follows.

Bolt-On Cover Plate Assemblies

1. Install the washer and plug into the hole for the sensor switch. Tighten the plug to 45-55 lb-ft (60-74 N•m). Figure 6.19.

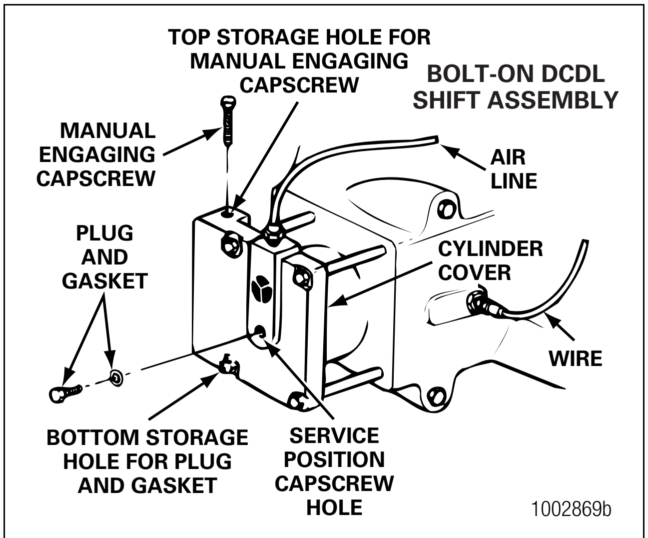


Figure 6.19

2. Apply silicone gasket material to the cover plate mounting surface on the carrier.
3. Install the four washers and capscrews. Tighten the capscrews to 7.4-8.9 lb-ft (10-12 N•m). Figure 6.20.

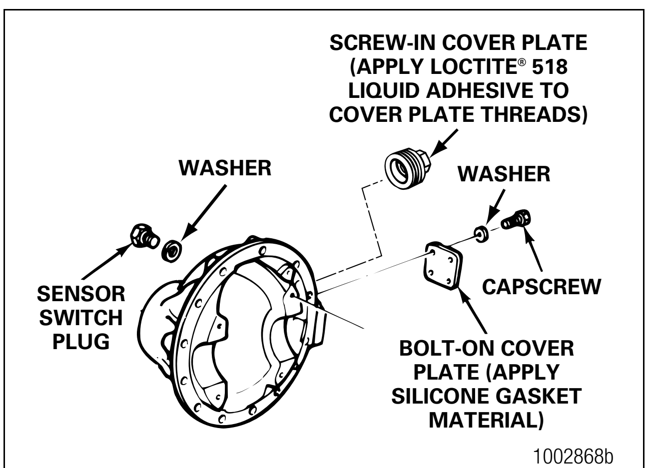


Figure 6.20

Screw-In Cover Plate Assemblies

1. Apply Loctite® 518 liquid adhesive to the plate threads.
2. Install the bolts and washers. Tighten the plate into the carrier opening to 7.5-9.0 lb-ft (10-12 N•m).

Carrier into the Axle Housing

WARNING

Solvent cleaners can be flammable, poisonous and cause burns. Examples of solvent cleaners are carbon tetrachloride, and emulsion-type and petroleum-base cleaners. Read the manufacturer's instructions before using a solvent cleaner, then carefully follow the instructions. Also follow the procedures below.

- **Wear safe eye protection.**
- **Wear clothing that protects your skin.**
- **Work in a well-ventilated area.**
- **Do not use gasoline, or solvents that contain gasoline. Gasoline can explode.**
- **You must use hot solution tanks or alkaline solutions correctly. Read the manufacturer's instructions before using hot solution tanks and alkaline solutions. Then carefully follow the instructions.**

1. Use a cleaning solvent and rags to clean the inside of the axle housing and the mounting surface. Blow dry the cleaned areas with compressed air. Refer to Section 4.
2. Inspect the axle housing for damage. If necessary, repair or replace the housing. Refer to Section 4.
3. Check for loose studs in the mounting surface of the housing where the carrier fastens. Remove and replace any studs where required.
4. Install the differential carrier into the housing, using the Manual Engaging Method.

Manual Engaging Method

1. Align the splines of the shift collar and the differential case half by hand or by installing the right-hand axle shaft through the shift collar and into the side gear.
2. Install the manual engaging capscrew into the threaded hole in the center of the cylinder cover.

⚠ CAUTION

There will be a small amount of spring resistance when you turn in the manual engaging capscrew. If a high resistance is felt before reaching the locked or engaged position, stop turning the capscrew. Damage to components can result.

3. Turn the manual adjusting capscrew to the right until the distance from the head of the capscrew is approximately 0.25-0.50-inch (6-13 mm) from the cylinder cover. Do not turn the capscrew beyond its normal stop. When the capscrew head is in the service position 0.25-0.50-inch (6-13 mm) from the top of the DCDL, the main differential lock is manually engaged.

   A high resistance on the capscrew indicates that the splines of the shift collar and the differential case half are not aligned or engaged.

   Lift the shift collar as required and rotate to align the splines of collar and case half while turning the manual engaging capscrew inward. When the normal amount of spring resistance is again felt on the capscrew, the splines are engaged. Continue to turn in the manual engaging capscrew until the 0.25-0.50-inch (6-13 mm) service position is achieved.
4. Clean both the DCDL actuator and the housing mounting surfaces.
5. Apply silicone gasket material to the cleaned housing surface for the DCDL actuator.
6. Remove the short plug and gasket from the storage hole of the DCDL.
7. Remove the long manual engaging capscrew from the service position in the center of the DCDL to disengage the main differential lock.
8. Clean the plug, gasket, cylinder cover and threaded service position hole in the center of the DCDL cylinder cover.
9. Install the manual engaging capscrew into the DCDL storage hole in the bolt-on or the screw-in DCDL assembly. Figure 6.19 and Figure 6.21. The sealing gasket must be under the head of the capscrew.
   A. On a bolt-on DCDL shift assembly, remove the short plug and gasket from the storage hole of the DCDL.

      Install the short plug and gasket into the service position hole in the center of the DCDL. Figure 6.19.
   B. On a screw-in DCDL shift assembly, install the short screw or plug into the storage hole located in the top of the screw-in DCDL shift assembly. Figure 6.21.

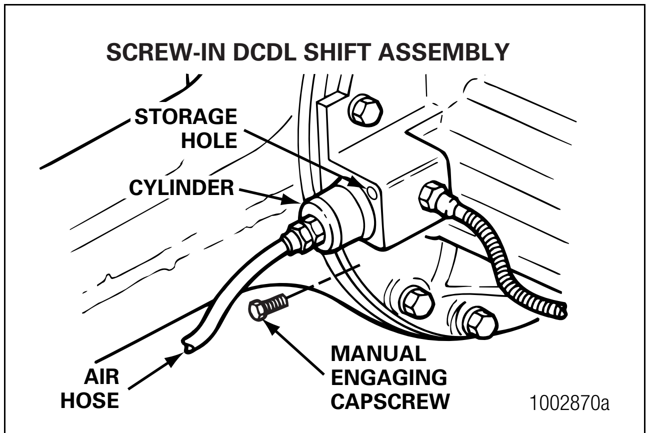


Figure 6.21

10. Tighten the plug, if equipped, to 44-55 lb-ft (60-75 N•m). Tighten the manual engaging capscrew to 22-28 lb-ft (30-38 N•m) for bolt-on style cylinders and to 7-11 lb-ft (10-15 N•m) for screw-in type reverse shifters.
11. Connect the vehicle air line to the differential lock actuator assembly.
12. Install the electrical connection on the sensor switch located in the carrier, below the actuator assembly.
13. Install the right- and left-hand axle shafts. Refer to Section 11.
14. Remove the safety stands from under the drive axle. Lower the vehicle to the floor.
15. Proceed to Check the Differential Lock.

Check the Differential Lock

1. Shift the vehicle transmission into neutral. Start the engine to get the system air pressure to the normal level.

⚠ WARNING

During DCDL disassembly, when the DCDL is in the locked or engaged position and one of the vehicle's wheels is raised from the floor, do not start the engine and engage the transmission. The vehicle can move and cause serious personal injury and damage to components.

2. Place the differential lock switch in the cab of the vehicle in the unlocked or disengaged position.
3. Drive the vehicle at 5-10 mph (8-16 km/h) and check the differential lock indicator light. The light must be off when the switch is in the unlocked or disengaged position.

4. Continue to drive the vehicle and place the differential lock switch in the locked or engaged position. Let up on the accelerator to remove the driveline torque and permit the shift. The light must be on when the switch is in the locked position.

   - **If the indicator light remains ON with the switch in the unlocked position:** The differential is still in the locked position. Verify that the manual engaging capscrew was removed from the cylinder cover of the DCDL shift assembly. Refer to the procedure in this section.

DCDL Driver Caution Label

Verify that the driver caution label is installed in the vehicle cab. Figure 6.22. The caution label must be placed in a location that is easily visible to the driver. The recommended location is on the instrument panel, next to the differential lock switch and lock indicator light.

1003395b

Figure 6.22

Technical Publications

To obtain these items, refer to the Service Notes page on the front inside cover of this manual.

- DCDL driver caution label, TP-86101
- DCDL Driver Instruction Kit (includes DCDL label and technical bulletin), TP-9579
- Traction-Control Video package, T-95125V

Capacities

Meritor recommends using a lubricant analysis program. Perform lubricant analysis at regularly-scheduled preventive maintenance intervals.

For complete information on lubricating drive axles and carriers, refer to Maintenance Manual 1, Preventive Maintenance and Lubrication. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Refer to Table R, Table S, Table T and Table U for standard information on lubricants, schedules and capacities.

Table R: Lubricant Cross Reference (Viscosity) and Temperature Chart

Meritor Lubricant Specification	Description	Cross Reference	Minimum Outside Temperature	Maximum Outside Temperature
O-76-A	Hypoid Gear Oil	GL-5, S.A.E. 85W/140	10° F (–12.2° C)	*
O-76-B	Hypoid Gear Oil	GL-5, S.A.E. 80W/140	–15° F (–26.1° C)	*
O-76-D	Hypoid Gear Oil	GL-5, S.A.E. 80W/90	–15° F (–26.1° C)	*
O-76-E	Hypoid Gear Oil	GL-5, S.A.E. 75W/90	–40° F (–40° C)	*
O-76-J	Hypoid Gear Oil	GL-5, S.A.E. 75W	–40° F (–40° C)	35° F (1.6° C)
O-76-L	Hypoid Gear Oil	GL-5, S.A.E. 75W/140	–40° F (–40° C)	*

* There is no upper limit on these outside temperatures, but the axle sump temperature must never exceed 250° F (121° C).

Table S: Oil Change Intervals and Specifications for All Front Drive and Rear Drive Axles

Vocation or Vehicle Operation	Linehaul Intercity Coach	City Delivery School Bus Fire Truck Motorhome	Construction Transit Bus Refuse Yard Tractor Logging Heavy Haul Mining Oil Field Rescue
Initial Oil Change	No longer required as of January 1, 1993		
Check Oil Level and Breather	Every 25,000 miles (40 000 km) or the fleet maintenance interval, whichever comes first	Every 10,000 miles (16 000 km), once a month or the fleet maintenance interval, whichever comes first	Every 5,000 miles (8000 km), once a month or the fleet maintenance interval, whichever comes first[1]
Petroleum-based oil change on axle with or without pump and filter system	Every 100,000 miles (160 000 km) or annually, whichever comes first	Every 50,000 miles (80 000 km) or annually, whichever comes first	Every 25,000 miles (40 000 km) or annually, whichever comes first
Synthetic oil change on axle with or without pump and filter system[2]	Every 500,000 miles (800 000 km)	Every 100,000 miles (160 000 km) or annually, whichever comes first	Every 50,000 miles (80 000 km) or annually, whichever comes first
Filter change on axle with pump and filter system	Every 100,000 miles (160 000 km)	Every 100,000 miles (160 000 km)	Every 100,000 miles (160 000 km)

1 For continuous heavy-duty operation, check the oil level every 1,000 miles (1600 km). Add the correct type and amount of oil as required.

2 This interval applies to approved semi-synthetic and full-synthetic oils only. For a list of approved extended-drain axle oils, refer to TP-9539, Approved Rear Drive Axle Lubricants. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

Use the lubricant capacities in Table T and Table U as a guide only. The capacities are measured with the drive pinion in the horizontal position. When the angle of the drive pinion changes, the lubricant capacity of the axle will change.

Table T: Single Drive Axles

Axle Model	Capacity* Pints	Liters
MX-10-120	16.0	7.6
MX-12-120	16.0	7.6
MX-14-120	16.0	7.6
MX-16-120	16.0	7.6
MX-21-160/160R	43.0	20.0
MX-23-160/160R	43.0	20.0
RF-7-120	15.3	7.2
RF-9-120	15.3	7.2
RF-12-120	15.3	7.2
RF-12-125	15.3	7.2
RF-16-145	36.4	17.2
RF-21-155	27.9	13.2
RF-21-156	27.9	13.2
RF-21-160	43.7	20.7
RF-21-185	39.3	18.6
RF-21-355	28.0	13.2
RF-22-166	43.7	20.7
RF-23-180	39.3	18.6
RF-23-185	39.3	18.6
RS-13-120	15.0	7.2
RS-15-120	15.0	7.2
RS-16-140	33.6	15.9
RS-16-141	33.6	15.9
RS-16-145	33.6	15.9
RS-17-140	32.0	15.4
RS-17-141	33.6	15.9
RS-17-144	32.3	15.3
RS-17-145	33.6	15.9
RS-19-144	32.3	15.3
RS-19-145	36.0	17.3
RS-21-145	35.0	16.9
RS-21-160	39.5	18.7
RS-23-160	43/41	20.7/19.5
RS-23-160A	39.5	18.7
RS-23-161/161A	37.2	17.6

Table T: Single Drive Axles

Axle Model	Capacity* Pints	Liters
RS-23-180	39.0	18.6
RS-23-185	39.0	18.6
RS-23-186	39.0	18.6
RS-25-160	39.0	18.6
RS-25-160A	37.2	17.6
RS-26-160	51.0	24.2
RS-26-180	38.0	18.3
RS-26-185	38.0	18.3
RS-30-180	38.0	18.3
RS-30-185	38.0	18.3

* Includes one pint (0.97 liter) for each wheel end and with a drive pinion angle at three degrees.

Table U: Rear Axle of Tandems

Axle Model	Capacity Pints	Liters
RT-34-140 (RR-17-140)	35.0	16.9
RT-34-144	25.8	12.2
RT-34-145 (RR-17-145 rear)	25.4	12.0
RT-34-145P	25.4	12.0
RT-34-146	25.4	12.0
RT-40-140 (RR-20-140)	25.8	12.2
RT-40-145/149 (RR-20-145 rear)	25.8	12.2
RT-40-145P	25.8	12.2
RT-40-146	25.8	12.2
RT-40-160	34.4	16.3
RT-40-169	34.4	16.3
RT-44-145 (RR-22-145 rear)	25.1	11.9
RT-44-145P	25.1	11.9
RT-46-160/169 (RR-23-160 rear)	34.4	16.3
RT-46-160A/160P	34.4	16.3
RT-46-164	33.2	15.7
RT-46-164EH/16HEH	33.2	15.7
RT-48-180 (RR-24-180 rear)	36.8	17.5
RT-50-160/160P	33.2	15.7
RT-52-160 (RR-26-160 rear)	41.2	19.5
RT-52-180/185 (RR-26-180 rear)	36.1	17.1
RT-58-180/185 (RR-29-180 rear)	36.1	17.1

Fasteners

The torque values in Table V are for fasteners that have a light application of oil on the threads.

- **If the fasteners are dry:** Increase the torque values by 10 percent.
- **If the fasteners have a heavy application of oil on the threads:** Decrease the torque values by 10 percent.

If you do not know the size of the fastener that is being installed, measure the fastener. Use the following procedure.

Compare the size of the fastener measured to the list of fasteners in Table V to find the correct torque value.

American Standard Fasteners

1. Measure the diameter of the threads in inches, dimension X. Figure 8.1.

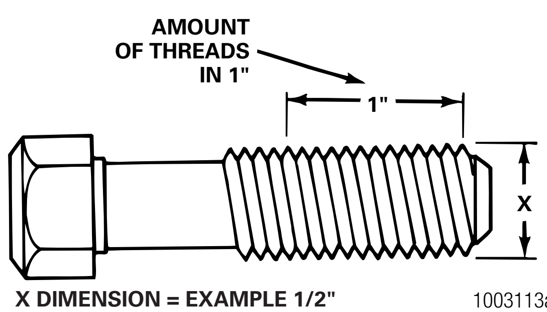


Figure 8.1

2. Count the amount of threads in one-inch. Figure 8.1.

Example

American Standard size fastener is 0.50-13.

- 0.50 is the diameter of the fastener in inches or dimension X.
- 13 is the amount of threads in one-inch.

Metric Fasteners

1. Measure the diameter of the threads in millimeters (mm), dimension X. Figure 8.2.

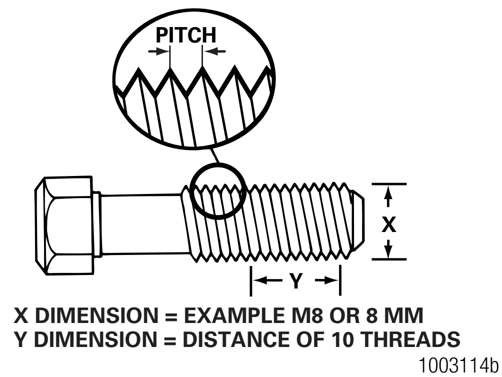


Figure 8.2

2. Measure the distance of 10 threads, point to point in millimeters (mm), dimension Y. Make a note of dimension Y. Figure 8.2.
3. Divide dimension Y by 10. The result will be the distance between two threads or pitch.

Example

Metric size fastener is M8 x 1.25.

- M8 is the diameter of the fastener in millimeters (mm) or dimension X.
- 1.25 is the distance between two threads or pitch.

Torque Specifications

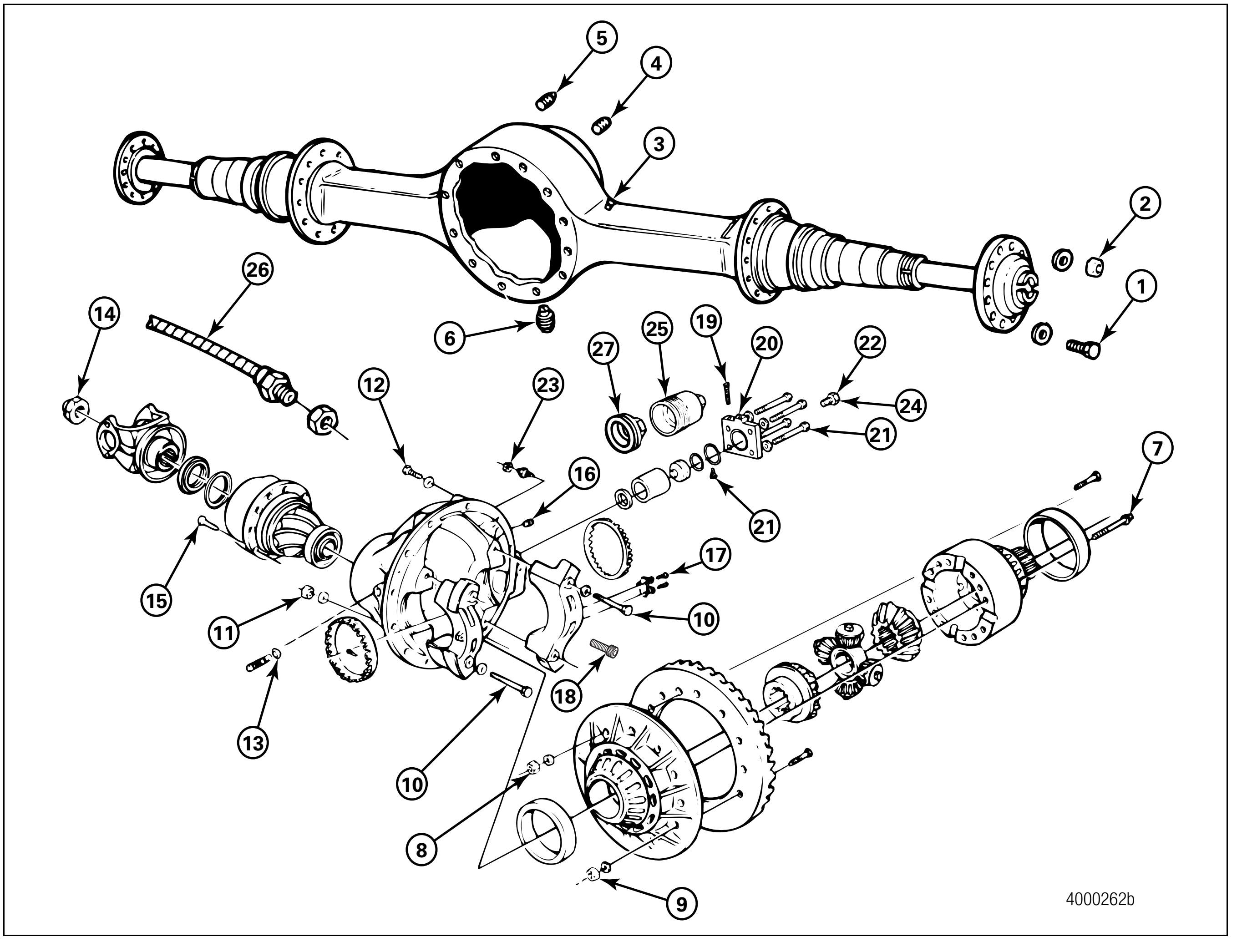


Table V: Torque Chart

Fastener		Thread Size	Torque lb-ft	Torque N•m
1	Axle Shaft Capscrew	0.31-24	18-24	24-33
		0.50-13	85-115	115-156
2	Axle Shaft Stud Nut	Plain Nut		
		0.44-20	50-75	68-102
		0.50-20	75-115	102-156
		0.56-18	110-165	149-224
		0.62-18	150-230	203-312
		Locknut		
		0.44-20	40-65	54-88
		0.50-20	65-100	88-136
		0.56-18	100-145	136-197
		0.62-18	130-190	176-258

Table V: Torque Chart

Fastener		Thread Size	Torque lb-ft	Torque N•m
3	Breather	0.38-18	20 minimum	27 minimum
4	Housing Oil Fill Plug	0.75-14	35 minimum	47.5 minimum
5	Heat Indicator Plug	0.50-14	25 minimum	34 minimum
6	Oil Drain Plug	0.50-14	25 minimum	34 minimum
7	Differential Case Capscrew	0.38-16	35-50	48-68
		0.44-14	60-75	81-102
		0.50-13	85-115	115-156
		0.56-12	130-165	176-224
		0.62-11	180-230	244-312
		M12 x 1.75, Grade 10.9 Flange Head	85-103	115-140
		M12 x 1.75, Grade 10.9 Standard Hex Head	74-96	100-130
		M12 x 1.75, Grade 12.9 Standard Hex Head	105-125	143-169
		M16 x 2, Grade 12.9 Flange Head	203-251	275-340
		M16 x 2, Grade 12.9 Standard Head	220-310	300-420
8	Differential Case Bolt Nut	0.50-13	75-100	102-136
		0.50-20	85-115	115-156
		0.62-11	150-190	203-258
		0.62-18	180-230	244-312
		0.87-14	600-700	815-950
		M12 x 1.75	74-96	100-130
		M16 x 2	220-310	300-420
9	Ring Gear Bolt Nut	0.50-13	75-100	102-136
		0.50-20	85-115	115-156
		0.62-11	150-190	203-258
		0.62-18	180-230	244-312
		0.87-14	600-700	816-952
		M12 x 1.25	66-81	90-110
		M12 x 1.75	77-85	104-115
		M16 x 1.5, Flange Head	192-214	260-190
		M16 x 1.5, Standard Hex Head	196-262	265-355
10	Bearing Cap Capscrew	0.56-12	110-145	149-197
		0.62-11	150-190	203-258
		0.75-10	270-350	366-475
		0.88-14	360-470	488-637
		0.88-9	425-550	576-746
		M16 x 2	181-221	245-300
		M20 x 2.5	347-431	470-585
		M22 x 2.5	479-597	650-810
11	Housing-to-Carrier Stud Nut	0.44-20	50-75	68-102
		0.50-20	75-115	102-156
		0.56-18	110-165	149-224
		0.62-18	150-230	203-312

Table V: Torque Chart

Fastener		Thread Size	Torque lb-ft	Torque N•m
12	Carrier-to-Housing Capscrew	0.44-14	50-75	68-102
		0.50-13	75-115	102-156
		0.56-12	110-165	149-224
		0.62-11	150-230	203-312
		0.75-10	270-400	366-542
		M12 x 1.75	74-89	100-120
		M16 x 2	181-221	245-300
13	Thrust Screw Jam Nut	0.75-16	150-190	203-258
		0.88-14	150-300	203-407
		1.12-16	150-190	203-258
		M22 x 1.5	148-210	200-285
		M30 x 1.5	236-295	320-400
14	Input Yoke-to-Input Shaft Nut	Refer to Table W.		
15	Bearing Cage Capscrew	0.38-16	30-50	41-68
		0.44-14	50-75	68-102
		0.50-13	75-115	102-156
		0.56-12	110-165	149-224
		0.62-11	150-230	203-312
		M12 x 1.75	70-110	90-150
16	Carrier Oil Fill Plug	0.75-14	25 minimum	34 minimum
		1.5-11.5	120 minimum	163 minimum
		M24 x 1.5	35 minimum	47 minimum
17	Lock Plate Capscrew	0.31-18	20-30	27-41
		M8 x 1.25	21-26	28-35
18	Adjusting Rings Capscrews	—	21-28	28-38
Torque Values for Carriers with Bolt-On Style Differential Lock Cylinders				
19	Manual Actuation Storage Position Capscrew	M10 x 1.5	15-25	20-35
20	Air Cylinder Adapter	M12 x 1.5	22-30	30-40
21	Air Cylinder Cover Capscrew	M6 x 1	7-12	10-16
22	Air Cylinder Cover Capscrew/ Plug, Operating and Storage Position	M10 x 1.5	15-25 15-25	20-35 20-35
23	Sensor Switch Locknut	M16 x 1	25-35	35-45
Torque Values for Carriers with Screw-In Style Differential Lock Cylinders				
24	Manual Actuation Storage Position Capscrew	M10 x 1.25	7-11	10-15
25	Air Cylinder	M60 x 2.0	80-100	109-136
26	Sensor Switch	M16 x 1.0	25-35	35-45
27	Screw-In DCDL Cylinder Plug or Cap	M60 x 2.0	80-100	109-136

Input and Output Yoke Pinion Nut Fastener Torque Specifications

Table W: Single and Rear of Tandem Axles

Axle Model Pinion Nut Location	RS-120, RS-125, RS-140	RS-144/145	RF-166, RS-160, RS-161, RS-185, RS-186	RS-210, RS-220, RS-230	RS-240	RS-380
Carrier Input Yoke	740-920 lb-ft (1000-1245 N•m)	920-1130 lb-ft (1250-1535 N•m)	1000-1230 lb-ft (1350-1670 N•m)	740-920 lb-ft (1000-1245 N•m)	740-920 lb-ft (1000-1245 N•m)	800-1100 lb-ft (1085-1496 N•m)
Fastener Size	M32 x 1.5	M39 x 1.5	M45 x 1.5	M32 x 1.5	M39 x 1.5	1-1/2 - 12 UNF

Table X: Drive Pinion Bearings — Preload

Specification	New bearings 5-45 lb-in (0.56-5.08 N•m) Used bearings in good condition 5-25 lb-in (1.7-2.8 N•m)
Adjustment	Preload is controlled by the thickness of the spacer between the bearings. To increase the preload, install a thinner spacer. To decrease the preload, install a thicker spacer.

Table Y: Drive Pinion — Depth in Carrier

Specification	Install the correct amount of shims between the inner bearing cup of the drive pinion and the carrier. To calculate, use the old shim pack thickness and the new and old pinion cone numbers.
Adjustment	Change the thickness of the shim pack to get a good gear tooth contact pattern.

Table Z: Hypoid Gear Set — Tooth Contact Patterns (Hand Rolled)

Specification	Conventional gear set Toward the toe of the gear tooth and in the center between the top and bottom of the tooth. Generoid gear set Between the center and toe of the tooth and in the center between the top and bottom of the tooth.
Adjustment	Tooth contact patterns are controlled by the thickness of the shim pack between the pinion bearing cage and carrier and by ring gear backlash. To move the contact pattern lower, decrease the thickness of the shim pack under the pinion bearing cage. To move the contact pattern higher, increase the thickness of the shim pack under the pinion bearing cage. To move the contact pattern toward the toe of the tooth, decrease the backlash of the ring gear. To move the contact pattern toward the heel of the tooth, increase the backlash of the ring gear.

Table AA: Main Differential Bearings — Preload

Specification	15-35 lb-in (1.7-3.9 N•m) or Expansion between bearing caps RS-140, RS-145 and RS-160 carrier models — 0.002-0.009-inch (0.05-0.229 mm) All other carrier models — 0.006-0.013-inch (0.15-0.33 mm)
Adjustment	Preload is controlled by tightening both adjusting rings after zero end play is reached.

Table AB: Main Differential Gears — Rotating Resistance

Specification	50 lb-ft (68 N•m) maximum torque applied to one side gear

Table AC: Ring Gear — Backlash

Specification	Ring gears that have a pitch diameter of less than 17-inches (431.8 mm) Range: 0.008-0.018-inch (0.20-0.46 mm) 0.012-inch (0.30 mm) for a new gear set Ring gears that have a pitch diameter of 17-inches (431.8 mm) or greater Range: 0.010-0.020-inch (0.25-0.51 mm) 0.015-inch (0.38 mm) for a new gear set
Adjustment	Backlash is controlled by the position of the ring gear. Change the backlash within specifications to get a good tooth contact pattern. To increase the backlash, move the ring gear away from the drive pinion. To decrease the backlash, move the ring gear toward the drive pinion.

Table AD: Ring Gear — Runout

Specification	0.008-inch (0.20 mm) maximum

Table AE: DCDL Sensor Switch — Installation

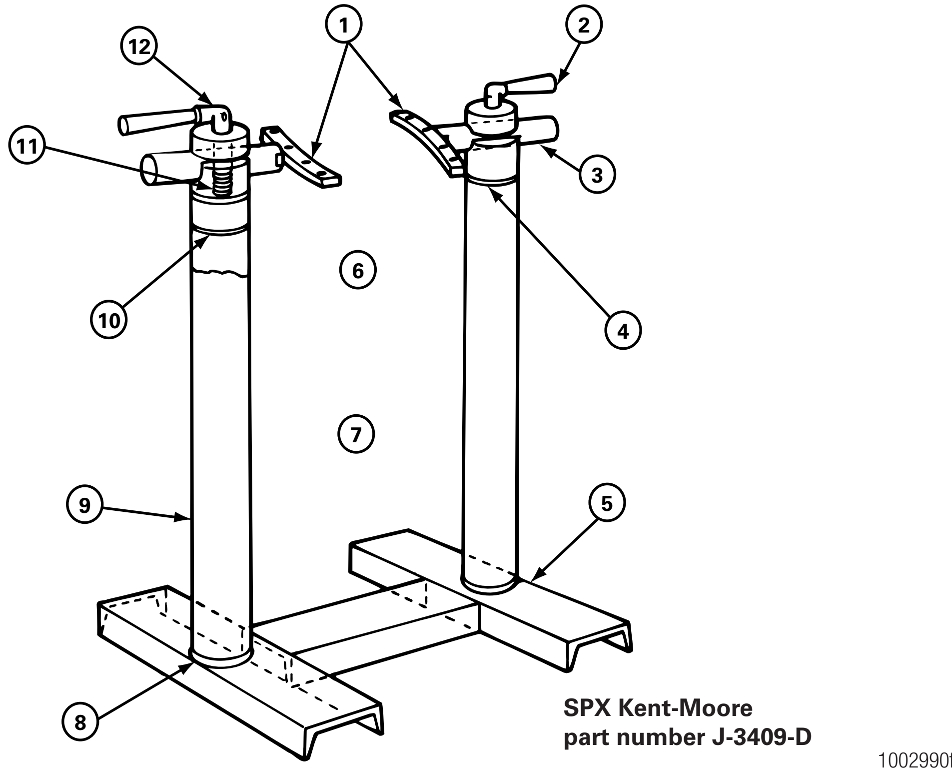
Adjustment	Shift the differential to the locked position. Tighten the sensor switch into the carrier until the test light illuminates. Tighten the sensor switch one additional turn. Tighten the jam nut to the specified torque.

Table AF: Spigot Bearing — Peening on the Drive Pinion

Specification	Apply 6,614 lb (3000 kg) load on a 0.375-inch (10 mm) ball. Peen the end of the drive pinion at a minimum of five points. Softening of the pinion stem end by heating may be required.

Specifications

Carrier Repair Stand



1 PLATES 8′ LONG x 3/4″ THICK x 1-1/4″ WIDE WITH A TONGUE TO FIT SLOT IN BAR WELD PLATES TO BAR
2 HANDLE 7″ LONG WITH SLOT IN ONE END TO FIT CLAMP SCREW
3 BAR 2″ DIAMETER x 9″ LONG WITH ONE END SLOTTED TO FIT PLATE
4 WELD ALL AROUND AFTER PRESSING PLUG IN PIPE
5 WELD
6 SHAPE AND SIZE OF HOLES TO FIT CARRIER
7 23-1/2″ CENTER TO CENTER OF PIPE
8 CHAMFER END OF PIPE FOR WELDING
9 4″ DIAMETER PIPE
10 PLUG 4″ DIAMETER x 7″ LONG WITH ONE END TURNED 3″ LONG TO FIT PIPE. DRILL 2″ HOLE AND MILL 3/16″ WIDE SLOT 2″ FROM TOP
11 SCREW 3-1/2″ LONG x 5/8″ DIAMETER WITH FLATS ON END TO FIT HANDLE AND 2-1/2″ LENGTH OF THREAD ON OTHER END
12 DRILL 3/8″ HOLE THROUGH HANDLE AND SCREW

Figure 10.1

To obtain a repair stand, refer to the Service Notes page on the front inside cover of this manual.

How to Make a Yoke Bar

1. Measure dimensions A and B of the yoke you are servicing. Figure 10.2.

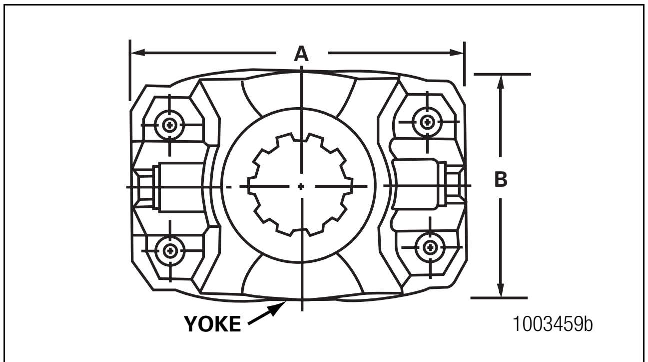


Figure 10.2

2. Calculate dimensions C and D of the yoke bar by adding 0.125-0.250-inch to dimensions A and B of the yoke. Figure 10.3.

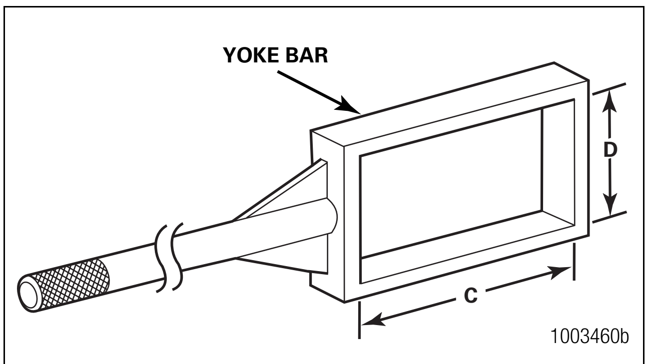


Figure 10.3

WARNING

Wear safe clothing and eye protection when you use welding equipment. Welding equipment can burn you and cause serious personal injury. Follow the operating instructions and safety procedures recommended by the welding equipment manufacturer.

3. To make the box section, cut and weld one-inch x two-inch mild steel square stock according to dimensions C and D. Figure 10.3.

4. Cut a four-foot x 1.25-inch piece of mild steel round stock to make the yoke bar handle. Center weld this piece to the box section. Figure 10.3.
   - **To increase yoke bar rigidity:** Weld two angle pieces onto the handle. Figure 10.3.

Unitized Pinion Seals and Seal Drivers

Refer to Table AG and Figure 10.4 for information on unitized pinion seals and seal drivers. To obtain Meritor seal driver KIT 4454, refer to the Service Notes page on the front inside cover of this manual.

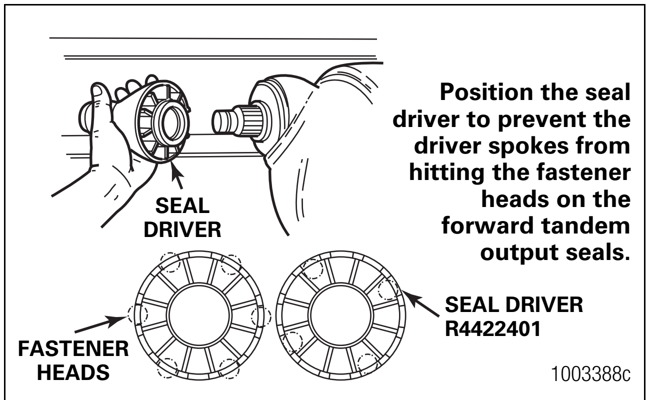


Figure 10.4

Table AG: Unitized Pinion Seals and Seal Drivers

Single Models	Tandem Models	Meritor Unitized Pinion Seal	Seal Installation Location	Meritor Seal Driver	Yoke Seal Diameter Inches
RS-17-145 RS-19-145 RS-21-145 RS-21-160 RS-23-160 /A RS-23-161 /A RS-25-160 /A RS-23-186 RS-26-185 RS-30-185	RT-34-144 /P RT-34-145 /P RT-40-145 /A /P RT-40-149 /A /P RT-44-145 /P RT-40-160 /A /P RT-40-169 /A /P RT-46-160 /A /P RT-46-169 /A /P RT-46-164EH /P RT-46-16HEH /P RT-50-160 /P RT-52-185* RT-58-185*	A-1205-R-2592	Tandem Forward Input — 145 models from November 1993 to present	R4422402	3.250 3.255
		A-1205-P-2590	Tandem Forward Output — Tandem Forward Input 145 models before November 1993 with seal A-1205-F-2424	R4422401	3.000 3.005
		A-1205-N-2588	Tandem and Single Rear Input — 145 models	R4422401	3.000 3.005
		A-1205-Q-2591	Tandem and Single Rear Input — 160/164/185 models	R4422402	3.250 3.255

* Forward and rear input only.

Multiple Lip Seals (MLS) and Seal Drivers

Refer to Table AH for information on multiple lip seals and seal drivers. To obtain Meritor seal driver KIT 4454, refer to the Service Notes page on the front inside cover of this manual.

Table AH: Multiple Lip Seals and Seal Drivers*

Single Models	Tandem Models	Axle Model and Position	Seal Service Part Number	Previous Seal Part Number	Seal Drivers	Sleeve Drivers
MX-21-160 MX-23-160R RF-16-145 RF-21-160 RF-22-166 RF-23-185 RS-17-145 RS-19-145 RS-21-145 RS-21-160 RS-23-160 /A RS-23-161 /A RS-25-160 /A RS-23-186 RS-26-185 RS-30-185	RT-34-144 /P RT-34-145 /P MT-40-143 RT-40-145 /A /P RT-40-149 /A /P RT-44-145 /P RT-40-160 /A /P RT-40-169 /A /P RT-46-160 /A /P RT-46-169 /A /P RT-46-164EH /P RT-46-16HEH /P RT-50-160 /P RT-52-185* RT-58-185*	14X/16X/18X/38X Forward-Rear Unit Input (FUI)	A1-1205X2728	A-1205R2592	2728T1	2728T2
		14X/16X Forward-Rear Unit Output (FUO)	A1-1205Y2729	A-1205P2590	2729T1	2729T2
		14X Rear-Rear Unit Input (RUI)	A1-1205Z2730	A-1205N2588	2730T1	Not Required — Sleeve is unitized
		16X/18X Rear-Rear Unit Input (RUI)	A1-1205A2731	A-1205Q2591	2731T1	Not Required — Sleeve is unitized

* Forward and rear input only.

Forward input and output seals must be serviced with the seal and sleeve. The service part number provides both when required.

Hazard Alert Messages

Read and observe all Warning and Caution hazard alert messages in this publication. They provide information that can help prevent serious personal injury, damage to components, or both.

⚠ WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Before you service a spring chamber, carefully follow the manufacturer's instructions to compress and lock the spring to completely release the brake. Verify that no air pressure remains in the service chamber before you proceed. Sudden release of compressed air can cause serious personal injury and damage to components.

Engage the parking brake to prevent the vehicle from moving before you begin maintenance or service procedures that require you to be under the vehicle. Serious personal injury can result.

⚠ CAUTION

If the vehicle is equipped with a front drive axle, tow the vehicle from the front, with the front wheels off the ground. If this is not possible, you must remove the front drive shaft before towing. Damage to components can result.

Do not use a chisel or wedge to loosen the axle shaft and tapered dowels. A chisel or wedge can result in damage to the axle shaft, the gasket and seal, and the axle hub.

NOTE: For complete towing information, refer to Technical Bulletin TP-9579, Driver Instruction Kit. To obtain this publication, refer to the Service Notes page on the front inside cover of this manual.

These instructions supersede all other instructions for the purpose of transporting vehicles for service or new vehicle drive-away dated before April 1995, including those contained in Meritor maintenance manuals.

When transporting a vehicle with the wheels of one or both drive axles on the road, it is possible to damage the axles if the wrong procedure is used before transporting begins. Meritor recommends that you use the following procedure.

Type of Axle

Single Axle with DCDL — Screw-In (Threaded) Shift Assembly, or Tandem Axle with DCDL — Screw-In (Threaded) Shift Assembly and with Inter-Axle Differential (IAD)

Before Towing or Drive-Away

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Apply the vehicle parking brakes using the switch inside the cab of the vehicle.
3. Shift the transmission into neutral and start the vehicle's engine.
4. Shift the DCDL and the IAD to the unlocked or disengaged positions using the switches inside the cab of the vehicle. The indicator lights in the cab will go off.
5. Stop the engine.

NOTE: Remove only the axle shaft(s), shown in Table AI at this time, from the axle(s) that will remain on the road when the vehicle is transported.

6. Remove the stud nuts or capscrews and washers from the flange of the axle shaft. Figure 11.1.

Table AI

Single Axles	
	Remove the left-hand, road side, axle shaft
Tandem Axles	
	Forward Axle
	Remove the right-hand, curbside, axle shaft
	Rear Axle
	Remove the left-hand, roadside, axle shaft

7. Loosen the tapered dowels, if used, in the flange of the axle shaft. Refer to Section 3 for the recommended tools and removal procedures.
8. Install a cover over the open end of each hub where an axle shaft was removed. This will prevent dirt from entering the bearing cavity and loss of lubricant.

NOTE: If an air supply will be used for the brake system of the transported vehicle, continue with Step 9 and Step 10, otherwise continue with Step 11.

9. Connect an auxiliary air supply to the brake system of the vehicle that is being transported. Before moving the vehicle, charge the brake system with the correct amount of air pressure to operate the brakes. Refer to the instructions supplied by the manufacturer of the vehicle for procedures and specifications. If an auxiliary air supply is not used, continue with Step 11.
10. When the correct amount of air pressure is in the brake system, release the parking brakes of the vehicle that is being transported. Step 11 is not required.
11. If there are spring or parking brakes on the axle(s) that will remain on the road when the vehicle is transported, and they cannot be released by air pressure, manually compress and lock each spring so that the brakes are released. Refer to the manufacturer's instructions.

After Towing or Drive-Away

1. If an auxiliary air supply was used, apply the vehicle parking brakes using the switch inside the cab of the vehicle. If an auxiliary air supply was not used, begin with Step 2.
2. Apply the vehicle spring or parking brakes by manually releasing each spring that was compressed before transporting started. Refer to the manufacturer's instructions.
3. Disconnect the auxiliary air supply, if used, from the brake system of the vehicle that was transported. Connect the vehicle's air supply to the brake system.
4. Remove the covers from the hubs.

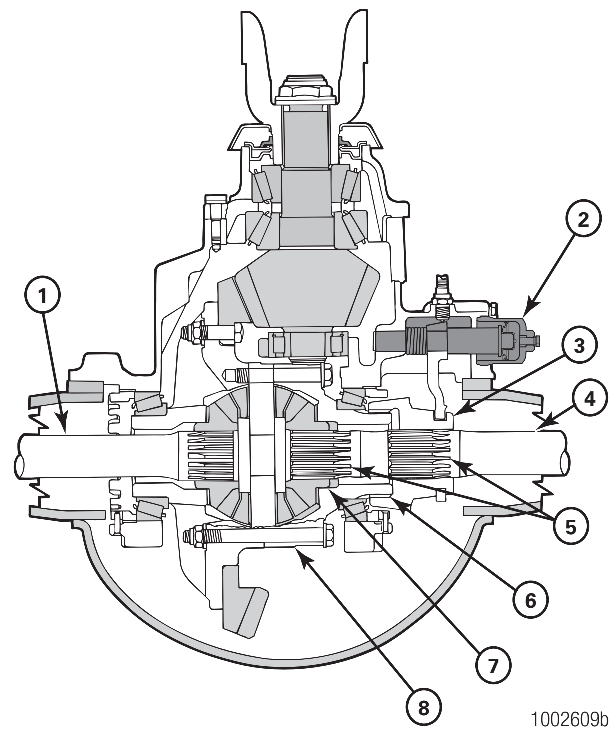
NOTE: Install only the axle shaft(s) shown in Table AJ at this time. These axle shafts have a double row of splines that engage with the splines of the side gear and shift collar in the main differential. Figure 11.1.

5. Install the gasket, if used, and axle shaft into the axle housing and carrier in the same location. The gasket and flange of the axle shaft must be flat against the hub. Rotate the axle shaft or the driveline as necessary to align the splines and the holes in the flange with the studs in the hub. Figure 11.1.

Table AJ

Single Axles	
	Install the right-hand, curbside, axle shaft
Tandem Axles	
Forward Axle	Install the left-hand, roadside, axle shaft
Rear Axle	Install the right-hand, curbside, axle shaft

SINGLE AXLE OR REAR AXLE OF TANDEM SHOWN WITH SCREW-IN DCDL SHIFT ASSEMBLY AND SHOWN IN THE LOCKED OR ENGAGED POSITION



1 LEFT-HAND, ROADSIDE, AXLE SHAFT
2 SHIFT ASSEMBLY
3 SHIFT COLLAR
4 RIGHT-HAND, CURBSIDE, AXLE SHAFT
5 DOUBLE ROW OF SPLINES
6 SHIFT COLLAR AND DIFFERENTIAL CASE SPLINES ENGAGED OR LOCKED
7 SIDE GEAR
8 DIFFERENTIAL CASE

Figure 11.1

6. Install the dowels, if used, over each stud and into the tapered holes of the flange.
7. Install the washers and capscrews or stud nuts. Determine the size of the fasteners and tighten the capscrews or nuts to the corresponding torque value shown in Table AK.

Table AK

Fastener	Thread Size	Torque Value lb-ft (N•m)
Capscrews	0.31"-24	18-24 (24-33)
	0.50"-13	85-115 (115-156)
Stud Nuts	0.44"-20	50-75 (68-102)
Plain Nut	0.50"-20	75-115 (102-156)
	0.56"-18	110-165 (149-224)
	0.62"-18	150-230 (203-312)
	0.75"-16	310-400 (420-542)
Locknut	0.44"-20	40-65 (54-88)
	0.50"-20	65-100 (88-136)
	0.56"-18	100-145 (136-197)
	0.62"-18	130-190 (176-258)
	0.75"-16	270-350 (366-475)

8. Unlock or disengage the DCDL by removing the manual engaging capscrew from the shift assembly.
9. Install the manual engaging capscrew into the storage hole. The storage hole of threaded shift assemblies is located in the shift tower of the carrier next to the cylinder. Tighten the capscrew to 15-25 lb-ft (20-35 N•m). Figure 11.2.
10. Connect the air hose to the shift cylinder. Tighten the air hose to 22-30 lb-ft (30-40 N•m).
11. Install the remaining axle shaft into the axle housing and carrier.
12. Check the lubricant level in the axles and hubs where the axle shafts were removed. Add the correct type and amount of lubricant if necessary. Refer to Section 7.

Single Axle with DCDL — Bolt-On Shift Assembly, or Tandem Axle with DCDL — Bolt-On Shift Assembly and with Inter-Axle Differential (IAD)

Before Towing or Drive-Away

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Apply the vehicle parking brakes using the switch inside the cab of the vehicle.
3. Shift the transmission into neutral and start the vehicle's engine.
4. Shift the DCDL and the IAD to the unlocked or disengaged positions using the switches inside the cab of the vehicle. The indicator lights in the cab will go off.
5. Stop the engine.

NOTE: Remove only the axle shaft(s), shown in Table AL at this time, from the axle(s) that will remain on the road when the vehicle is transported.

6. Remove the stud nuts or capscrews and washers from the flange of the axle shaft. Figure 11.2.

Table AL

Single Axles	
	Remove the left-hand, roadside, axle shaft
Tandem Axles	
	Forward Axle
	Remove the right-hand, curbside, axle shaft
	Rear Axle
	Remove the left-hand, roadside, axle shaft

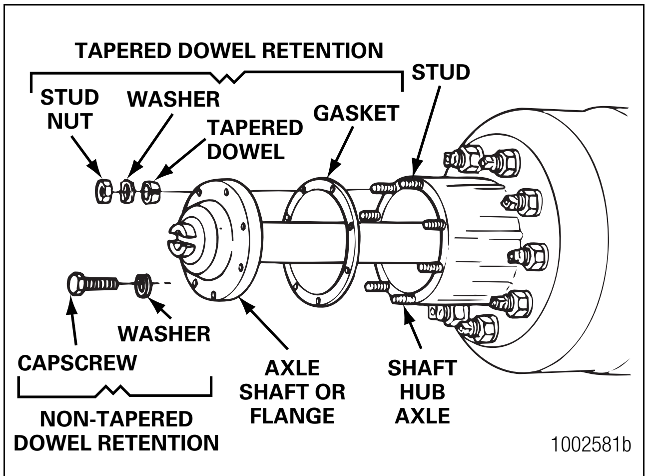


Figure 11.2

7. Loosen the tapered dowels, if used, in the flange of the axle shaft. Figure 11.2.
8. Identify each axle shaft that is removed from the axle assembly so they can be installed in the same location after transporting or repair is completed.
9. Remove the tapered dowels, gasket, if used, and the axle shaft from the axle assembly. Figure 11.2.
10. Remove the manual engaging capscrew from the storage hole. The storage hole of the bolted-on shift assemblies is located in the top side of the shift cylinder cover. Figure 11.3.

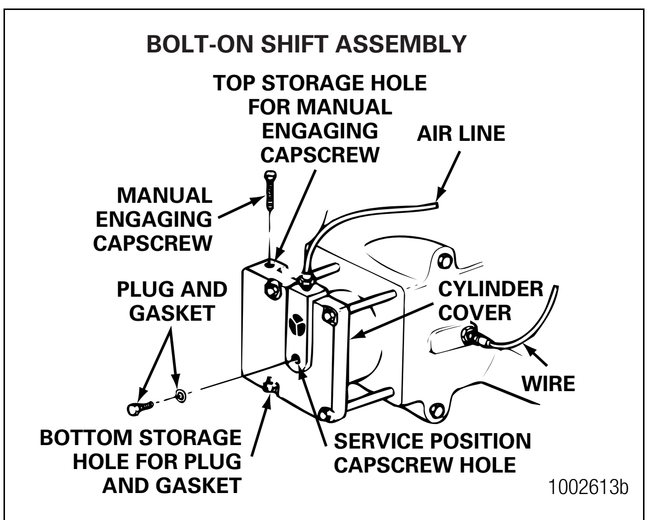


Figure 11.3

11. Remove the plug and gasket from the center of the shift cylinder cover. Install the plug and gasket into the bottom side storage hole of the shift cylinder cover, on the opposite end of the storage hole for the manual engaging capscrew. Tighten the plug to 15-25 lb-ft (20-35 N•m). Figure 11.3.
12. Lock or engage the main differential using one of the two following methods: Air Pressure Method or Manual Engaging Method.
13. Lock or engage the main differential using the air pressure method.
    A. Install the manual engaging capscrew into the threaded hole in the center of the cylinder cover. Turn the capscrew to the right three to five turns. Figure 11.4.
    B. Shift the transmission into neutral and start the vehicle's engine. Let the engine idle to increase the pressure in the air system. Do not release the parking brake.
    C. Shift the main differential to the locked or engaged position using the switch inside the cab of the vehicle. When the differential is locked, the indicator light in the cab will go on.
        - **If the light does not go on:** Rotate the main driveline or the IAD by hand until the main differential is locked and the indicator light goes on.

NOTE: When the shift collar is completely engaged with the splines of the main differential case, the differential is locked and the driveline cannot be rotated. Figure 11.5.

    D. While the differential is held in the locked position by air pressure, turn the manual engaging capscrew to the right until you feel resistance against the piston. Stop turning the capscrew.
    E. Place the main differential lock switch in the unlocked or disengaged position.
    F. Stop the engine. Proceed to Step 15.

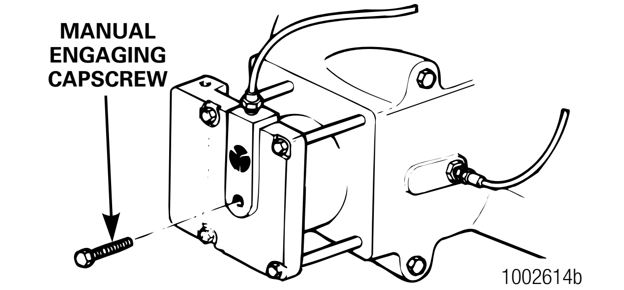
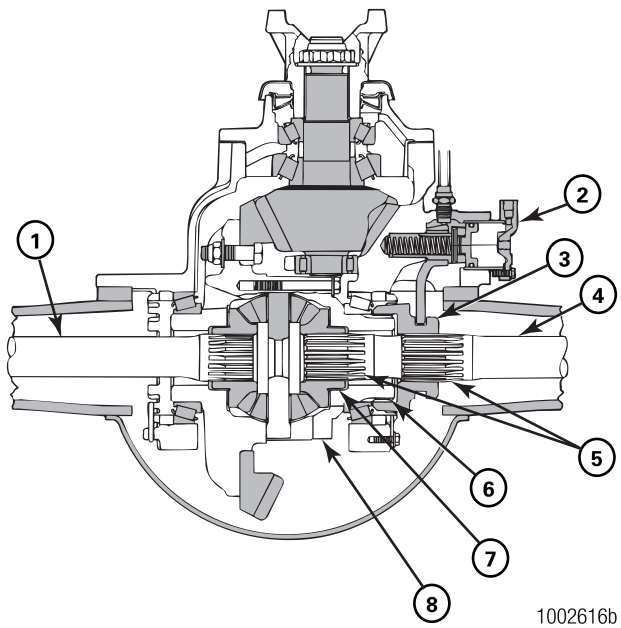


Figure 11.4



1 LEFT-HAND, ROADSIDE, AXLE SHAFT
2 SHIFT ASSEMBLY
3 SHIFT COLLAR
4 RIGHT-HAND, CURBSIDE, AXLE SHAFT
5 DOUBLE ROW OF SPLINES
6 SHIFT COLLAR AND DIFFERENTIAL CASE SPLINES ENGAGED, LOCKED
7 SIDE GEAR
8 DIFFERENTIAL CASE

Figure 11.5

14. Lock or engage the main differential using the manual engaging method.

A. Install the manual engaging capscrew into the threaded hole in the center of the cylinder cover. Figure 11.4.

⚠ CAUTION

When you turn the manual engaging capscrew and you feel a high resistance, stop turning the capscrew. A high resistance against the capscrew indicates that the splines of the shift collar and differential case are not aligned. Damage to the threads of the cylinder cover and capscrew will result.

B. Turn the capscrew to the right until the head is approximately 0.25-0.50-inch (6.4-12.7 mm) from the cylinder cover. The capscrew is now in the service position and the main differential is locked or engaged. Figure 11.6. When you turn the capscrew, you will feel a small amount of resistance. This is normal.

- **If you feel a high resistance before achieving the 0.25-0.50-inch (6.4-12.7 mm) distance between the capscrew head and cylinder:** Stop turning the capscrew, and continue with Step C, Step D and Step E.

C. Rotate the main driveline or the IAD a small amount by hand.

D. Turn the manual engaging capscrew again to the right. If you still feel a high resistance, stop turning the capscrew.

E. Repeat Step C and Step D until you feel a low resistance on the capscrew. Continue with Step B.

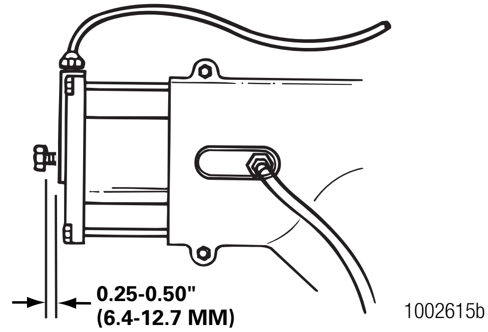


Figure 11.6

15. Remove the remaining axle shaft(s) from the axle(s) that will remain on the road when the vehicle is transported.
16. Install a cover over the open end of each hub where an axle shaft was removed. This will prevent dirt from entering the bearing cavity and loss of lubricant.

NOTE: If an air supply will be used for the brake system of the transported vehicle, continue with Step 17 and Step 18. Otherwise, continue with Step 19.

17. Connect an auxiliary air supply to the brake system of the vehicle that is being transported. Before moving the vehicle, charge the brake system with the correct amount of air pressure to operate the brakes. Refer to the instructions supplied by the manufacturer of the vehicle for procedures and specifications. If an auxiliary air supply is not used, continue with Step 19.
18. When the correct amount of air pressure is in the brake system, release the parking brakes of the vehicle that is being transported. Step 19 is not required.
19. If there are spring or parking brakes on the axle(s) that will remain on the road when the vehicle is transported, and they cannot be released by air pressure, manually compress and lock each spring so that the brakes are released. Refer to the manufacturer's instructions.

After Towing or Drive-Away

1. If an auxiliary air supply was used, apply the vehicle parking brakes using the switch inside the cab of the vehicle. If an auxiliary air supply was not used, begin with Step 2.
2. Apply the vehicle spring or parking brakes by manually releasing each spring that was compressed before transporting started. Refer to the manufacturer's instructions.
3. Disconnect the auxiliary air supply, if used, from the brake system of the vehicle that was transported. Connect the vehicle's air supply to the brake system.
4. Remove the covers from the hubs.

NOTE: Install only the axle shaft(s) shown in Table AM at this time. These axle shafts have a double row of splines that engage with the splines of the side gear and shift collar in the main differential. Figure 11.5.

5. Install the gasket, if used, and axle shaft into the axle housing and carrier in the same location. The gasket and flange of the axle shaft must be flat against the hub. Rotate the axle shaft or the driveline as necessary to align the splines and the holes in the flange with the studs in the hub. Figure 11.2.

Table AM

Single Axles	
	Install the right-hand, curbside, axle shaft
Tandem Axles	
	Forward Axle
	Install the left-hand, roadside, axle shaft
	Rear Axle
	Install the right-hand, curbside, axle shaft

6. Install the dowels, if used, over each stud and into the tapered holes of the flange.
7. Install the washers and capscrews or stud nuts. Determine the size of the fasteners and tighten the capscrews or nuts to the torque value shown in Table AN.

Table AN

Fastener	Thread Size	Torque Value lb-ft (N•m)
Capscrews	0.31"-24	18-24 (24-33)
	0.50"-13	85-115 (115-156)
Stud Nuts	0.44"-20	50-75 (68-102)
Plain Nut	0.50"-20	75-115 (102-156)
	0.56"-18	110-165 (149-224)
	0.62"-18	150-230 (203-312)
	0.75"-16	310-400 (420-542)
Locknut	0.44"-20	40-65 (54-88)
	0.50"-20	65-100 (88-136)
	0.56"-18	100-145 (136-197)
	0.62"-18	130-190 (176-258)
	0.75"-16	270-350 (366-475)

8. Unlock or disengage the DCDL by removing the manual engaging capscrew from the shift assembly.
9. Install the manual engaging capscrew into the storage hole. The storage hole of bolted-on shift assemblies is located in the top side of the shift cylinder cover. Tighten the capscrew to 15-25 lb-ft (20-35 N•m). Figure 11.3.
10. Remove the plug and gasket from the storage hole. Install the plug and gasket into the threaded hole in the center of the shift cylinder cover. Tighten the plug to 15-25 lb-ft (20-35 N•m).
11. Install the remaining axle shaft into the axle housing and carrier.
12. Check the lubricant level in the axles and hubs where the axle shafts were removed. Add the correct type and amount of lubricant if necessary. Refer to Section 7.

Single Axle Without DCDL or Tandem Axle Without DCDL and with Inter-Axle Differential (IAD)

Before Towing or Drive-Away

1. Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving.
2. Apply the vehicle parking brakes using the switch inside the cab of the vehicle.

NOTE: For a single axle, continue with Step 6. For a tandem axle, continue with Step 3.

3. Shift the transmission into neutral and start the vehicle's engine.
4. Shift the IAD to the unlocked or disengaged position using the switch inside the cab of the vehicle. The indicator light in the cab will go off.
5. Stop the engine.

NOTE: Remove both axle shafts from the axle(s) that will remain on the road when the vehicle is transported.

6. Remove the stud nuts or capscrews and washers from the flange of the axle shaft. Figure 11.7.
7. Loosen the tapered dowels, if used, in the flange of the axle shaft. Figure 11.7.

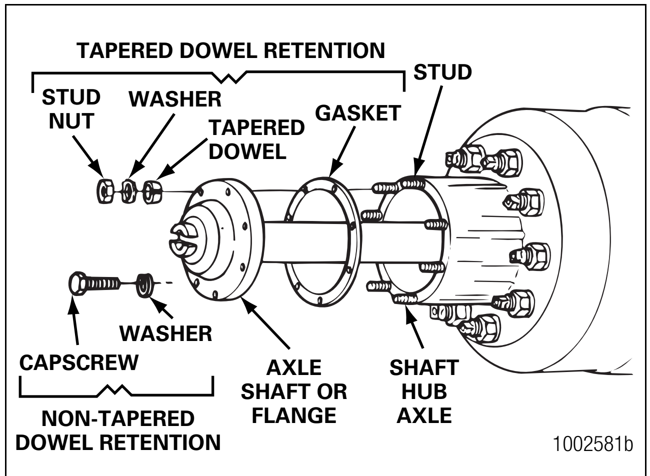


Figure 11.7

8. Identify each axle shaft that is removed from the axle assembly so they can be installed in the same location after transporting or repair is completed.
9. Remove the tapered dowels, gasket, if used, and the axle shaft from the axle assembly. Figure 11.7.
10. Install a cover over the open end of each hub where an axle shaft was removed. This will prevent dirt from entering the bearing cavity and loss of lubricant.

NOTE: If an air supply will be used for the brake system of the transported vehicle, continue with Step 11 and Step 12, otherwise continue with Step 13.

11. Connect an auxiliary air supply to the brake system of the vehicle that is being transported. Before moving the vehicle, charge the brake system with the correct amount of air pressure to operate the brakes. Refer to the instructions supplied by the manufacturer of the vehicle for procedures and specifications. If an auxiliary air supply is not used, continue with Step 13.
12. When the correct amount of air pressure is in the brake system, release the parking brakes of the vehicle that is being transported. Step 13 is not required.
13. If there are spring or parking brakes on the axle(s) that will remain on the road when the vehicle is transported and they cannot be released by air pressure, manually compress and lock each spring so that the brakes are released. Refer to the manufacturer's instructions.

After Towing or Drive-Away

1. If an auxiliary air supply was used, apply the vehicle parking brakes using the switch inside the cab of the vehicle. If an auxiliary air supply was not used, begin with Step 2.
2. Apply the vehicle spring or parking brakes by manually releasing each spring that was compressed before transporting started. Refer to the manufacturer's instructions.
3. Disconnect the auxiliary air supply, if used, from the brake system of the vehicle that was transported. Connect the vehicle's air supply to the brake system.
4. Remove the covers from the hubs.
5. Install the gasket, if used, and axle shaft into the axle housing and carrier in the same location. The gasket and flange of the axle shaft must be flat against the hub. Rotate the axle shaft or the driveline as necessary to align the splines and the holes in the flange with the studs in the hub. Figure 11.7.
6. Install the dowels, if used, over each stud and into the tapered holes of the flange.
7. Install the washers and capscrews or stud nuts. Determine the size of the fasteners and tighten the capscrews or nuts to the torque value shown in Table AO.

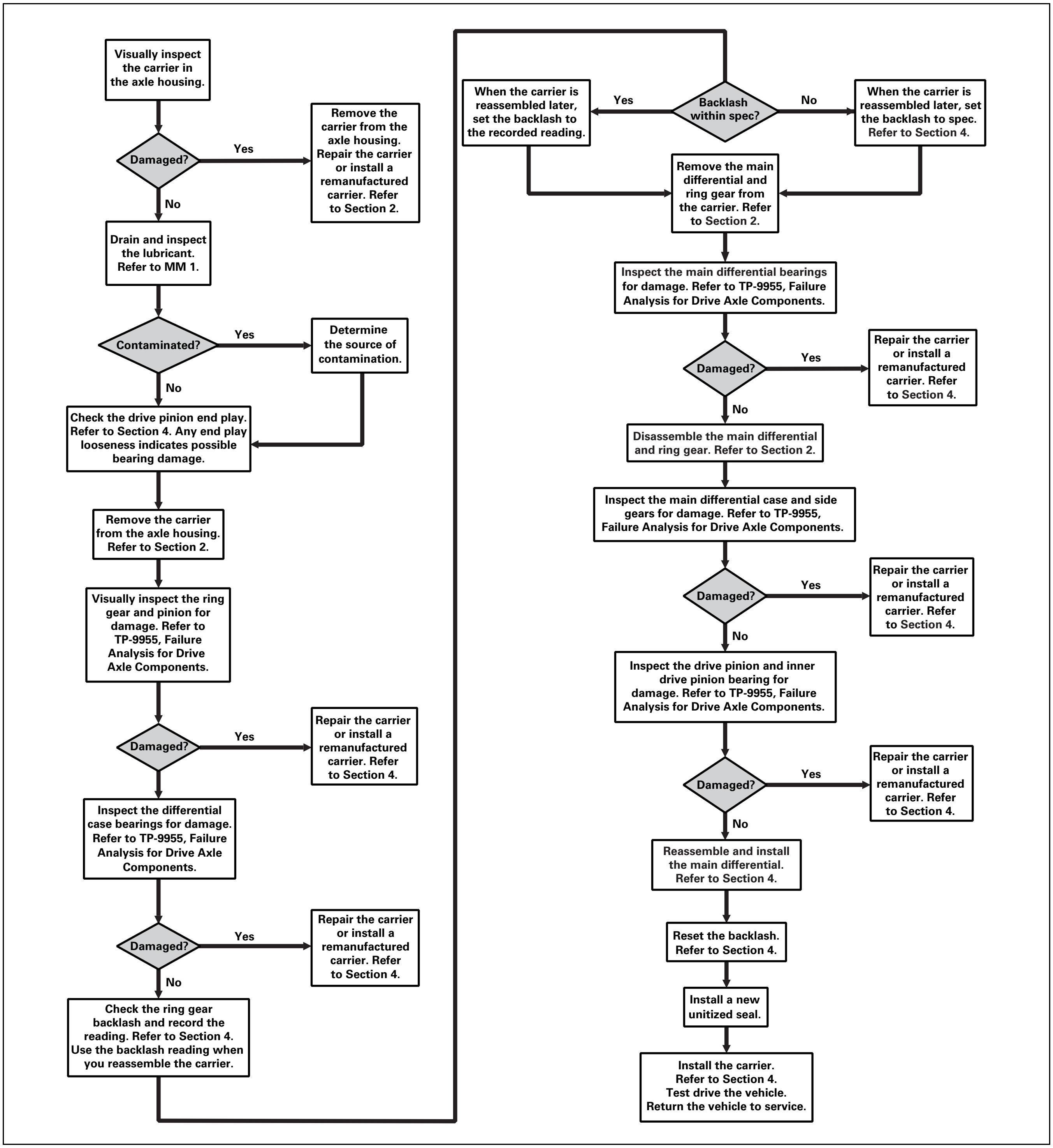
Table AO

Fastener	Thread Size	Torque Value lb-ft (N•m)
Capscrews	0.31"-24	18-24 (24-33)
	0.50"-13	85-115 (115-156)
Stud Nuts	0.44"-20	50-75 (68-102)
Plain Nut	0.50"-20	75-115 (102-156)
	0.56"-18	110-165 (149-224)
	0.62"-18	150-230 (203-312)
	0.75"-16	310-400 (420-542)
Locknut	0.44"-20	40-65 (54-88)
	0.50"-20	65-100 (88-136)
	0.56"-18	100-145 (136-197)
	0.62"-18	130-190 (176-258)
	0.75"-16	270-350 (366-475)

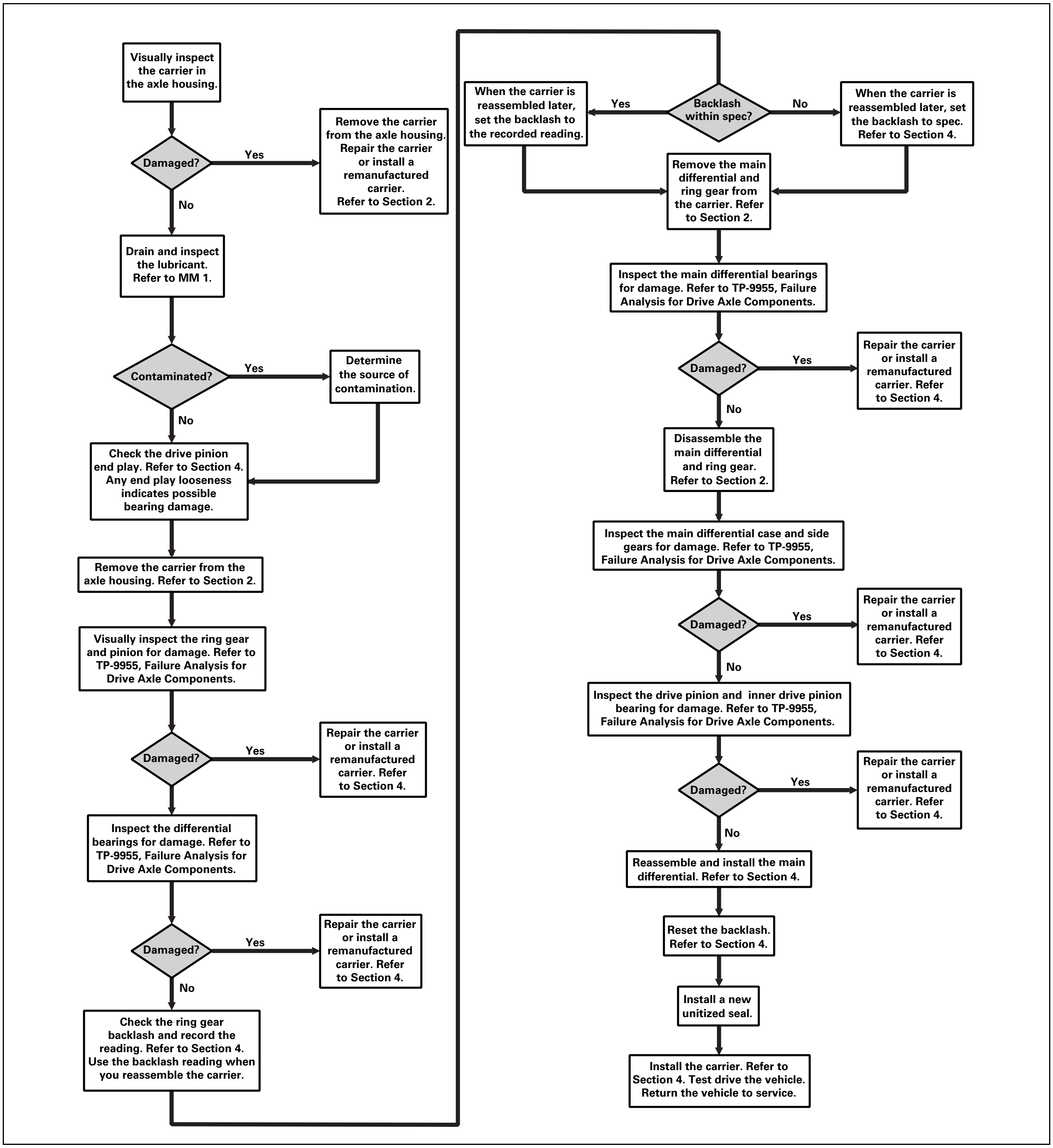
8. Check the lubricant level in the axles and hubs where the axle shafts were removed. Add the correct type and amount of lubricant if necessary. Refer to Section 7.

Troubleshooting

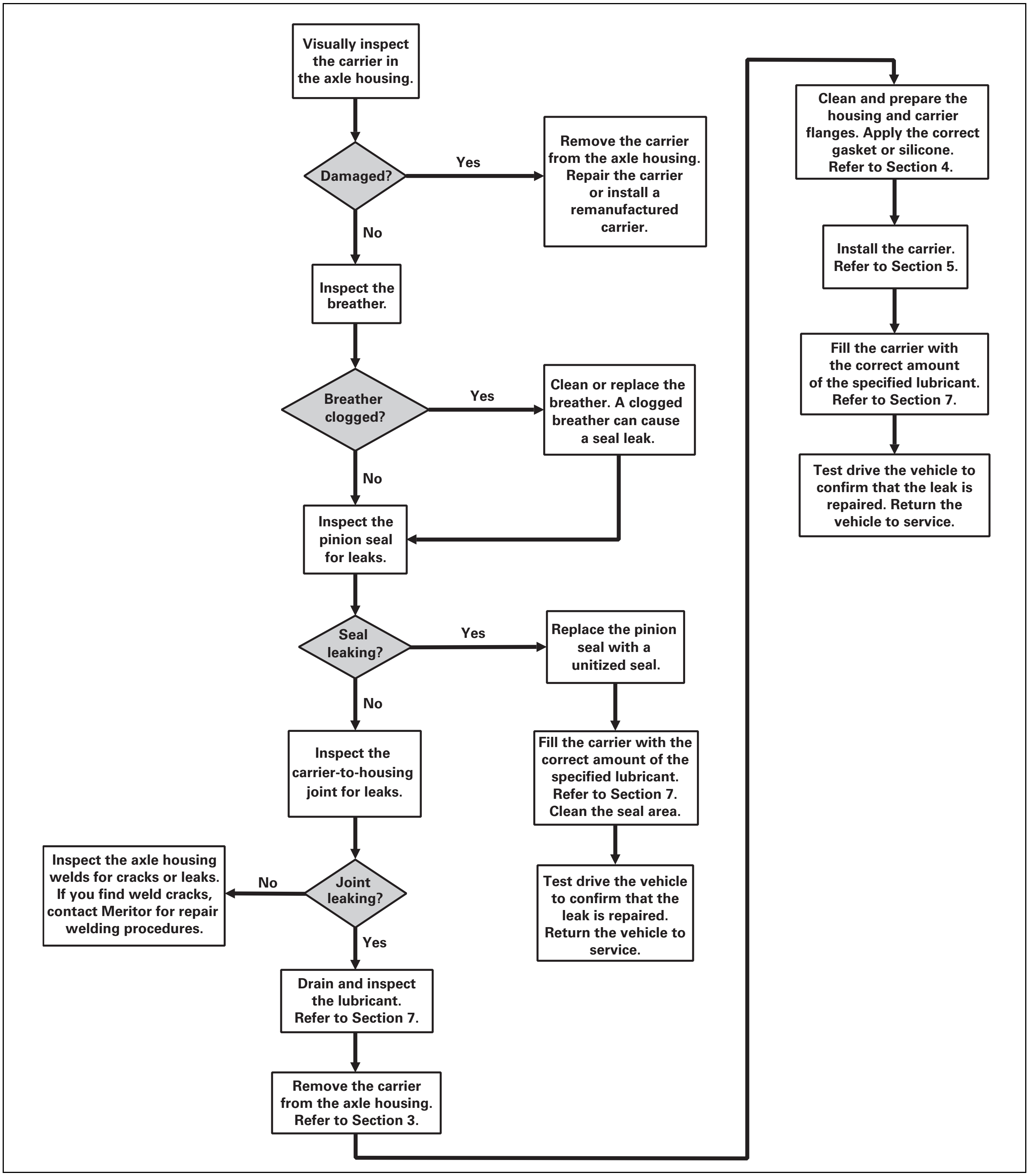
Vehicle Will Not Move



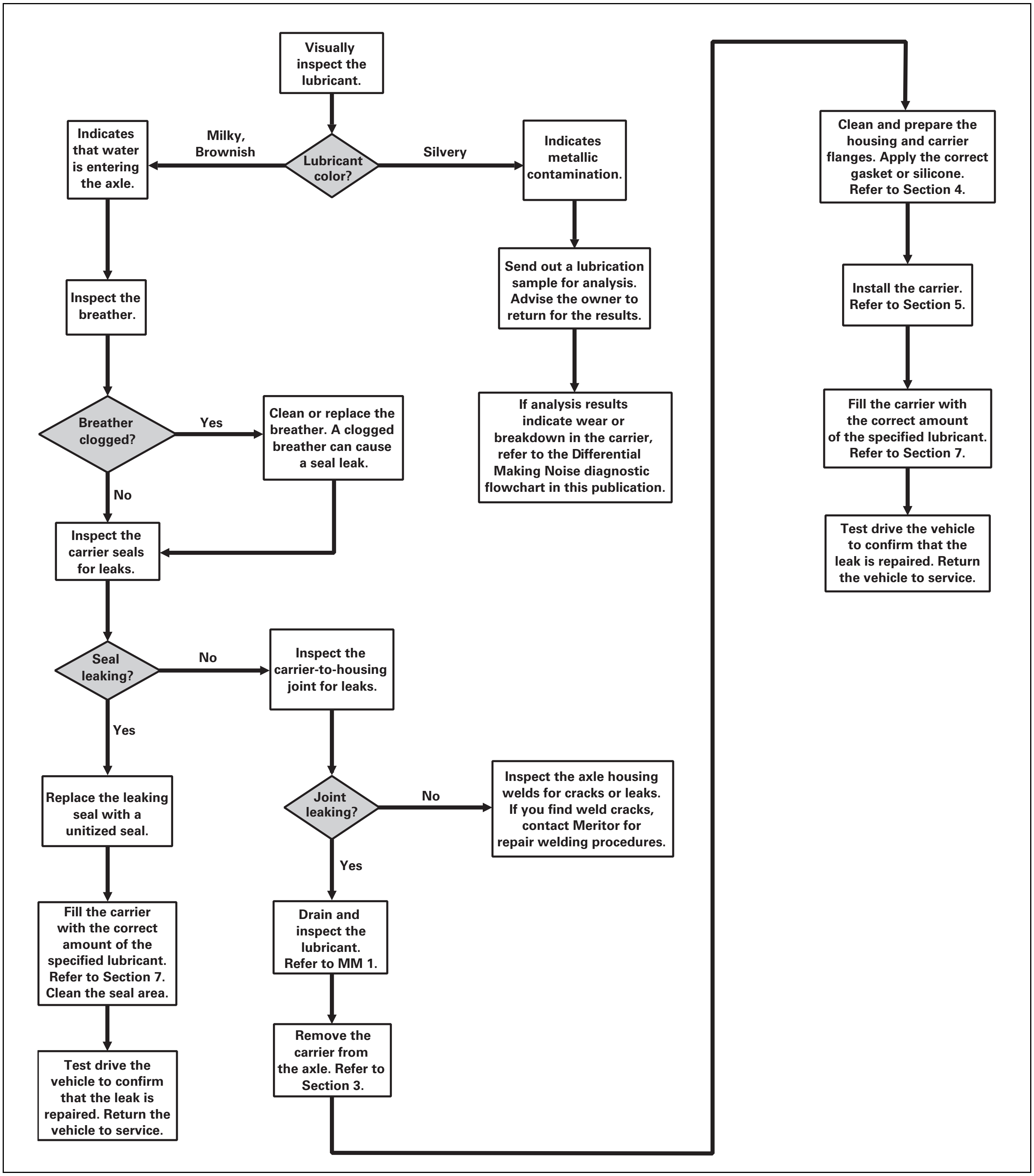
Differential Making Noise



Oil Leak


Visually inspect the carrier in the axle housing.
Damaged?
Yes
Remove the carrier from the axle housing. Repair the carrier or install a remanufactured carrier.
No
Inspect the breather.
Breather clogged?
Yes
Clean or replace the breather. A clogged breather can cause a seal leak.
No
Inspect the pinion seal for leaks.
Seal leaking?
Yes
Replace the pinion seal with a unitized seal.
Fill the carrier with the correct amount of the specified lubricant. Refer to Section 7. Clean the seal area.
Test drive the vehicle to confirm that the leak is repaired. Return the vehicle to service.
No
Inspect the carrier-to-housing joint for leaks.
Joint leaking?
No
Inspect the axle housing welds for cracks or leaks. If you find weld cracks, contact Meritor for repair welding procedures.
Yes
Drain and inspect the lubricant. Refer to Section 7.
Remove the carrier from the axle housing. Refer to Section 3.
Clean and prepare the housing and carrier flanges. Apply the correct gasket or silicone. Refer to Section 4.
Install the carrier. Refer to Section 5.
Fill the carrier with the correct amount of the specified lubricant. Refer to Section 7.
Test drive the vehicle to confirm that the leak is repaired. Return the vehicle to service.

Contaminated Lubricant Found During Preventive Maintenance



MERITOR

Technical Bulletin

Lubrication Intervals for All Meritor Rear Drive Axles

How to Obtain Additional Maintenance and Service Information

Refer to Maintenance Manual 1, Preventive Maintenance and Lubrication; TP-9539, Approved Rear Drive Axle Lubricants; or the appropriate maintenance manual for the axle. To obtain these publications, call ArvinMeritor's Customer Service Center at 800-535-5560, or visit the Tech Library on our website at arvinmeritor.com.

Lubrication Analysis Recommendations

Meritor recommends using a lubricant analysis program. Perform lubricant analysis at regularly-scheduled preventive maintenance intervals. Refer to Maintenance Manual 1, Preventive Maintenance and Lubrication, pages 1 and 2, for drive axle differential oil analysis guidelines.

Check and Adjust the Oil Level

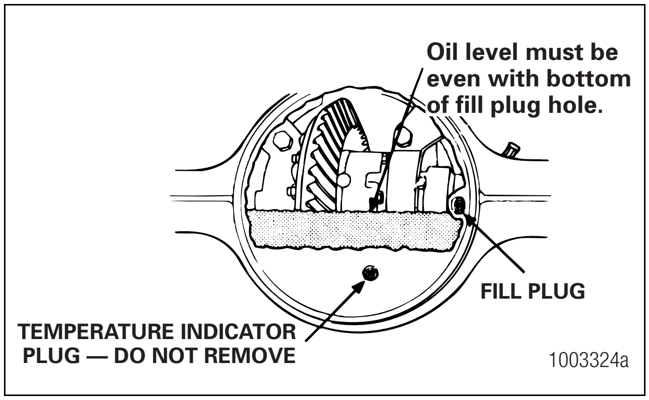
WARNING

To prevent serious eye injury, always wear safe eye protection when you perform vehicle maintenance or service.

Park the vehicle on a level surface. Block the wheels to prevent the vehicle from moving. Support the vehicle with safety stands. Do not work under a vehicle supported only by jacks. Jacks can slip and fall over. Serious personal injury and damage to components can result.

Check the oil level when the axle is at room temperature. When hot, the oil temperature may be 190°F (88°C) or more and can cause burns. A correct level is not obtained when the axle is warm or hot. Serious personal injury and damage to components can result.

1. Wear safe eye protection.
2. Park the vehicle on a level surface. Place blocks under the front wheels to prevent the vehicle from moving. The axle must be cold or near room temperature.
3. Clean the area around the fill plug. Remove the fill plug from the differential carrier or the axle housing bowl, depending on the axle. Do not remove the temperature indicator plug.
4. Check the oil level. The level must be even with the bottom of the fill plug hole.



5. Install the fill plug. Tighten the plug to 35-50 lb-ft (48-67 N•m).

Vocation or Vehicle Operation	Linehaul	Intercity Coach	City Delivery, School Bus, Fire Truck, Motorhome	Construction, Transit Bus, Refuse, Yard Tractor, Logging, Heavy Haul, Mining, Oil Field, Rescue
Initial Oil Change	Not required			
Check Oil Level Add the correct type and amount of oil as required.	Every 25,000 miles (40 000 km) or the fleet maintenance interval, whichever comes first	Every 25,000 miles (40 000 km) or the fleet maintenance interval, whichever comes first	Every 10,000 miles (16 000 km), once a month or the fleet maintenance interval, whichever comes first	Every 5,000 miles (8000 km), once a month or the fleet maintenance interval, whichever comes first[1]
Petroleum-Based Oil Change on Axles with or without Pump and Filter System	Every 100,000 miles (160 000 km) or annually, whichever comes first	Every 100,000 miles (160 000 km) or annually, whichever comes first	Every 50,000 miles (80 000 km) or annually, whichever comes first	Every 25,000 miles (40 000 km) or annually, whichever comes first
Synthetic Oil Change on Axles with or without Pump and Filter System[2]	Every 500,000 miles (800 000 km) or every 4 years, whichever comes first	Every 250,000 miles (400 000 km) or every 4 years, whichever comes first	Every 250,000 miles (400 000 km) or every 3 years, whichever comes first	Every 100,000 miles (160 000 km) or every 2 years, whichever comes first[3]
Filter Change on Axles with Pump and Filter System	Every 100,000 miles (160 000 km)	Every 100,000 miles (160 000 km)	Every 100,000 miles (160 000 km)	Every 100,000 miles (160 000 km)

1 For continuous heavy-duty operation, check the oil level every 1,000 miles (1600 km).

2 These intervals apply to approved semi-synthetic and full-synthetic oils only. For a list of approved extended-drain axle oils, refer to TP-9539, Approved Rear Drive Axle Lubricants.

3 The change interval for transit bus can be increased to **150,000 miles (241 400 km)** or **3 years**, whichever comes first, contingent upon:
a. documented 10% fleet oil sampling with results below Meritor guidelines per Maintenance Manual 1, Preventive Maintenance and Lubrication,
b. a minimum of 6 magnets in the housing (the 61163/71163 drive axles come standard with 6 magnets in the housing),
c. use of approved extended-drain interval lubricants per TP-9539 Approved Rear Drive Axle Lubricants (the drive axles excluded are RC-26-633/634 and RC-26/27-720).

ArvinMeritor

Meritor Heavy Vehicle Systems, LLC
2135 West Maple Road
Troy, MI 48084 USA
800-535-5560
arvinmeritor.com

Printed in the USA

TP-0460
Revised 02-05
(16579/24240)

TP-9539
Revised 06-07

MERITOR®

Technical Bulletin

Approved Rear Drive Axle Lubricants

CAUTION

You must fill Meritor axles with Meritor-specified lubricants only. Do not fill an axle with non-approved lubricants, which will void Meritor's warranty. Damage to axle components also can result.

To avoid axle component damage, fill Meritor axles with approved lubricants only. Using non-approved lubricants also will void Meritor's warranty.

For complete lubrication information, refer to Maintenance Manual 1, Preventive Maintenance and Lubrication. To obtain this publication, call ArvinMeritor's Customer Service Center at 800-535-5560, or visit Literature on Demand on our website at meritorhvs.com.

Table A: Oil Change Intervals and Specifications for All Rear Drive Axles

Vocation or Vehicle Operation	Linehaul	Intercity Coach	City Delivery, School Bus, Fire Truck, Motorhome	Construction, Transit Bus, Refuse, Yard Tractor, Logging, Heavy Haul, Mining, Oil Field, Rescue
Initial Oil Change	Not required			
Check Oil Level **Add the correct type and amount of oil as required.**	Every 25,000 miles (40 000 km), or the fleet maintenance interval, whichever comes first		Every 10,000 miles (16 000 km), once a month, or the fleet maintenance interval, whichever comes first	Every 5,000 miles (8000 km), once a month, or the fleet maintenance interval, whichever comes first ①
Petroleum-Based Oil Change on Axle with or without Pump and Filter System ②	Every 100,000 miles (160 000 km), or annually, whichever comes first		Every 50,000 miles (80 000 km), or annually, whichever comes first	Every 25,000 miles (40 000 km), or annually, whichever comes first
Synthetic Oil Change on Axle with or without Pump and Filter System ③	Every 500,000 miles (800 000 km), or every 4 years, whichever comes first	Every 250,000 miles (400 000 km), or every 4 years, whichever comes first	Every 250,000 miles (400 000 km), or every 3 years, whichever comes first	Every 100,000 miles (160 000 km), or every 2 years, whichever comes first ④
Filter Change on Axle with Pump and Filter System	Every 100,000 miles (160 000 km)			

① For continuous heavy-duty operation, check the oil level every 1,000 miles (1600 km).

② All ArvinMeritor GL5 approved gear lubricants have been SAE J2360 tested and approved. A current list of approved oils is available at www.pri.sae.org/PRI/IMprograms/Lubricant.

③ These intervals apply to approved semi-synthetic and full synthetic oils only. For a list of approved extended-drain axle oils, refer to **Table C** or **Table D**.

④ The change interval for transit buses can be increased to **150,000** miles or **3** years, whichever comes first, contingent upon:
1) documented 10% fleet oil sampling with results below ArvinMeritor guidelines per Maintenance Manual 1,
2) minimum of six magnets in housing (61163/ 71163 drive axles come standard with six magnets in housing), and
3) use of approved extended-drain interval lubricants per **Table B**. (Drive axles excluded are: RC-26-633/634 and RC-26/27-720.)

Table B: Axle Oil Specifications

	Gear Oil Type	A.P.I. Specification	SAE Viscosity Grade	ArvinMeritor Specification	SAE Specification	Outside Temperature
Standard Drain Lubricants	Petroleum with EP additives	GL-5	85W/140	O76-A	SAE J2360 Tested and Approved	Above +10°F (–12°C)
			80W/140	O76-B		Above –15°F (–26°C)
			80W/90	O76-D		Above –15°F (–26°C)
			75W/90	O76-E		Above –40°F (–40°C)
			75W	O76-J		From –40°F (–40°C) to +35°F (+2°C)
			75W/140	O76-L		Above –40°F (–40°C)
Extended-Drain Lubricants	Petroleum with Extended-Drain Base Oils and EP additives	GL-5	75W/90, 80W/90, 80W/140 or 75W/140	O76-Q, O76-R	SAE J2360 Tested and Approved	Depends on viscosity. Refer to the viscosity grades listed above.
	Petroleum with Semi-Synthetic Base Oils and EP additives		80W/90	O76-P		Above –15°F (–26°C)
	Fully Synthetic Base Oil and EP additives		75W/140	O76-M		Above –40°F (–40°C)
	Fully Synthetic Base Oil and EP additives		75W/90	O76-N		Above –40°F (–40°C)

Table C: Extended-Drain-Approved Synthetic Axle Oil Suppliers — United States Distributors

Name of Lubricant	Viscosity	Manufacturer
Allied Mag Synthetic EP	75W/90, 80W/140	Allied Oil and Supply Incorporated
Altra Syntec GT-7	75W/90, 80W/140	Allegheny Petroleum Products
Amalie Synthetic Gear Lubricant	75W/90, 80W/140	Amalie Refining Company
Amoco Ultimate Multipurpose Gear Lube	75W/90, 80W/140	Amoco Oil Company
Archer Synthetic	75W/90, 80W/140	McCollister & Co.
Brad Penn Full Syn. Hypoid Gear Lube	75W/90, 80W/140	American Refining Group
Bulldog Syn Gear Lube	75W/90, 80W/140	Mack Truck Company
Chevron Delo Synthetic Gear Lubricant	75W/90	Chevron Global Lubricants
Chevron RPM Synthetic Gear Lubricant	75W/90, 80W/140	Chevron Global Lubricants
Citgo Synthetic Gear Lube	75W/90, 80W/140	Citgo Petroleum Corporation
Coastal HD	75W/90, 80W/140	Coastal Unilube Inc.
Dyna-Plex 21C Synzol	75W/90, 80W/140	Universal Lubricants
Dyno-Tech HD	75W/90, 80W/140	Chemtool Inc.
Emgard EP	75W/90, 80W/140	Cognis Corporation
Emgard FE Fuel Efficient Synthetic Gear Lubricant	75W/90	Cognis Corporation
Emgard Synthetic Gear Lubricant	75W/90, 80W/140	Cognis Corporation
Emgard 2986	75W/90	Cognis Corporation
Fleetrite Synthetic	75W/90, 80W/140	International Truck & Engine Group
FS Synthetic	75W/90, 80W/140	Growmark
Gear Plus Super EW	75W/90, 80W/140	Pennzoil-Quaker State

(16579/22882)
Printed in USA

Table C: Extended-Drain-Approved Synthetic Axle Oil Suppliers — United States Distributors

Name of Lubricant	Viscosity	Manufacturer
Gibraltar Syn-Gear	75W/90, 80W/140	David Weber Oil Company
Gulf Syngear	75W/90, 80W/140	Gulf Oil
Hi-Tek Synthetic	75W/90, 80W/140	Industrial Oils Limited
Imperial SGO	75W/90, 80W/140	IPAC
Lubemaster Syn EP	75W/90, 80W/140	Lubemaster (A Division of Certified Labs)
Maxtron GL	75W/90, 80W/140	Country Energy LLC
Mobil Delvac Synthetic Gear Oil	75W/90, 80W/140	ExxonMobil Corporation
Mobilube SHC	75W/90, 80W/140	ExxonMobil Corporation
Monarch Syngear Plus	75W/90, 80W/140	Royal Manufacturing Co. Inc.
Mystik Synguard SX-7000	75W/90, 80W/140	Cato Oil and Grease Company
NEO	75W/90, 80W/140	Neo Lubricants
Pennzoil Long-Life EW	75W/90, 80W/140	Shell Oil U.S.
Quaker State FCI Synthetic	75W/90, 80W/140	Shell Oil U.S.
Raloy Transintex Plus EP	75W/90, 80W/140	Raloy Lubricantes S. A. de C.V.
Roadranger FE Fuel Efficient Synthetic Gear Lubricant	75W/90	Eaton Corporation
Roadranger Synthetic Gear Lubricant	75W/90, 80W/140	Eaton Corporation
Schaeffer Synthetic EP	75W/90, 80W/140	Schaeffer Manufacturing Company
SHP Gear Lube	75W/90, 80W/140	Kendall Lubricants
Spirax S	75W/90, 80W/140	Shell Lubricants
SYN HD Gear Oil	75W/90, 80W/140	Lyondell Lubricants
Syn. Axle Lubricant 12345841	75W/90, 80W/140	General Motors Service Parts
Syncon HP Synthetic Gear Oil	75W/90, 80W/140	Conoco Lubricants
SYN-EP Gear Lubricant	75W/90, 80W/140	Black Bear Company Incorporated
Synergy Syn. Gear Lube EP	75W/90, 80W/140	Northland Products Company
Syn-Gear	75W/90, 80W/140	Castrol Heavy Duty Lubricants, Inc.
Syngear EP	75W/90, 80W/140	American AGIP
Synolec	75W/90, 80W/140	Lubrication Engineers Incorporated
Synpro	75W/90, 80W/140	Fina Oil and Chemical Company
Syn-Star GL	75W/90, 80W/140	Texaco Lubricants Company
Synsure Synthetic Lubricant	75W/90, 80W/140	D-A Lubricant Company Incorporated
Syn-Tech EP	75W/90, 80W/140	Benz Oil
Syntex 2700	75W/90, 80W/140	Texas Refinery Corporation
Texaco Syn-Star GL	75W/90, 80W/140	Chevron Global Lubricants
Traxon E Synthetic	75W/90, 80W/140	Petro-Canada Lubricants Centre
Triton Syn Lube EP	75W/90, 80W/140	76 Lubricants
United Syn	75W/90, 80W/140	McCollister & Co.
Valvoline HD Synthetic Gear Oil EP	75W/90, 80W/140	Valvoline Incorporated

Table D: Additional Extended-Drain-Approved Axle Oil Suppliers

CANADA:

Name of Lubricant	Viscosity	Manufacturer
HDH Synthetic	75W/90, 80W/140	Irving Oil Limited
NEMCO Syngear	75W/90, 80W/140	NemCo Resources Limited
Sonic MP Gear Oil	75W/90, 80W/140	Federated Cooperatives Limited
Titan Syndrive	75W/90, 80W/140	Fuchs Lubricants Canada Limited

MEXICO:

Name of Lubricant	Viscosity	Manufacturer
Akron Axle Synthetic	75W/90, 80W/140	Mexicano de Lubricantes, S.A. de C.V.
Q.S. Synquest Gear	80W/140	Commercial Importada, S.A. de C.V.
Sun Gear Gold Syn	75W/90, 80W/140	Aceites Y Parafinas Industriales
Syn-Star GL	75W/90, 80W/140	Productos Texaco, S.A. de C.V.
Transintex Plus EP	75W/90, 80W/140	Raloy Lubricantes, S.A. de C.V.

AUSTRALIA/NEW ZEALAND:

Name of Lubricant	Viscosity	Manufacturer
Synstar GL	75W/90, 80W/140	Caltex Oil Pty. Limited
Syntrax E	75W/90, 80W/140	Castrol Australia PTY Limited
TransGear S	80W/140	BP Oil Company
Tutela Truck FE Axle	80W/140	Fiat Lubrificanti

Other Approved Extended-Drain Gear Oils

Name of Lubricant	Viscosity	Manufacturer
Delo Gear Lubricant ESI	80W/90, 85W/140	Chevron Global Lubricants
PED 6449	75W/90	Chevron Global Lubricants
Pennzoil Long-Life EW	75W/90, 80W/140	Shell Lubricants
SAF-AM	80W/90	Castrol Heavy Duty Lubricants
Shell Spirax EW	75W/90, 80W/140	Shell Lubricants
Synergyn Blended Synthetic	80W/90	Synergyn Racing Products
Texaco Star Gear Lubricant	80W/90, 85W/140	Chevron Global Lubricants
Triton Syn Lube LDO	75W/90, 80W/140	76 Lubricants
Super Three Star	75W/90, 80W/140	Kendall

(16579/22882)
Printed in USA

For Meritor R-170 Axles Equipped With Traction Equalizer®

Meritor's R-170 axles with Traction Equalizer normally operate with either standard petroleum, semi-synthetic or full-synthetic oils.

When to Use "Limited Slip Friction Modifiers"

Occasionally the Traction Equalizer will "slip" or "stick." When this happens, you will hear intervals of shrill noises when the vehicle operates at low speed or when the vehicle makes sharp turns. You can correct this condition by adding "limited slip friction modifiers."

NOTE: "Limited slip friction modifiers" usually deteriorate more quickly than extreme pressure (EP) additives. Shorten the lubricant change schedule if you add a friction modifier.

- **At the initial lubricant change interval for an R-170 equipped with Traction Equalizer:** Replace the factory-installed lubricant with an approved lubricant and one of the additives specified in the following table.
- **After the initial change interval:** Change the lubricant and the additive at or before 50,000 miles (80 000 km).

Specifications

For all GL-5 oils (petroleum oil or synthetic), add one of the following modifiers specified in the following table.

Manufacturer	Specification
DSL-178	Guardsman Products
Equa-Torque #2411 and #2414	Sta-Lube Corporation
Lubrizol #6178	Lubrizol Corporation

Quantities for R-170 Axles With and Without Traction Equalizer

WITH Traction Equalizer	WITHOUT Traction Equalizer
40 pints oil (18.9 liters) + 3 pints additive (1.4 liters)	43 pints oil (20.3 liters)

Lubrication Analysis Recommendations

Meritor recommends using a lubricant analysis program. Perform lubricant analysis at regularly-scheduled preventive maintenance intervals. Refer to Maintenance Manual 1, Preventive Maintenance and Lubrication, for drive axle differential oil analysis guidelines.

Meritor Heavy Vehicle Systems, LLC
2135 West Maple Road
Troy, MI 48084 USA
800-535-5560
meritorhvs.com

Printed in USA

TP-9539
Revised 06-07
16579/22882

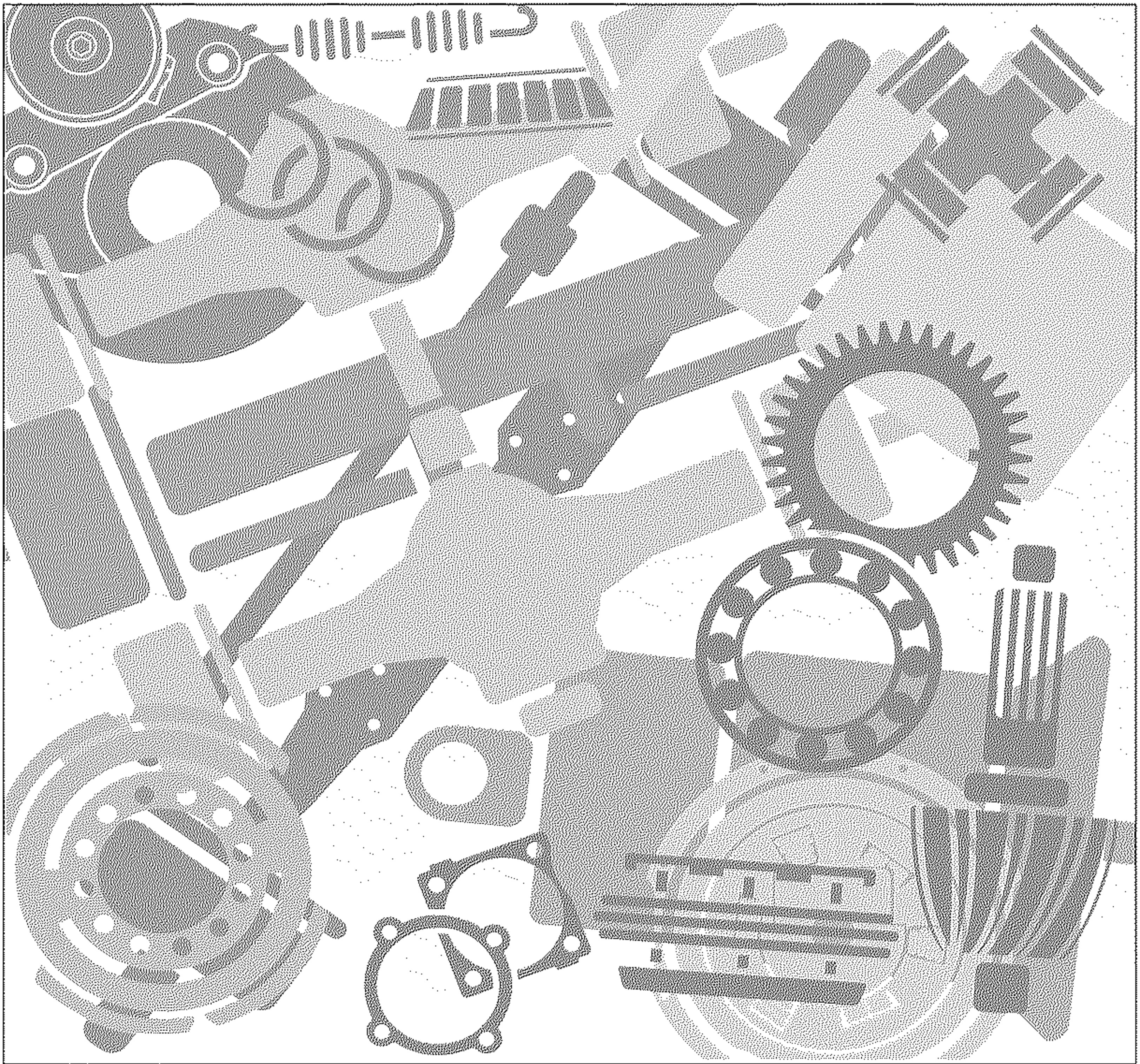
SPICER®
DRIVETRAIN COMPONENTS

Dana® Spicer® Driveshaft

Universal Joints and Driveshafts
1000-1880 Series

DANA

Service Manual DSSM3264 July 2006



Safety

Note: Spicer 10 Series™ Driveshafts are found on vehicles throughout the world. Therefore, this manual includes worldwide terminology.

General Safety

The following **WARNINGS** and **CAUTIONS** should be read and understood before attempting any service or repair on the various components of the driveshaft assembly.

CAUTION

Under no circumstances should individuals attempt to perform driveline service and/or maintenance procedures for which they have not been trained or do not have the proper tools or equipment.

WARNING

Failure to take common sense, precautionary measures when working on a vehicle or other machinery could result in property damage, serious personal injury, or death. To avoid property damage, serious personal injury, or death, please follow basic safety rules as noted below.

1. **ALWAYS** wear safety glasses when performing maintenance or service. Failure to do so can result in personal injury and/or partial or complete vision loss.
2. **NEVER** perform service or maintenance tasks underneath a vehicle while the engine is running. Be sure the vehicle engine is off and the keys are removed from the ignition.
3. **NEVER** perform service or maintenance tasks underneath a vehicle that is not on a level or flat surface.
4. **NEVER** work on a driveshaft without blocking the vehicle wheels and releasing all parking brakes.
5. **ALWAYS** wear gloves when handling parts with sharp edges or abrasive surfaces.
6. **NEVER** lift a vehicle without the appropriate weight-rated vehicle-lift equipment. Always properly support the vehicle with appropriate weighted support equipment.
7. **NEVER** remove a driveshaft from a vehicle without keeping the transmission in neutral.

CAUTION

Spicer 10 Series™ Driveshaft assemblies can weigh in excess of 100 pounds (46 kilograms). Be sure to use proper lifting techniques when handling Spicer 10 Series™ Driveshaft assemblies. More than one person may be needed when handling driveshaft assemblies.

8. **ALWAYS** use support straps to prevent the driveshaft from falling out of the vehicle during the removal and installation process.

Note: This manual does not discuss the removal and installation of Spicer 10 Series™ Driveshaft assemblies from the vehicle. It only covers the disassembly and reassembly of component parts of the driveshaft assembly. Please refer to the original-equipment manufacturer's service documentation for removal and installation procedures.

9. **NEVER** heat components, and never use sledgehammers or floor jacks to remove the driveshaft from the vehicle.

Note: For driveshaft applications that have pillow blocks, dampers, parking brakes, or retarders, refer to these component manufacturers' or the original equipment manufacturer's service manuals for the proper procedures. NEVER perform any unauthorized procedures that will change the disconnected properties of Spicer products.

WARNING

ROTATING DRIVESHAFTS

- Rotating auxiliary driveshafts are dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.
- Do not go under the vehicle when the engine is running.
- Do not work on or near an exposed shaft when engine is running.
- Shut off engine before working on power take-off or driven equipment.
- Exposed rotating driveshafts must be guarded.

Component Safety

Driveline

⚠ WARNING

Failure to replace damaged driveline components can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Reassembly of a driveline out of original phase can cause vibration and failure of the driveline and attaching components. Driveline failure can result in separation of the driveline from the vehicle, resulting in property damage, serious personal injury, or death.

Driveshaft assemblies can weigh in excess of 100 pounds (46 kilograms). Be sure to use proper lifting techniques when handling driveshafts. More than one person may be needed when handling driveshaft assemblies.

⚠ CAUTION

Never heat components, never use sledge hammers, and never use floor jacks to disassemble driveshafts. This can result in damaged, weakened, or bent components.

End Fitting

⚠ WARNING

A loose end-fitting can result in driveline failure, which can in turn lead to separation of the driveline from the vehicle. A separated driveline can lead to property damage, serious personal injury, or death.

Universal Joint

⚠ WARNING

Excessive looseness across the end of universal joint bearing cup assemblies can cause imbalance or vibration in the driveshaft assembly. Imbalance or vibration can cause component wear, which can result in separation of the driveline. A separated driveline can lead to property damage, serious personal injury, or death.

DO NOT reuse bolts or use inferior grade bolts. Reuse of bolts and/or use of inferior grade bolts can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Failure to torque bolts to specification can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

⚠ CAUTION

Use a journal locator to avoid nicking journal cross trunnions or damaging oil seal slingers.

If a bearing assembly or journal cross is worn or damaged, the universal joint assembly must be replaced.

Be sure the snap rings are properly seated in the snap ring grooves.

Slip Member

⚠ WARNING

Excessive radial looseness in the slip member assembly can cause imbalance or vibration in the driveshaft. Imbalance or vibration can cause components to wear, which in turn can result in separation of the driveline from the vehicle. A separated driveline can cause property damage, serious personal injury or death.

Yoke (Includes Slip Yoke, Yoke Shaft, and Tube Yoke)

⚠ WARNING

A loose or damaged slip yoke seal allows contaminants to invade the slip member assembly. Invasion of contaminants into the slip member assembly can degrade the grease, and damage slip member components, which can result in driveline separation. A separated driveline can result in property damage, serious personal injury, or death.

DO NOT deform yoke cross holes by removing excessive metal. Raised metal or deformed yoke cross holes can be a cause of cross and bearing failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Yoke shaft assemblies can weigh in excess of 50 pounds (23 kilograms). Be sure to use proper lifting techniques when handling yoke shafts.

Tubing

WARNING

Bent or dented tubing can cause imbalance or vibration in the driveshaft assembly. Imbalance or vibration can cause component wear, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

CAUTION

Do not bend or dent the tube when handling or servicing driveshaft.

Midship Nut

WARNING

DO NOT reuse the midship nut. Reuse of the midship nut can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

DO NOT touch or disturb the micro-encapsulated adhesive found on the midship nut threads. Doing so may initiate the curing process and impair the installation of the nut. Premature curing of the micro-encapsulated adhesive will result in the improper installation of the midship nut. Improper installation of this nut can cause driveline failure, which can result in a separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Failure to torque the midship nut to required specifications can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

A loose midship nut can result in driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Center Bearing

WARNING

Loose center bearing bracket bolts can result in driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Damaged center bearings or center bearing components can cause imbalance or vibration in the driveshaft assembly. Imbalance or vibration can cause component wear, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Foreign Material

WARNING

Build-up of foreign material, excessive paint, or undercoating on a driveshaft can cause imbalance or vibration in the driveshaft assembly. Imbalance or vibration can cause component wear, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

A contaminated slip member can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Hardware

WARNING

Loose, missing, or damaged bearing retainers or stamped straps, retaining bolts, nuts, end fitting tangs, snap rings, or rotating bearing cups can result in driveline failure. A separated driveline can lead to property damage, serious personal injury, or death.

DO NOT reuse bolts, straps, nuts, or damaged bearing retainers, or use inferior grade bolts. Reuse of bolts, straps, nuts, or damaged bearing retainers, or use of inferior grade bolts, can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

CAUTION

If loosening or removing bolts, always install a new strap and bolts and torque bolts to specification.

Lubrication (When Applicable)

⚠ WARNING

A missing, loose, or fractured grease zerk (nipple) fitting or plug eliminates the ability to lubricate the universal joint. Improper or inadequate lubrication can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Improper lubrication techniques can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

A missing, loose, damaged, or fractured plug or grease zerk (nipple) fitting can allow contaminants to invade the universal joint. Invasion of contaminants into the universal joint can degrade grease and cause universal joint damage, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Incompatible greases that are applied to universal joints and/or slip members can result in driveline failure and can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Hand tightening of grease zerk (nipple) fittings or plugs is NOT recommended. Failure to torque grease zerk (nipple) fittings to specifications can result in separation of the driveline from the vehicle. A separated driveline can cause property damage, serious personal injury, or death.

⚠ CAUTION

In cold temperatures, be sure to drive the vehicle immediately after lubrication. This activates the slip spline and removes excess grease. Failure to do so could cause excess grease to stiffen in the cold weather and force the plug out. The end of the spline would then be open to collect contaminants and cause the spline to wear and/or seize.

All slip yoke and universal joint seals should be completely purged.

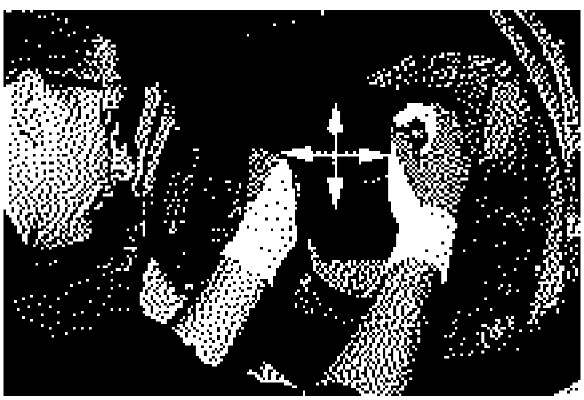
Inspection

Spicer 10 Series™ Driveshafts should be carefully inspected at recommended original-equipment manufacturer's service intervals and/or at Spicer recommended lubrication intervals as shown in the Lubrication section on page 11.

End Fitting Inspection

This information refers to axle, transmission, transfer case, and center bearing end fittings. Please refer to the End Fitting information in Component Safety on page 2.

1. Visually inspect all end-fitting retaining nuts or bolts for any gaps or looseness between mating surfaces. If gaps are present, consult transmission, axle, or transfer case original-equipment manufacturer's service and maintenance manual for proper fastener specifications. If looseness is evident between the nut, yoke, or center bearing, take the driveshaft to a qualified driveshaft facility for further inspection and repair.
2. Check all end fittings for looseness. Grasp the end fitting with both hands and try to move it vertically and horizontally to feel any looseness.



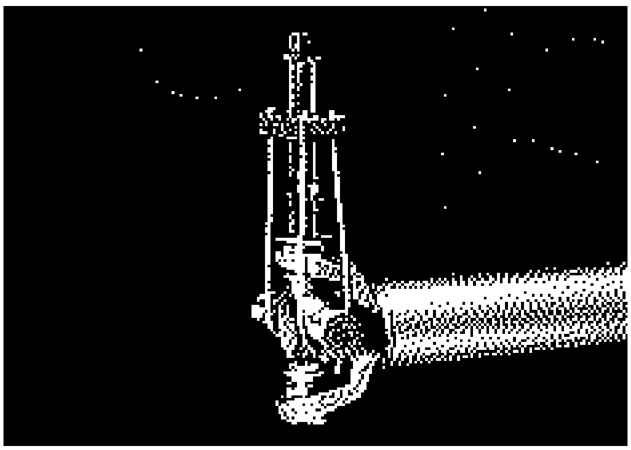
3. Grasp the end fitting with both hands and rotate left to right, feeling for play and backlash. There should not be any movement in the end fittings relative to the output or input shafts to which they are connected. If looseness is evident, consult transmission, axle, or transfer case original-equipment manufacturer's service and maintenance manuals for proper end fitting to shaft specifications.

4. Visually inspect for:
   - damaged half round bearing straps
   - loose bearing strap bolts
   - loose companion flange bolts and nuts
   - damaged or worn tangs on end fittings
   - damaged or missing snap rings
   - rotating bearing cups

If any of these conditions are present, component replacement is necessary. Refer to the original-equipment manufacturer's recommendations for removal instructions.

Bearing Plate (Full Round) Yoke Inspection
Please refer to the End Fitting information in the Component Safety section on page 2.

1. Refer to original-equipment manufacturer for removal of the driveshaft from the vehicle.
2. Place the driveshaft in v-blocks to remove the cross and bearing assemblies. Completely remove the cross and bearings from the yokes at both ends of the driveshaft using a universal joint removal tool. Next, disassemble the bearing assemblies from the slip yoke (and flange yoke, where applicable), using a tool kit.

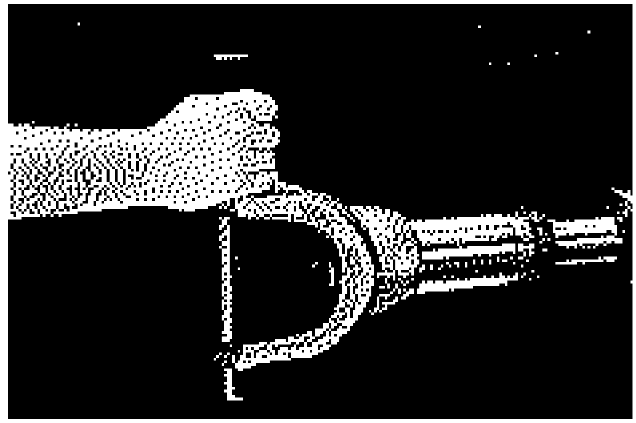


3. Clean the cross holes on the yoke, and inspect the cross hole surfaces for damage or raised metal. Raised metal or fretting can be removed from yoke cross holes with a fine-toothed file and/or emery cloth.

WARNING

DO NOT deform yoke cross holes by removing excessive metal. Raised metal or deformed yoke cross holes can cause cross and bearing failure, which can result in separation of the driveline from the vehicle.

4. Check the yoke lug cross holes with a No-Go Wear Gauge, and then use a Spicer Alignment Bar to inspect for damage by sliding through both cross holes simultaneously.



The alignment bar will identify yoke lugs that have taken a set because of excessive torque. The raised metal or distorted lugs can be a cause of premature cross and bearing problems.

5. If, after proper cleaning of the cross holes, the alignment bar will not pass through both cross holes simultaneously, the yoke lugs are distorted, and the yoke or yokes should be replaced.

Quick Disconnect™ (Half Round) End Yoke Inspection
Please refer to the End Fitting information in the Component Safety section on page 2.

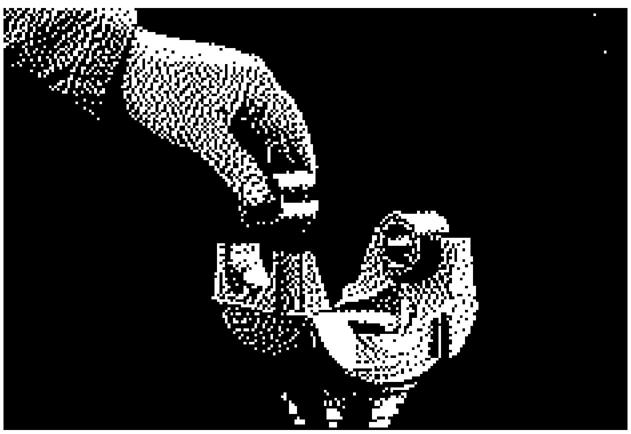
1. Remove the universal joint assembly from the end yoke, and clean the cross hole surfaces for inspection.
2. Inspect the cross hole surfaces for damaged or raised metal. Raised metal or fretting can be removed from yoke cross holes with a fine-toothed file and/or emery cloth.

WARNING

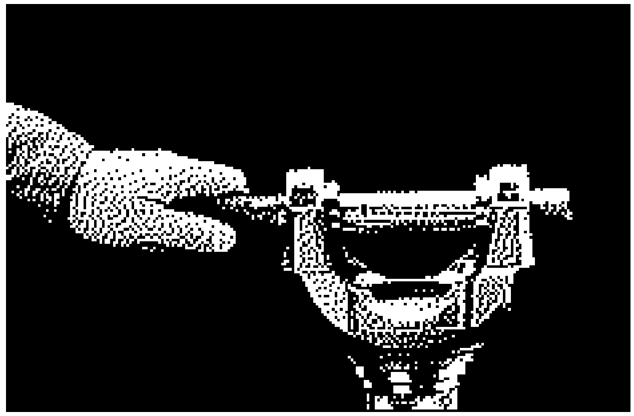
DO NOT deform yoke cross holes by removing excessive metal. Raised metal or deformed yoke cross holes can cause cross and bearing failure, which can result in separation of the driveline from the vehicle.

Inspect the bearing caps for any indication of rotation within the cross holes. If rotation is apparent, the yoke should be replaced.

3. Check the yoke for cross hole alignment using the Spicer alignment gauge. Place the correct bushing in each lug ear, allowing a .030" (.75 mm) to .060" (1.5 mm) clearance between the tang and the bushing.



4. Assemble bearing straps and bolts, tightening bolts a minimum of 30 lbs. ft. (41 N•m). Insert the alignment bar into one bushing. If the bar enters and passes through the opposite bushing, alignment is correct. If the alignment bar will not enter the opposite bushing, re-inspect for yoke seat burrs.



5. If, after proper cleaning, the alignment bar still does not pass through both bushings, the yoke lugs are distorted, and the yoke should be replaced.

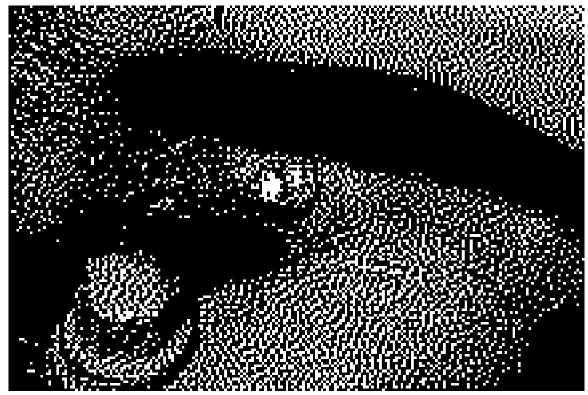
Universal Joint Inspection

Please refer to the Universal Joint information in the Component Safety section on page 2.

1. Check for excessive looseness between the ends of the universal joint bearing cup assemblies and trunnions.
2. Grasp the inboard yoke on the driveshaft with both hands and attempt to move the yoke horizontally and vertically. There should be less than .006" (.15 mm) movement in the universal joint relative to the inboard or outboard yokes. If looseness is greater than .006" (.15 mm) in either direction, the universal joint must be replaced. See Disassembly and Reassembly on page 16.

Re-lubable Style Universal Joints

1. With re-lubable style universal joints, check for the presence of all grease zerk (nipple) fittings. Grease zerk (nipple) fittings should not be missing, loose, or fractured.



2. If a grease zerk (nipple) fitting is loose, tighten it to required specifications. See the Universal Joint Grease Zerk (Nipple) Fitting and Plug Torque table on page 26.
3. If a grease zerk (nipple) fitting is fractured or missing, the entire universal joint must be replaced. Refer to Disassembly and Reassembly on page 16 for removal and replacement instructions.

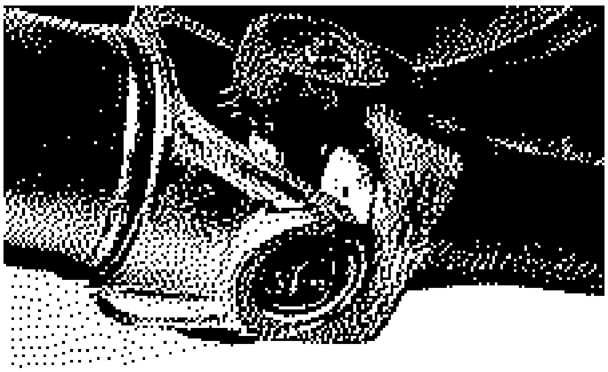
Permanently Greased Plug Style Universal Joints
Please refer to the Universal Joint information in Component Safety on page 2.

1. Permanently greased plug style universal joints have a plug rather than grease zerk (nipple) fittings. Make sure the plug is not missing, loose, or fractured. If the plug is loose, tighten it to required specifications. See the Universal Joint Grease Zerk (Nipple) Fitting and Plug Torque table on page 26.
2. If a plug is missing or fractured, the entire universal joint must be replaced. Refer to recommendations in the Disassembly and Reassembly on page 16 for removal and replacement instructions.

Slip Member Assembly

This information refers to slip yokes and tube shaft assemblies. Please refer to the Slip Member information in the Component Safety section on page 2.

1. Check all slip yoke assemblies to be sure the slip yoke plug is not loose, missing, or damaged. If any of these situations are evident, replacement of the yoke assembly is necessary.



2. Visually inspect for the presence of the grease zerk (nipple) fitting, if applicable, on the slip yoke. Grease zerk (nipple) fittings should not be missing, loose, or fractured.
3. If a grease zerk (nipple) fitting is loose, tighten it to required specifications. See the Universal Joint Grease Zerk (Nipple) Fitting and Plug Torque table on page 26.
4. If a grease zerk (nipple) fitting is missing or damaged, the slip member assembly must be replaced.
5. Check the slip yoke seals and dust caps. Make sure the seal is properly attached to the slip yoke and is not loose or damaged. If any of these situations are evident, replacement of the slip member and/or seal may be necessary.
6. For an inboard and outboard slip yoke assembly design, check to be sure the slip yoke welch plug is not loose, missing, or damaged.
7. If there is excessive looseness between the mating components, with the presence of vibration, all slip assembly components should be replaced.

Tubing

Please refer to the Tubing information in the Component Safety section on page 2.

1. Check the driveshaft for bent or dented tubing or missing balance weights. If any of these conditions is evident, replacement of the complete driveshaft assembly or tube is necessary.
2. Make certain there is no build-up of foreign material on the driveshaft. If found, build-up should be removed carefully to avoid damaging the driveshaft.

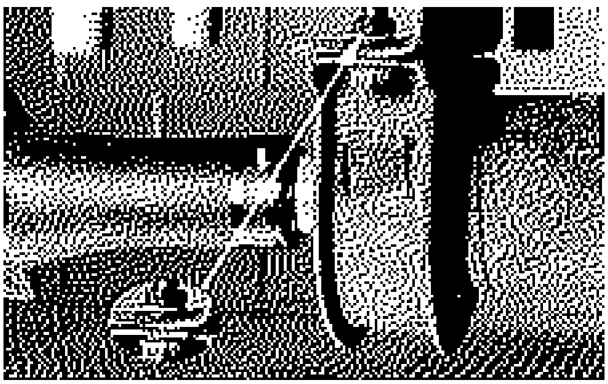
⚠ CAUTION

Do not allow solvents to come in contact with seals or greasible areas of the driveshaft assembly. If foreign material cannot be removed without complete assurance that the driveshaft will not be damaged, the complete driveshaft should be replaced with a new OEM driveshaft.

Center Bearings

Please refer to the Center Bearing information in the Component Safety section on page 2.

1. Inspect the center bearing bracket bolts for looseness. If looseness is evident, re-tighten the center bearing bracket bolts. Consult the vehicle manufacturer's documentation for proper bolt torque. Check the alignment of the bracket before tightening the bolt. Bracket should not be skewed more than 3° in relation to the centerline of the driveshaft.



2. Visually inspect the center bearing rubber cushion for damage. Make sure the slingers are not rubbing against the rubber cushion. Verify that the rubber cushion is properly seated in the metal bracket. If any of these conditions are evident, replacement of the center bearing assembly is necessary. Refer to recommendations in the Disassembly and Reassembly on page 16 for proper center bearing replacement procedures.

Midship End Fitting
Please refer to the safety information in the General Safety section and the Midship Nut information in the Component Safety section on page 2.

1. Inspect the center bearing end fitting and bolt hole threads for damage. If the bolt hole threads are damaged, the end fitting must be replaced.

2. Check the center bearing end fitting and fitting nut washer for any looseness. Grasp the end fitting with both hands, and try to move it both vertically and horizontally to feel for looseness. There should NOT be any movement in the center bearing end fitting relative to the midship tube shaft to which it is connected. If any of these conditions are present, the center bearing end fitting and midship tube shaft must be replaced as a pair.
3. Refer to the End Fitting Inspection section on page 5 for proper procedures.

Note: Repeat the same inspection steps for all center bearings within the driveline.

Lubrication

Lack of proper lubrication is among the most common causes of universal joint and slip member problems. Properly sized Spicer universal joints that are adequately lubricated at recommended intervals will normally meet or exceed vehicle operation requirements.

Note: Spicer 10 Series™ relube style universal joints contain only enough grease to provide needle roller bearing protection during storage and shipment. It is therefore necessary to completely lubricate each replacement universal joint after assembly into the end fitting.

Inadequate service intervals and failure to properly lubricate the universal joints will cause universal joint failures. Proper lubrication purges all universal joint seals, thus removing abrasive contaminants from the bearing assemblies. Slip members must also be adequately lubricated to prevent slip member failure.

Members Lubrication Intervals

1. Carefully review the lubrication specifications found in this manual.
2. Be sure to lubricate at the recommended intervals. See the table below.
3. Be sure to use only recommended greases that meet the listed criteria. See “Lubrication for Universal Joints” on page 12.
4. Carefully follow driveshaft inspection procedures as outlined in this manual.

Note: It is essential that all bearing seals be completely purged of old grease and contaminants. If only fresh grease can be seen at all seals, the purging process is complete, and the universal joint is properly lubricated.

Spicer 10 Series™ Universal Joint and Slip

The Spicer 10 Series™ Driveshafts include 1310 through 1880.

City	Highway	Line Haul	On/Off Highway	Off-Highway and Industrial*
5,000/8,000 Miles (8,000/12,000Km) or 3 months (whichever comes first)	10,000/15,000 Miles (16,000/24,000Km) or 3 months (whichever comes first)	10,000/15,000 Miles (16,000/24,000Km) or 30 days (whichever comes first)	5,000/8,000 Miles (8,000/12,000Km) or 3 months (whichever comes first)	500/200 Hrs.
*Grease cycles for off-highway and industrial uses vary depending on the application and operating conditions. In general, to obtain maximum life, lubrication should occur every 500 hours for normal service and every 200 hours for continuous service or severe environmental conditions. Spicer Driveshaft recommends lubricating with a compatible grease meeting N.L.G.I. Grade 2 specifications with an operating range of +325° F to -10° F (163° C to -23° C). For more information on Spicer Driveshaft lubrication intervals, please refer to Form #3283-SDD.				

- **City** is defined as all applications requiring a minimum of 90 percent of operation time within city limits.
- **Highway** is defined as all applications requiring less than 10 percent of operating time on gravel, dirt, or unpaved roads.
- **Line Haul** is defined as 100 percent of operating time on smooth concrete or asphalt.
- **On/Off Highway** is defined as all applications operating primarily on paved roads but requiring more than 10 percent of operating time on gravel, dirt, or unpaved roads.
- **Off-Highway and Industrial** is defined as 100 percent on gravel, dirt, or unpaved roads, or stationary applications.

Lubrication for Universal Joints

Spicer recommends the following requirements be met for any grease used to service most vehicular and industrial applications and all auxiliary driveshaft applications:

- Use a good quality E.P. (extreme pressure) grease (Timken Test Load - 50 lbs. / 23 kg. minimum), and that
- Meets N.L.G.I. (National Lubricating Grease Institute) Grade 2 specifications, and has an
- Operating range of +325° F to -10° F (163° C to -23° C), which is
- Compatible with commonly used multi-purpose greases. For information about grease compatibility, see the Grease Compatibility section below. Consult your local grease source for greases that meet these specifications.

Note: There are instances when special lubrication is required due to original-equipment manufacturer specifications or customer requests. The lubrication recommendations listed in this manual are authorized by Spicer Driveshaft engineering. Any alternate greases or lubrication procedures are the responsibility of the user.

Grease Compatibility
To help reduce the effects of incompatible greases, be sure to thoroughly purge all four bearing seals on each universal joint with the new grease. Purge seals until the **fresh** grease is visible on the outside of all four bearing seals. **It is recommended that all purged grease be wiped clean to prevent discharge into the general environment. Contact your local grease supplier for grease compatibility information.**

Lubrication Procedure for Universal Joints
Please refer to the Lubrication information in the Component Safety section.

Required Materials:

- N.L.G.I. Grade-2, E.P. Grease
- Grease gun

May Need If Bearing(s) Will Not Purge:

- C-Clamp
- New straps
- New bolts

1. Use the proper grease to purge all four seals of each universal joint. This flushes abrasive contaminants from each bearing assembly and assures all four bearings are filled. Purge the seals. Spicer seals are made to be purged. Make sure **fresh** grease is evident at all four universal joint bearing seals.
2. If any of the seals fail to purge, try to push the driveshaft away from the seal that will not purge, while applying grease gun pressure. There will occasionally be one or more bearing assemblies that will not purge.

Quick Disconnect™ (Half Round) Universal Joints

Series	Strap Kit Assemblies	Recommended Bolt Torque	N•m
1310	2-70-18X	13-18 lbs. ft.	17.6 - 24.4
1330	2-70-18X	13-18 lbs. ft.	17.6 - 24.4
1350	3-70-18X	30-35 lbs. ft.	40.7 - 46.5
1410	3-70-18X	30-35 lbs. ft.	40.7 - 46.5
1480	3-70-28X	45-60 lbs. ft.	61 - 81.3
1550	3-70-28X	45-60 lbs. ft.	61 - 81.3
1610	5-70-28X	45-60 lbs. ft.	61 - 81.3
1710	6.5-70-18X	115-135 lbs. ft.	162.7 - 183
1760	6.5-70-18X	115-135 lbs. ft.	162.7 - 183
1810	6.5-70-18X	115-135 lbs. ft.	162.7 - 183

The bolt torque specifications refer to Spicer bearing straps and bearing plates only. If using original-equipment bearing straps and bearing plates, refer to manufacturer's service manual for proper bolt torque specifications.

Note: Unless otherwise noted all recommended bolt torques are with dry threads.

1. If any of the bearing assemblies fail to purge removal of the driveshaft is necessary. See the original-equipment manufacturer for proper driveshaft removal procedures.
2. Place the driveshaft in v-blocks and apply a C-clamp across the half round bearings. Apply grease gun pressure. Completely purge both bearings.
3. If outboard bearings fail to purge, slightly loosen C-clamp and reapply grease gun pressure until both half round bearings purge.
4. After **all** four bearings purge fresh grease, re-tighten the C-clamp to squeeze out excess grease and wipe clean. This will ease installation of universal joint kit back into yoke. Install universal joint kit in the yoke using new straps and bolts, and torque bolts to the required specifications. Reference bolt torque specifications in the above table.
5. If the bearings still will not purge, complete removal of the universal joint kit is needed to determine the cause of blockage. Refer to original-equipment manufacturer's service manual for removal procedures.

Bearing Plate (Full Round) Universal Joints

Series	Bolt Part Number	Recommended Bolt Torque	N•m
1610	5-73-709	26-35 lbs. ft.	35.3 - 47.5
1710	6-73-209	38-48 lbs. ft.	51.5 - 65.1
1760	6-73-209	38-48 lbs. ft.	51.5 - 65.1
1810	6-73-209	38-48 lbs. ft.	51.5 - 65.1
1880	7-73-315	60-70 lbs. ft.	81.3 - 94.9

The bolt torque specifications refer to Spicer bearing straps and bearing plates only. If using original-equipment bearing straps and bearing plates, refer to manufacturer's service manual for proper bolt torque specifications.

Note: Unless otherwise noted all recommended bolt torques are with dry threads.

1. There will occasionally be one or more bearing assembly seals that will not purge. Release seal tension by loosening the bolts holding the bearing assembly that does not purge. It may be necessary to loosen the bearing assembly approximately 1/16" minimum. If loosening it does not cause purging, remove the bearing assembly to determine the cause of blockage.

Note: It is essential that all seals be completely purged of old grease and contaminants. If fresh grease can be seen at these seals, the purging process is complete, and the universal joint is properly lubricated.

Note: Spalling and/or brinelling can be caused if contaminants (water, air, etc.) are left in the universal joint and/or the bearing seals. Purge old grease thoroughly.

2. Install new bolts, and torque to specifications in the above table.

Snap Ring Universal Joints

1. There will occasionally be one or more bearing assembly seals that will not purge. If any of the seals will not purge, replacement of the universal joint kit is necessary. See the Reassembly - Inboard Slip Style under "Center Bearing Assembly" on page 20 for proper replacement procedures.

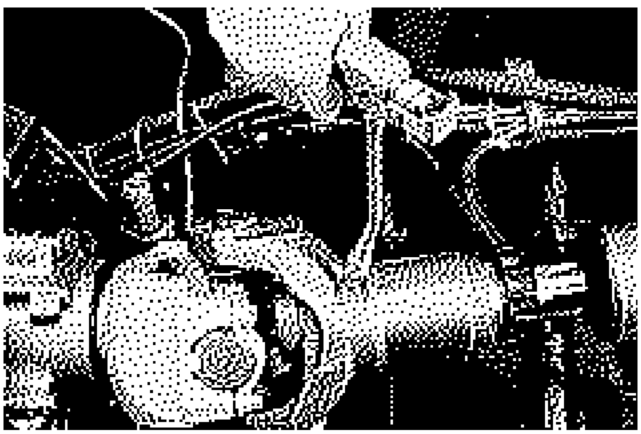
Lubrication for Slip Members

Please refer to the Lubrication information in the Component Safety section on page 2.

The grease used for universal joints is satisfactory for slip members. Glidecote® and steel splines both use a high quality E.P. grease meeting N.L.G.I. Grade 2 specifications.

Grease splines at the intervals recommended in the Lubrication Intervals table page 11.

1. Apply grease gun pressure to the grease zerk (nipple) fitting until grease appears at the pressure relief hole in the plug.

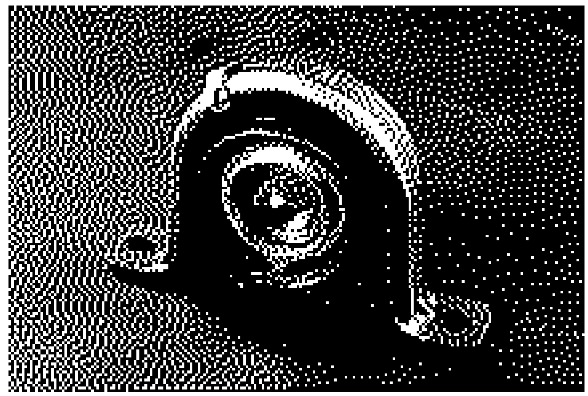


2. Now cover the pressure relief hole with your finger and continue to apply pressure until grease appears at the slip yoke seal.

Note: Use caution to prevent seal damage when using high pressure lubrication systems.

Lubrication of Center Bearing Assemblies

Spicer center bearings are lubricated for life. No attempt should be made to add to or change grease within the bearing itself.



Note: For pillow blocks, use original-component manufacturer's recommended greases and lubrication intervals.

Disassembly and Reassembly

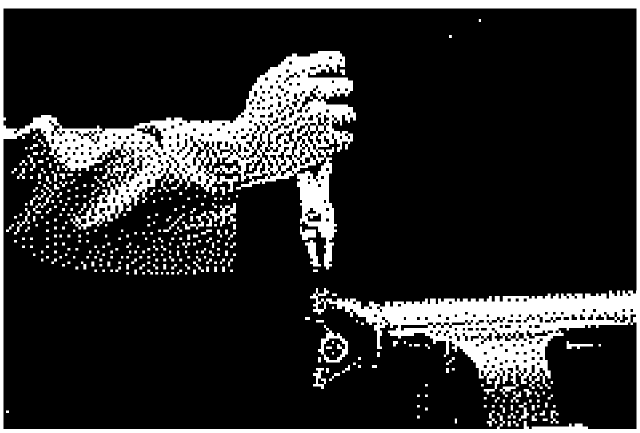
For procedures used in the removal and installation of Spicer Driveshafts from the vehicle, please consult the vehicle manufacturer's service manual. This manual concerns itself only with the disassembly and reassembly of driveshaft components.

Universal Joint

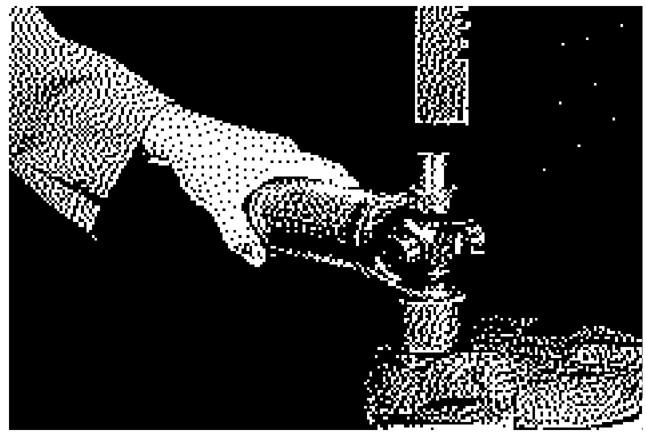
Disassembly - Snap Ring Design
Please refer to the Universal Joint information in the Component Safety section on page 2.

With the driveshaft removed, the following procedure should be followed:

1. Using snap ring pliers, remove the snap rings from the yoke ears.



2. Set the yoke in the arbor press with a piece of tube stock beneath it. Position the yoke with the universal joint grease zerk (nipple) fitting pointing up to prevent interference during disassembly. Place an appropriate push rod on the upper bearing assembly, and press it through to release the lower bearing assembly.



⚠ CAUTION

Do not distort yoke ears with excessive force while in the arbor press.

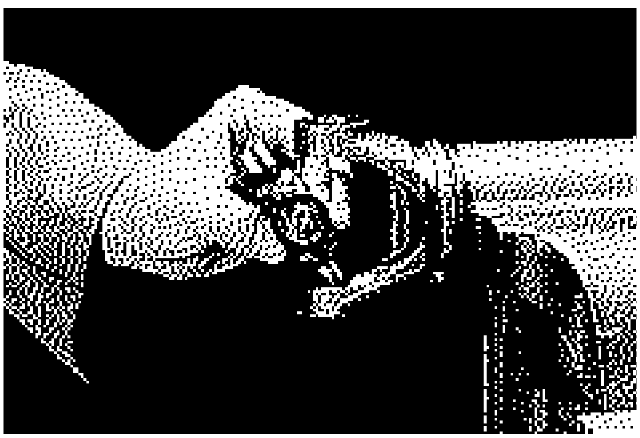
3. If the bearing assembly will not pull out by hand after pressing, grip the bearing cup and pull from the yoke.
4. Place the yoke in the arbor press with the remaining bearing cup face down. Using an appropriate push rod, press on the end of the journal cross trunnion. Continue to press down on the journal cross trunnion until the shoulder of the journal cross makes contact with the inside of the yoke ear.
5. Repeat steps three and four on the remaining bearing assemblies to remove the cross from the yoke.
6. Inspect all yoke cross hole surfaces for damage. Raised metal or fretting can be removed from yoke cross holes with a fine-toothed file and/or emery cloth.

Reassembly - Snap Ring Design

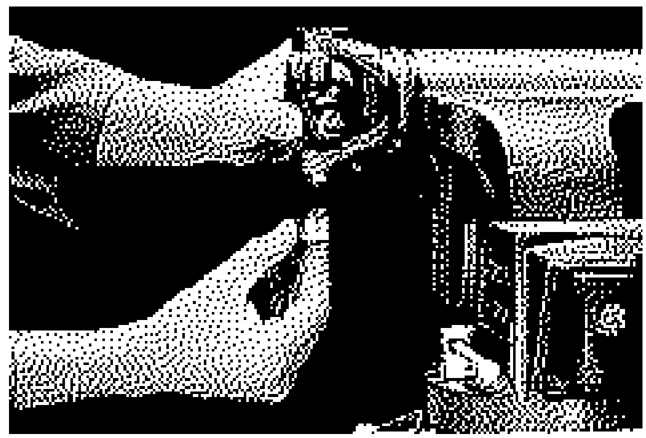
Please refer to the Universal Joint information in the Component Safety section on page 2.

1. Using a high quality N.L.G.I., grade 2 extreme pressure (E.P.) grease, apply adequate grease to each bearing cup assembly. Fill all the cavities between the needle rollers, and also apply a liberal coating of grease in the bottom of each bearing cup and on the lip of the seal. Be careful not to get grease on the outside machined surface of the bearing cup.

2. Position the journal cross in the yoke cross holes with the grease zerk (nipple) fitting inward toward the tubing. **Failure to properly position the universal joint may result in the inability to lubricate the universal joint.** If using an arbor press, proceed to Step 3. If using a universal joint installation tool, follow the tool manufacturer's instructions.

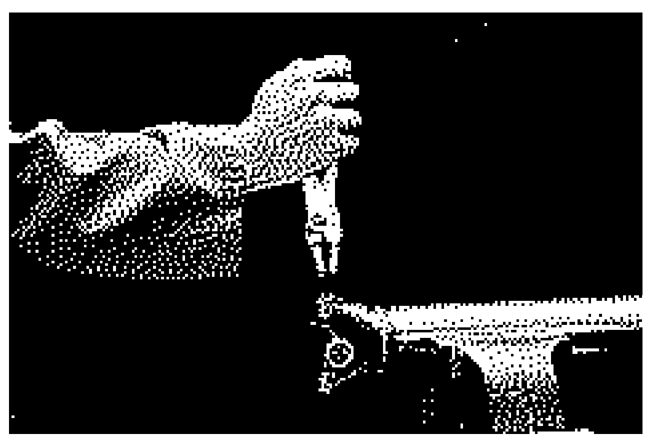


3. Move one end of the journal cross to cause a trunnion to project through the cross hole beyond the outer machined face of the yoke ear. Check the bearings for skewed or dropped needle rollers. Place the bearing cup assembly over the protruding trunnion diameter and align it to the yoke cross hole. Align the yoke in an arbor press with the bearing assembly resting on the base of the press. Cover the yoke ear with a metal plate that has .150" (6.4 mm) minimum thickness. Push the yoke onto the bearing cup assembly until it is flush with the cross hole face.

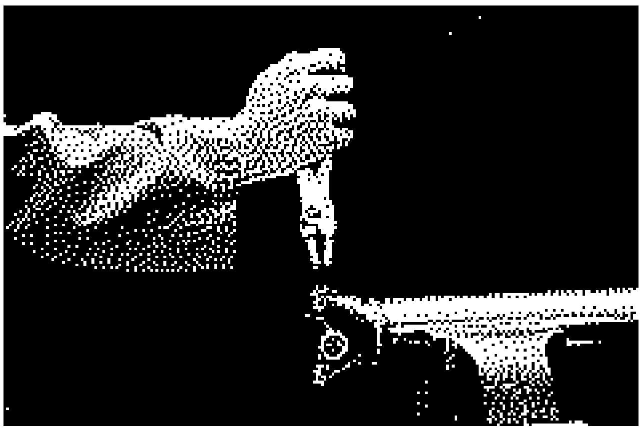


4. Place a push rod that is smaller than the diameter of the bearing cup assembly under the bearing cup assembly, and continue pressing into the yoke cross hole until a snap ring can be installed.

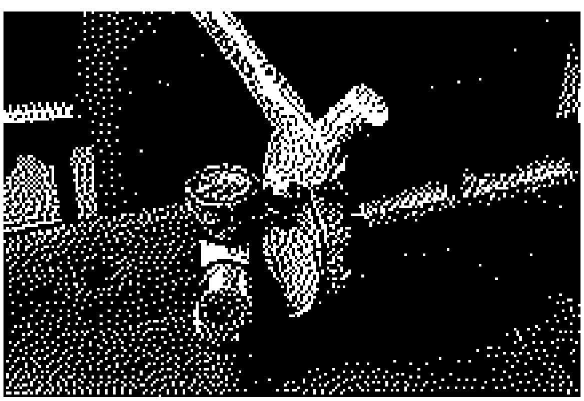
5. Remove the yoke from the arbor press. Install a snap ring using snap ring pliers.



6. Flip the yoke 180°. Check the bearings for skewed or dropped needle rollers. Place another bearing cup assembly over trunnion diameter, and align it to the yoke cross holes. Align the yoke in arbor press with previously installed bearing cup assembly resting on the base of the press. Place a push rod that is smaller than the bearing cup assembly on top of the bearing cup assembly. Press bearing cup assembly into the yoke cross hole until a snap ring can be installed.
7. Remove the yoke from the arbor press. Install a snap ring using snap ring pliers.



8. Ensure snap rings are seated into the snap ring grooves.
9. Flex the journal cross to make sure it moves freely by hand. Some resistance is acceptable. If it does not move freely, tap the yoke ear as shown.

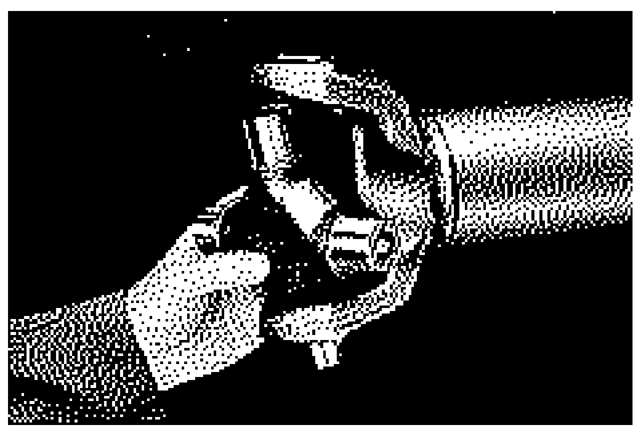


Disassembly - Bearing Plate Style
Please refer to the Universal Joint information in the Component Safety section on page 2.

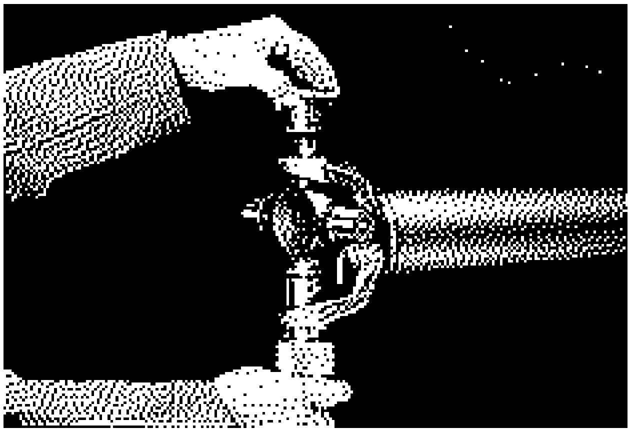
With the driveshaft removed, see "Inspection" on page 5 for Bearing Plate (Full Round) Yoke Inspection disassembly procedures.

Reassembly - Bearing Plate Style
Please refer to the Universal Joint information in the Component Safety section on page 2.

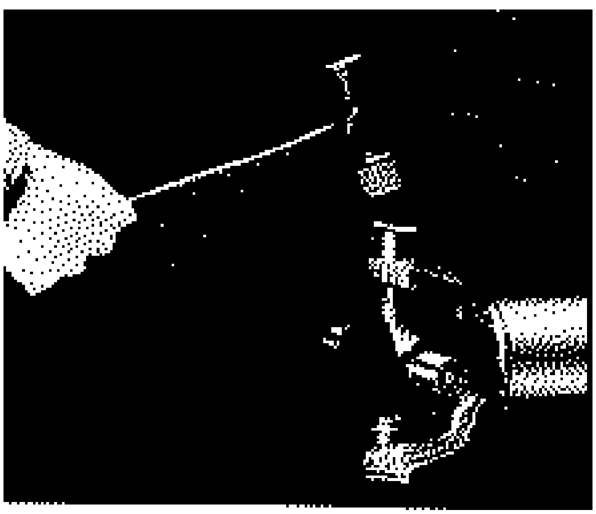
1. Remove the cross and bearings from the box and remove all four bearing assemblies. Rotate the cross to inspect for the presence of a positive purging valve in each grease hole of all four trunnions. Then position the cross into the end yoke with its grease fitting in line as near as possible with the slip spline grease fitting. Keep the grease fitting on the inboard side.
2. Using a high quality N.L.G.I., grade 2 extreme pressure (E.P.) grease, apply adequate grease to each bearing cup assembly. Fill all the cavities between the needle rollers, and also apply a liberal coating of grease in the bottom of each bearing cup and on the lip of the seal. Be careful not to get grease on the outside machined surface of the bearing cup.
3. Position one end of the cross to cause a trunnion to project through the hole beyond the outer machined face of the yoke lug.



4. Place a bearing assembly over the trunnion diameter and align it to the cross hole.



5. Holding the trunnion in alignment with the cross hole, install the bearing assembly by hand until it is flush with the face of the end yoke. If the universal joint bearing cap is pressed into place, the bearings and bearing surfaces could be damaged.
6. If the bearing assembly binds in the cross hole, tap it with a soft-faced hammer directly on the center bearing assembly. Do not tap the outer edges of the bearing assembly.

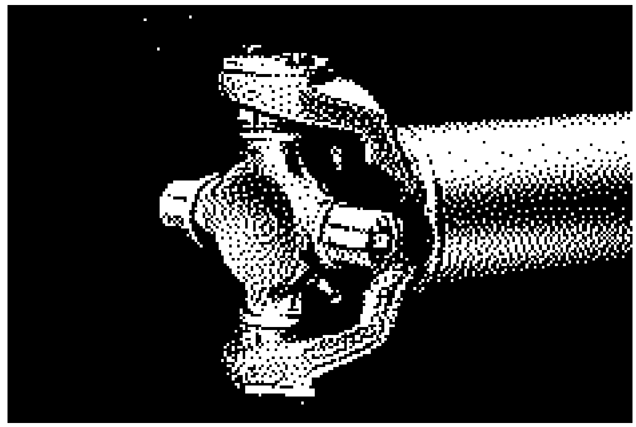


CAUTION

Exact fit of all driveline components is extremely important. The correct parts and clean mating services are essential for safe operation, long life, and good repair.

7. When the bearing assembly is completely seated, put the lock plate tab (if used) in place and use the "Grade 8" cap screws furnished with the universal joint and insert them through the cap screw holes in both the lock strap and/or the bearing plate assembly. Thread by hand or with a wrench into the tapped holes in the yoke. Do not torque down the bolts.

Note: The self-locking bolt design for full round yokes uses serrated bolts with lock patch and does not require a lock strap. DO NOT reuse any retaining bolt. If loosening or removal of a bolt is necessary, replace it with a new one.



8. Move the cross laterally to the opposite side and through the cross hole, beyond the machined surface of the yoke lug. Place a bearing assembly over the cross trunnion and slide it into the cross hole, seating the plate to the face of the lug. Thread the bolts by hand or with a wrench into tapped holes in the yoke.

Note: Projecting the trunnion through a cross hole beyond the machined surface of the lug will provide a surface to help align the bearing assembly with the cross hole.

9. For flange yoke applications, install the flange yoke, bearing assemblies, and bolts at this time.

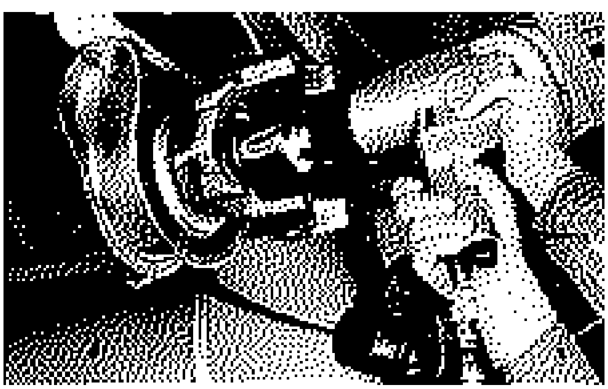
Center Bearing Assembly

Disassembly - Inboard Slip Style
Please refer to the Center Bearing information in the Component Safety section on page 2.

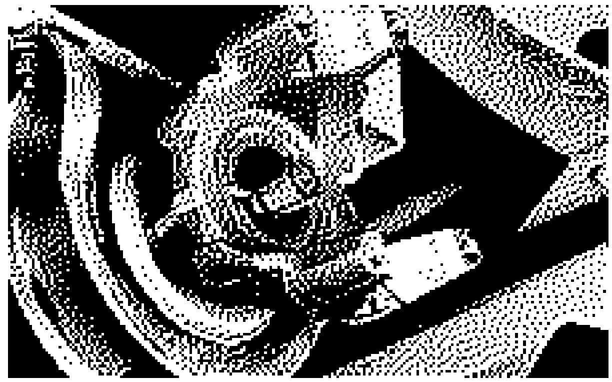
This information includes procedures for disassembling SAE, DIN, and T-Type Companion Flange / Flange Yoke, Quick Disconnect, and Bearing Plate Styles.

1. Remove the midship nut. Reference the midship nut specification in the Midship Nut Specifications table. Discard the nut. If the washer is damaged, discard and replace it. Otherwise, reuse the washer.

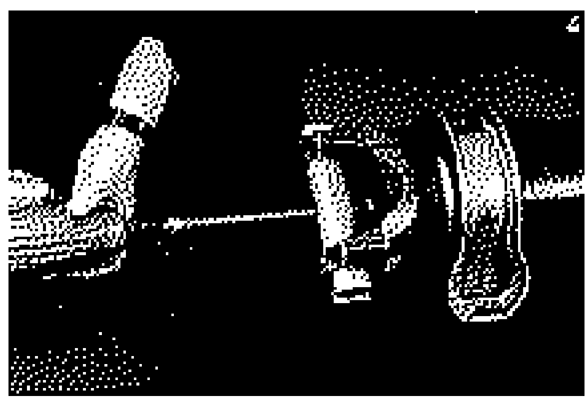
Note: The midship nut can be removed when the coupling shaft is still in the vehicle. For coupling shaft removal, please refer to original-equipment manufacturer's service document.



2. Remove driveshaft per original-equipment manufacturers instructions, and then place the driveshaft in v-blocks.
3. Mark the counterbore of the coupling shaft end yoke to midship "nose" with a marking stick, paint marker or other legible marking device. This assures proper reassembly of the coupling shaft end yoke in its original phased position.

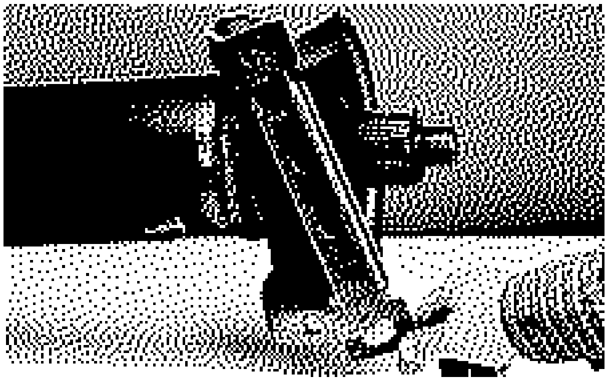


4. Using a puller, follow the tool manufacturer's instructions to remove the end fitting. The end fitting has a press fit and should NOT be removed with a hammer. If the end fitting is loose enough to be removed by hand, the entire coupling shaft must be replaced. Remove and discard the slinger from the yoke.

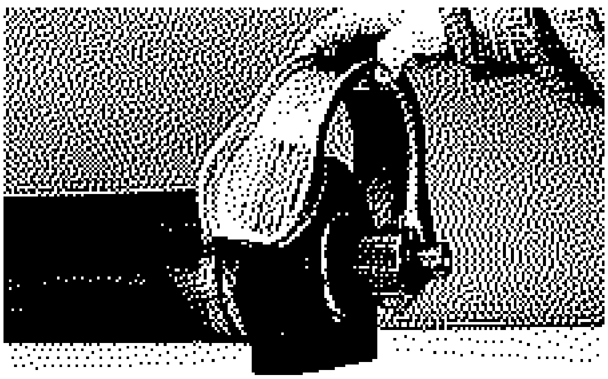


5. Visually inspect the splines of the center bearing end yoke. If the yoke splines are damaged, missing or twisted, the yoke must be replaced. If the yoke hub has cracked, the yoke must be replaced.
6. Visually inspect the midship splines and threads. If the splines or threads are damaged, missing or twisted, replacement of the entire coupling shaft is necessary.

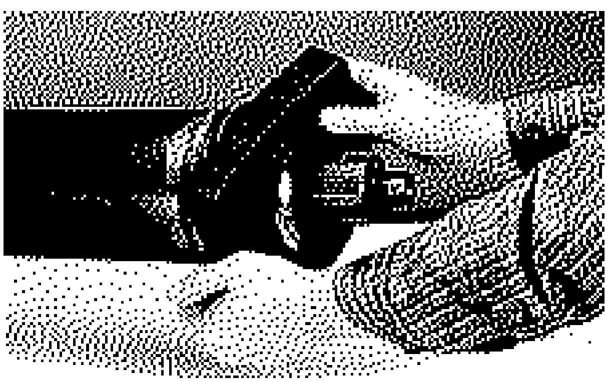
7. On some Spicer center bearing assemblies, a metal retainer spans the outside center bearing bracket. If the metal retainer is present, remove it and discard.



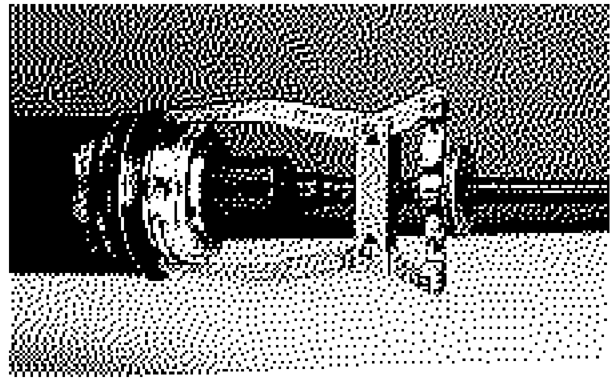
8. Remove and discard the center bearing bracket.



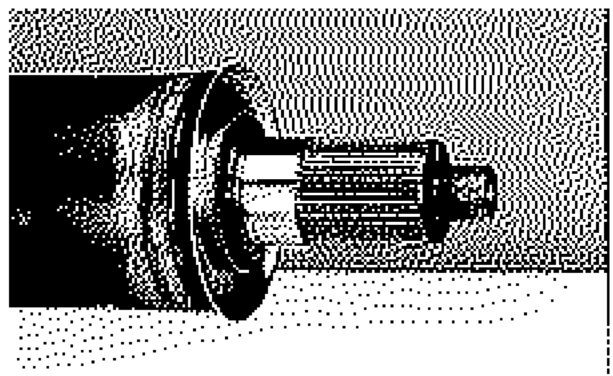
9. Remove and discard the rubber cushion.



10. Using a puller, follow the tool manufacturer's instructions to remove the bearing assembly from the midship. Discard the center bearing.



11. Inspect the midship for wear on the bearing diameter. If the midship is damaged from a seized bearing, replacement of the entire coupling shaft is necessary.



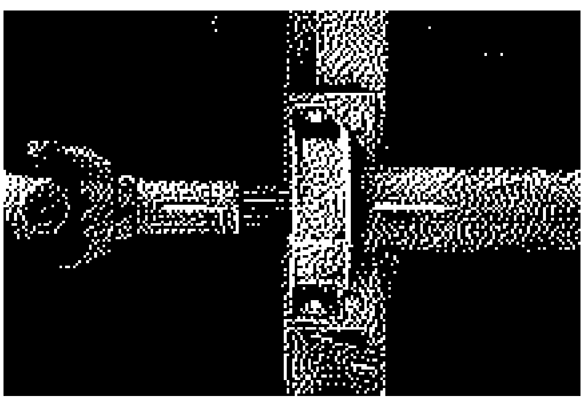
12. If no damage is apparent, remove the slinger, and proceed to the installation of the center bearing, described in the "Reassembly - Inboard Slip Style" section.

Midship Nut Specifications Table

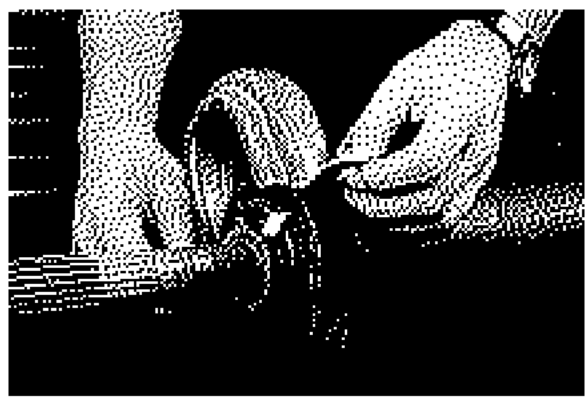
Series	Nut Part Number	Nut Catalog Color	Washer Part Number	Head Size	Nut Torque N•m	Nut Torque lbs. ft.
1310	231781	cadium plate & wax	230123-12 230123-14	15/16"	136-163	100-120
1310 (Toyota Only)	10-74-101	cadium plate & wax	230123-12 230123-14	15/16"	136-163	100-120
1410	16-74-101	silver	230123-15	1-5/16"	373-440	275-325
1480	16-74-101	black	230123-15	1-5/16"	542-610	400-450
1480	16-74-101	silver	230123-15	1-5/16"	373-440	275-352
1550	231502	black	none	1-5/8"	644-712	475-530
1610	231502	black	none	1-5/8"	644-712	475-525
1710	20-74-91	black	230123-6	1-5/8"	644-712	475-525
1710	231502	black	none	1-5/8"	644-712	475-525
1760	20-74-91	black	230123-6	1-5/8"	644-712	475-525
1810	20-74-91	black	230123-6	1-5/8"	644-712	475-525

Disassembly - Outboard Slip Style

1. Mark the slip yoke barrel and midship tube shaft with a marking stick, paint marker, or other legible marking device. This ensures proper reassembly of the mating components in their original phased position.

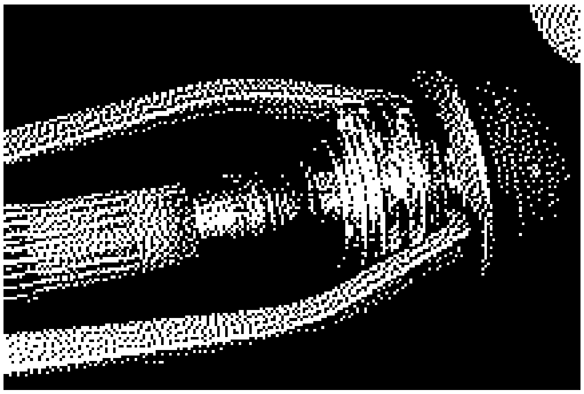


2. Refer to original-equipment manufacturer's instructions for removal of the coupling shaft.
3. Visually inspect midship tube shaft, looking for wear on spline surface. If splines are damaged, missing or twisted, or Glidecote® is missing, replacement of entire coupling shaft is necessary.
4. On some Spicer center bearing assemblies, a metal retainer spans the outside center bearing bracket. If the metal retainer is present, remove it and discard.
5. Remove and discard the center bearing bracket.

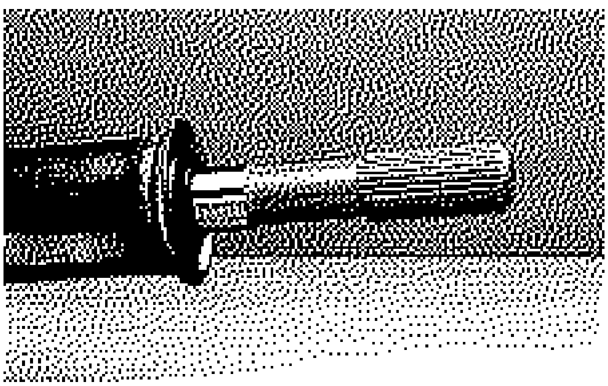


6. Remove and discard the rubber cushion.

7. Using a puller, follow the tool manufacturer's instructions to remove the bearing assembly from the midship. Discard the center bearing.



8. Inspect the midship for wear on the bearing diameter. If the midship is damaged from a seized bearing, replacement of the entire coupling shaft is necessary.



9. If no damage is apparent, remove the slinger and proceed to the installation of the center bearing, described in the "Reassembly - Outboard Slip Style" section.

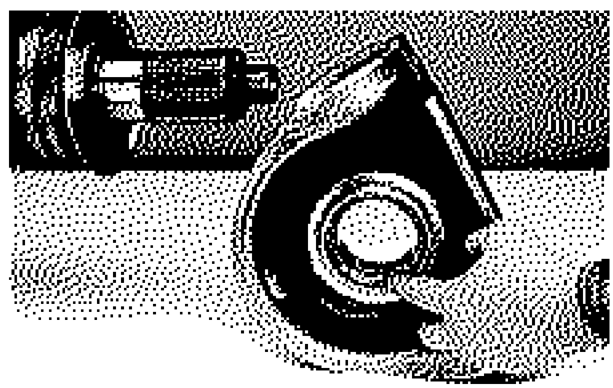
Reassembly - Inboard Slip Style

Please refer to the Center Bearing information in the Component Safety section on page 2.

This information pertains to SAE, DIN, and T-Type Companion Flange/Flange Yoke, Quick Disconnect, and Bearing Plate styles.

1. Wipe the bearing surface of the midship tube shaft with a fine emery cloth.
2. Install a new slinger (included in the center bearing replacement parts kit) on the midship tube shaft. Use a section of tubing to avoid damaging the slinger. Make sure the slinger is completely seated against the midship tube shaft shoulder.
3. Before installing the new center bearing assembly, be sure to fill the entire cavity around the bearing with a waterproof lubricant.

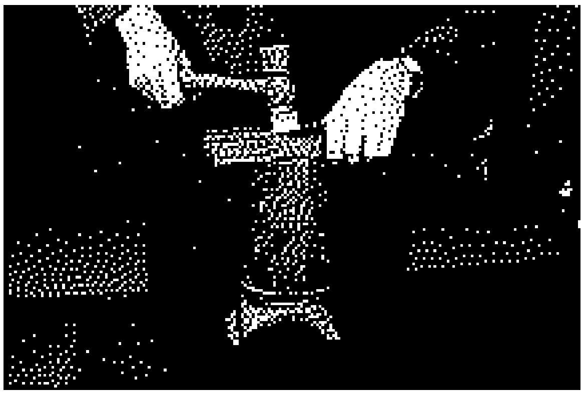
   Enough lubricant must be applied to fill the cavity to the extreme edge of the slinger surrounding the bearing. Lubricants must be waterproof.



Recommended Center Bearing Lubricants

Lubricants	*Source*
Rykon Premium No. 3	*Amoco Oil Company*
Amolith 8516	*Amoco Oil Company*
Van Talgar No. 4	*Exxon Company*

4. Carefully align the new center bearing assembly with the ground surface of the midship tube shaft. Install the center bearing onto the midship tube shaft. Minimal force should be necessary to push the center bearing onto the midship tube shaft, provided the shaft and bearing are in alignment.
5. Install the remaining slinger on the end yoke using a section of tubing to avoid damaging the slinger.

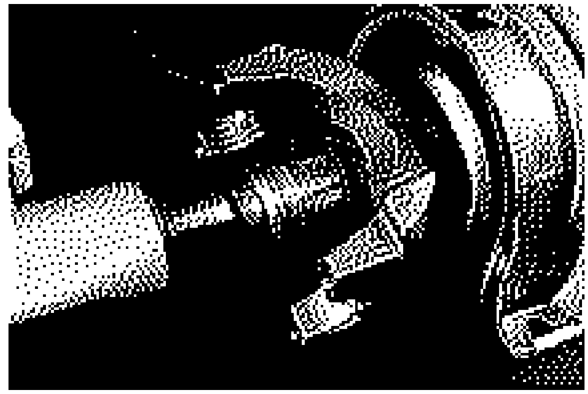


6. **Make sure that the phasing marks from driveshaft removal are aligned, and** using an installation tool, press the yoke onto the midship tube shaft. **Do not strike yoke with hammer or use midship nut to install yoke.**
7. Installation of the driveshaft onto the vehicle can now proceed. Refer to the vehicle manufacturer's documentation for installation procedures. See the Midship Nut information in the Component Safety section on page 2.

Midship Nut Installation Procedure
Only work on components when they are cool to the touch. Installing the midship nut onto a threaded midship which is above the ambient temperature will cause the adhesive to cure too rapidly, and the midship nut may not install correctly.

Do not use the midship nut to pull the end fitting onto the midship. This may result in improper seating of the end fitting and will begin the curing of the midship nut adhesive. As a result, the midship nut may not install correctly.

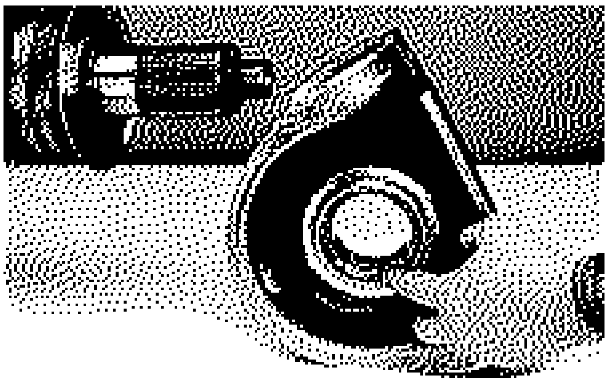
1. Visually inspect the midship washer (if applicable) for flatness, corrosion, or cracks. If the washer is bent, corroded, or cracked, the washer must be replaced.



2. Thoroughly clean midship threads with mineral spirits. Wipe the midship threads dry with a clean, dry rag. **Do not use a wire brush to clean threads.** This may distort the midship threads and result in the midship not being able to properly retain the midship nut.
3. Thoroughly clean the midship washer (if applicable) and the inboard, machined face of the end fitting with mineral spirits. Wipe components with a clean, dry cloth.
4. Do not apply any additional compounds to midship threads, washer (if applicable), or nut. These compounds may interfere with the adhesive that is preapplied to the midship nut and will be detrimental to its effectiveness. Unacceptable compounds include, but are not limited to:
   - thread lockers, such as Loctite.™
   - anti-seizing compounds, such as Never-Seez.™
   - lubricants, such as oil, grease, silicone, graphite, or soap.
5. Install the midship washer (if applicable) onto the midship and up against the machined surface of the end fitting.
6. By hand, start the midship nut onto the midship threads until it will no longer spin freely. Use a socket and a torque wrench with a suggested range of 600 lbs. ft. (800 N•m) or equivalent device capable of installing the midship nut to a final torque at a maximum rate of 120 rpm. (Refer to the Midship Nut Specifications table for proper socket size and torque specs.)

Reassembly - Outboard Slip Style

1. Wipe the bearing surface of the midship tube shaft with a fine emery cloth.
2. Install a new slinger (included in the center bearing replacement parts kit) on the midship tube shaft, using a section of tubing to avoid damaging the slinger. Make sure the slinger is completely seated against the midship tube shaft shoulder.



3. When replacing a center bearing assembly, be sure to fill the entire cavity around the bearing with a waterproof lubricant. Enough lubricant must be applied to fill the cavity to the extreme edge of the slinger surrounding the bearing. Refer to the below table.

Recommended Center Bearing Lubricants

Lubricants	***Source***
Rykon Premium No. 3	*Amoco Oil Company*
Amolith 8516	*Amoco Oil Company*
Van Talgar No. 4	*Exxon Company*

4. Carefully align the new center bearing assembly with the ground surface of the midship tube shaft. Physically push the center bearing onto the midship tube shaft. Minimal force should be necessary to push the center bearing onto the midship tube shaft provided the shaft and bearing are in alignment.
5. Press the remaining slinger on the midship tube shaft using a section of tubing to avoid damaging the slinger.
6. Installation of the driveshaft onto the vehicle can now proceed. Refer to the vehicle manufacturer's documentation for installation procedures. Ensure phasing marks are aligned on mating components.

Grease Zerk (Nipple) Fittings or Plugs

For procedures used in the removal and installation of Spicer Driveshafts from the vehicle, please consult the vehicle manufacturer's service manual.

Once the driveshaft has been removed or the defective grease zerk (nipple) fitting or plug is accessible, follow the steps listed in the Disassembly - Universal Joint section on page 16 for replacement. Please refer to the Lubrication information in the Component Safety section page 2.

Universal Joints and Slip Member Assembly

1. Tilt the universal joint or flange yoke and universal joint to allow access to the defective grease zerk (nipple) fitting or plug. Using pliers or an open-ended wrench, turn the grease zerk (nipple) fitting or plug counter-clockwise until it is removed from the journal cross or slip member assembly. Discard the grease zerk (nipple) fitting or plug.
2. Check the threads in the journal or slip member. If threads are damaged, replacement of the universal joint or slip member is necessary. See disassembly procedures for universal joints and slip member in the Disassembly and Reassembly section on page 16.
3. Thoroughly wipe the grease zerk (nipple) fitting or plug threaded hole.
4. Install the new grease zerk (nipple) fitting or plug. Tighten to a minimum 40-55 lbs. in. (4.5 - 6.2 N•m). Continue to turn only until the grease zerk (nipple) fitting is correctly positioned.

Universal Joint Grease Zerk (Nipple) Fitting and Plug Torque

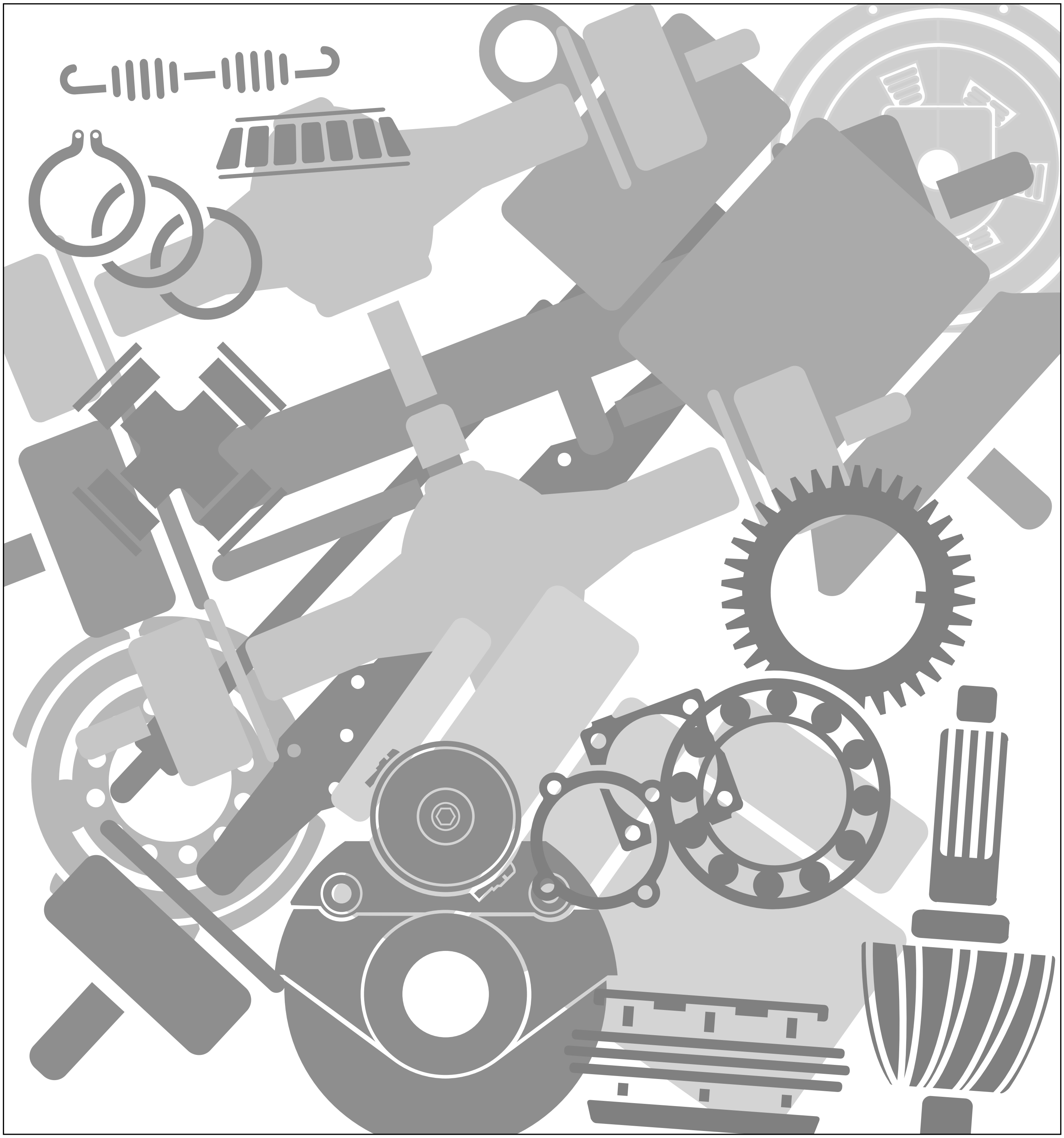
		Minimum Zerk Torque	
Part Number	Description	N•m	lbs. in.
500174-1	.250-28 NF Tapered Thread	4.5 - 6.2	40 - 55
500168-2	.125-27 PTF	4.5 - 6.2	40 - 55

Glossary

Alignment Bar	A device (gauge) used to check yoke cross hole alignment.
Ball Yoke	See Tube Yoke.
Bearing Cross Hole	See Cross Hole.
Bearing Cup Assembly	Consists of a bearing cup with needle rollers, generally held in place by a seal guard and bearing seal. Sometimes the assembly includes a thrust washer.
Bearing Cup	A cup-shaped member used as the bearing bore of a bearing cup assembly and for positioning a thrust end of a cross trunnion.
Bearing Seal	A flexible member of a bearing cup assembly that prevents the escape of grease from or entry of foreign matter into a bearing.
Bearing Strap	A narrow, stamped metal plate used to retain a bearing cup assembly in a half round end yoke or flange yoke design.
Center Bearing	Consists of a rolling element bearing isolated in rubber and a bracket configuration for attachment to the vehicle frame.
Companion Flange	A fixed flange member that attaches a driveshaft to another drivetrain component.
Coupling Shaft	The coupling member or members of a multiple-piece driveline, which consists of a universal joint, tube, center bearing, and a slip or fixed spline shaft.
Coupling Shaft Length (Centerline to Centerline)	The distance between the outermost universal joint centers on a driveshaft. On coupling shafts with fixed centers, it is the nominal dimension.
Cross	See Journal Cross.
Cross Hole	A through hole in each lug ear of a yoke used to locate a bearing assembly.
Deflector	See Slinger.
Driveline	An assembly of one or more coupling shafts and a driveshaft with provisions for axial movement, which transmits torque and/or rotary motion at a fixed or varying angular relationship from one drivetrain component to another.
Driveshaft	An assembly of one or two universal joints connected to a tubular shaft member, which accommodates axial movement.
Driveshaft Length (Centerline to Centerline)	The distance between the outermost universal joint centers on a driveshaft. On driveshafts with variable length centers, driveshaft length is usually measured in the compressed or installed lengths.
Ear	One of two projecting parts of a yoke symmetrically located with respect to the rotation axis of the yoke.
End Fitting	An end yoke or companion flange (including SAE, DIN, and T-Type styles) that attaches a driveshaft to another drivetrain component.
End Yoke	A half round yoke that attaches a driveshaft to another drivetrain component.
Flange Yoke	A full round or half round style yoke that attaches a driveshaft to a companion flange.
Flinger	See Slinger.
Glidecote®	The blue, nylon, wear-resistant coating on Spicer yoke shafts and tube shafts.
Grease Zerk (Nipple) Fitting	The fitting on the shoulder or center of a journal cross or on a greaseable slip spline that allows for lubrication.

Half Round Cross Hole	A semicircular hole located on the end of each lug ear of some end yoke and flange yoke designs used to locate a bearing cup assembly.
Inboard Bearing Assembly	Contained in inboard yoke.
Inboard Yokes	Yokes that make up the ends of a driveshaft or coupling shaft assembly, i.e. tube yokes, slip yokes, yoke shafts, and center bearing end yokes.
Journal Cross	The core component of a universal joint, which is an intermediate drive member with four equally spaced trunnions in the same plane.
Lug Ear	See Ear.
Midship Shaft	A machined element consisting of spline teeth, a pilot for a center bearing, and a piloting hub that attaches to the tube of a coupling shaft assembly.
Needle Rollers	One of the rolling elements of a bearing cup assembly.
Nib	See Tang.
Outboard Bearing Assembly	Contained in an outboard yoke.
Outboard Yokes	Yokes that are not a part of a driveshaft or coupling shaft assembly, i.e. transmission, axle, transfer case end yokes.
Phase Angle	The relative rotational position for each yoke on a driveshaft or driveline.
Pillow Block	Consists usually of a rolling element bearing and a bracket configuration for attachment.
Pressure Relief Hole	A hole in the welch plug of Spicer slip yokes that allows air to escape from the slip member assembly.
Purge	The act of flushing old grease and contaminants from universal joints and slip member assemblies with fresh grease.
Retaining Ring	See Snap Ring.
Retaining Ring Groove	See Snap Ring Groove.
Round Bearing Assembly	See Bearing Cup Assembly.
Seal Guard	A covering member used to protect a bearing seal on the bearing cup assembly.
Serrated Flange	See T-Flange.
Shaft Support Bearing	See Center Bearing.
Slinger	A stamped metal or non-metal ring, which prevents the entry of foreign matter into a center bearing, transmission, axle, or transfer case.
Slip	The total permissible length of axial travel.
Slip Yoke	A yoke that accommodates axial movement.
Slip Yoke Plug	See Weld Plug.
Slip Yoke Seal	Pop-on or threaded ring that contains a seal that protects the slip member assembly from environmental contaminants and retains grease.
Snap Ring	A removable member used as a shoulder to retain and position a bearing cup assembly in a yoke cross hole.
Snap Ring Groove	A groove used to locate a snap ring.
Spline	A machined element consisting of integral keys (spline teeth) or keyways (spaces) equally spaced around a circle or portion thereof.

Stub Shaft	See Tube Shaft.
Tang	A nib of metal found on half round end yoke and/or flange yoke style cross holes, used to locate a bearing cup assembly.
T-Flange	A companion flange and flange yoke design, which has a serrated flange face. Found most often in European applications.
T-Type Flange	See T-Flange.
Thrust Washer	A washer found in the bottom of a bearing cup assembly that reduces needle roller friction and bearing heat, and guards against end galling on the journal cross trunnions.
Tube	The tubular connecting member of a driveshaft. Pipe or piping is not an equivalent.
Tubing	See Tube.
Tube O.D.	The outside diameter (O.D.) of a tube.
Tube Yoke	An inboard yoke with a piloting hub for attachment to a tube or spline sleeve.
Tube Shaft	A machined element consisting of spline teeth and a piloting hub that attaches to the tube of a driveshaft assembly.
Trunnion(s)	Any of four projecting journals of a cross.
Universal Joint	A mechanical device that can transmit torque and/or rotary motion from one shaft to another at fixed or varying angles of intersection of the shaft axes. Usually consisting of a journal cross, grease zerk (nipple) fitting, and four bearing cup assemblies.
U-Joint	See Universal Joint.
Welch Plug	A plug in the slip yoke face that seals off one end of the spline opening. Also known as a slip yoke plug.
Weld Yoke	See Tube Yoke.
Yoke Lug Ear Cross Hole	See Cross Hole.
Yoke Shaft	A slip member yoke with a male machined spline used for axial movement.



National Institute for AUTOMOTIVE SERVICE EXCELLENCE

SPICER® DRIVETRAIN COMPONENTS

DANA

DSSM3264
Printed in USA

Dana® Spicer® Driveshaft

Application Guidelines

Application Guidelines DSAG-0200 May 2004

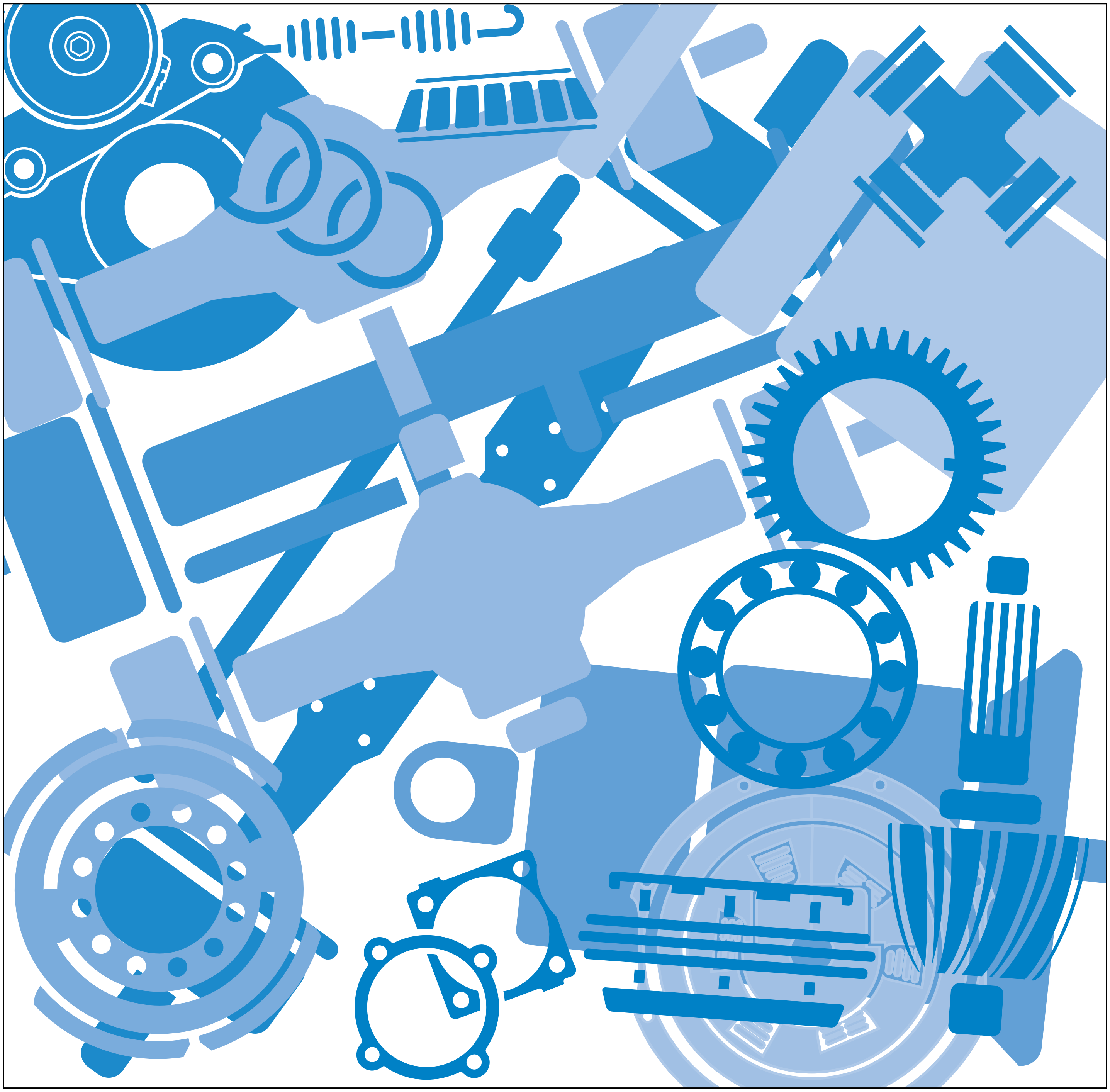


Table of Contents

Driveline Sizing

Critical Speed

Center Bearing Mounting

Driveline Analysis

Appendix

Revisions from: 10/06/03

- Formulas simplified to make calculations easier on pages 3-5.
- Joint Kit Attaching Hardware updated.
- Book structure updated.

Revised date: 03/15/04

Specifying a Spicer Driveline

Driveline Specification Criteria

Prime Factors:

- Net torque input
- Baseline duty cycle
  - On-highway tractor - 80,000 lbs. CGW
- Modifiers (+/- factors)
  - Duty cycle (vocation)
  - Gross Vehicle Weight (GVW/GCW)
  - Rear axle ratio
  - Universal joint working angle

Application Definitions

- Domestic applications - restricted to the continental United States and Canada.
  - On-highway - operation on well-maintained, concrete and asphalt roadways including turnpikes, interstates, and state routes with not more than 10% off-highway operation.
  - Off-highway - operation on unimproved dirt or gravel roads, as well as, poorly maintained paved roads, more than 10% of the time.
  - Line haul - operation on well maintained concrete and asphalt roadways including turnpikes, interstates, and state routes 100% of the time.
- Export applications - outside of the continental United States and Canada.

  Driveline sizing for export applications is based on Maximum Driveshaft Torque **only** (see "Calculating Maximum Driveshaft Torque (Export Applications)" on page 5).

Calculating Maximum Low Gear Torque

Step 1 - Low Gear Torque Calculation

LGT = T x TLGR x TE x SR x TCR x C

LGT = Maximum Driveshaft Low Gear Torque

T = Net Engine Torque or 95% of the Gross Engine Torque

TLGR = Transmission Low Gear Ratio (forward)*

TE = Transmission Efficiency (automatic = 0.8; manual = 0.85)

SR = Torque Converter Stall Ratio (if applicable)

TCR = Transfer Case Ratio (if applicable)

C = Transfer Case Efficiency (if applicable, 0.95)

* Some applications require deep reduction transmissions for speed-controlled operations such as paving and pouring. In these applications it may be more appropriate to use the second lowest forward transmission ratio to calculate the Maximum Low Gear Torque. To use the second lowest forward gear ratio to calculate LGT, **all three** of the following conditions must be met:

1. Lowest forward gear ratio numerically greater than 16:1.
2. Split between the lowest forward gear ratio and the second lowest forward gear ratio is greater than 50%.
3. Startability Index must be greater than 25 (see below calculation).

Startability Index Calculation

SI = (T x TR x AR x TCR x 942.4) / (RR x GCW)

SI = Startability Index

T = Engine Clutch Engagement Torque at 800 RPM

TR = Transmission Second Lowest Forward Gear Ratio

AR = Axle Ratio

TCR = Transfer Case Ratio (if applicable)

RR = Tire Rolling Radius (in)

GCW = Maximum Gross Combination Weight (lbs)

Step 2 - Wheel Slip Calculation

WST = (.71 x W x RR) / (11.4 x AR)

WST = Wheel Slip Torque Applied to the Driveshaft

W = Axle Capacity (lbs)

RR = Tire Rolling Radius (in)

AR = Axle Ratio

Step 3 - Gradeability Calculation

Calculate the torque required for 25% gradeability.

Note: For Linehaul applications with 3.10 axle ratio or numerically larger only.

GT = (.265 x RR x GVW) / (11.4 x AR)

GT = Net Driveline Torque at 25% Gradeability

RR = Tire Rolling Radius (in)

GVW = Gross Vehicle Weight (lbs)

AR = Axle Ratio

Step 4 - Overall Low Gear Ratio Calculation

OLGR = TLGR x SR x TCR

OLGR = Overall Low Gear Ratio

TLGR = Transmission Low Gear Ratio

SR = Torque Converter Stall Ratio (if applicable)

TCR = Transfer Case Ratio (if applicable)

Step 5 - Driveline Series Selection

To select a driveline series:

1. Use the torque determined from Steps 1, 2, and 3 with the overall low gear ratio (OLGR) from Step 4 to find the applicable series for each torque value.
2. Find the appropriate driveline series for SPL or Ten Series using the "Application Guidelines" on page 6 & 7.
3. Use the smallest series for the main driveline series, as determined from Steps 1, 2, and 3.

Note: The selected driveline series can not be more than one series smaller than the series selected from Step 1 (LGT).

Step 6 - Specifying the Interaxle Driveline (if applicable)

To specify the interaxle driveline, use:

1. 60% of the Driveline Series Selection torque from Step 5 and the OLGR from Step 4.
2. Find the appropriate interaxle driveline series for SPL or Ten Series using the "Application Guidelines" on page 6 & 7.

Note: High angle (45°) interaxle driveshafts are available in SPL-170 and 1710 Series only.

Calculating Maximum Driveshaft Torque (Export Applications)

Step 1 - Low Gear Torque Calculation

LGT = T x TLGR x TE x SR x TCR x C

LGT = Maximum Driveshaft Low Gear Torque

T = Net Engine Torque or 95% of the Gross Engine Torque

TLGR = Transmission Low Gear Ratio (forward)

TE = Transmission Efficiency (automatic = 0.8; manual = 0.85)

SR = Torque Converter Stall Ratio (if applicable)

TCR = Transfer Case Ratio (if applicable)

C = Transfer Case Efficiency (if applicable, 0.95)

Step 2 - Overall Low Gear Ratio Calculation

OLGR = TLGR x SR x TCR

OLGR = Overall Low Gear Ratio

TLGR = Transmission Low Gear Ratio

SR = Torque Converter Stall Ratio (if applicable)

TCR = Transfer Case Ratio (if applicable)

Step 3 - Driveline Series Selection

To select a driveline series:

1. Use the torque determined from Step 1 with the overall low gear ratio (OLGR) from Step 2 to find the applicable series from the appropriate Driveline Sizing graph. See “Application Guidelines” on page 6 & 7.

Step 4 - Specifying the Interaxle Driveline (if applicable)

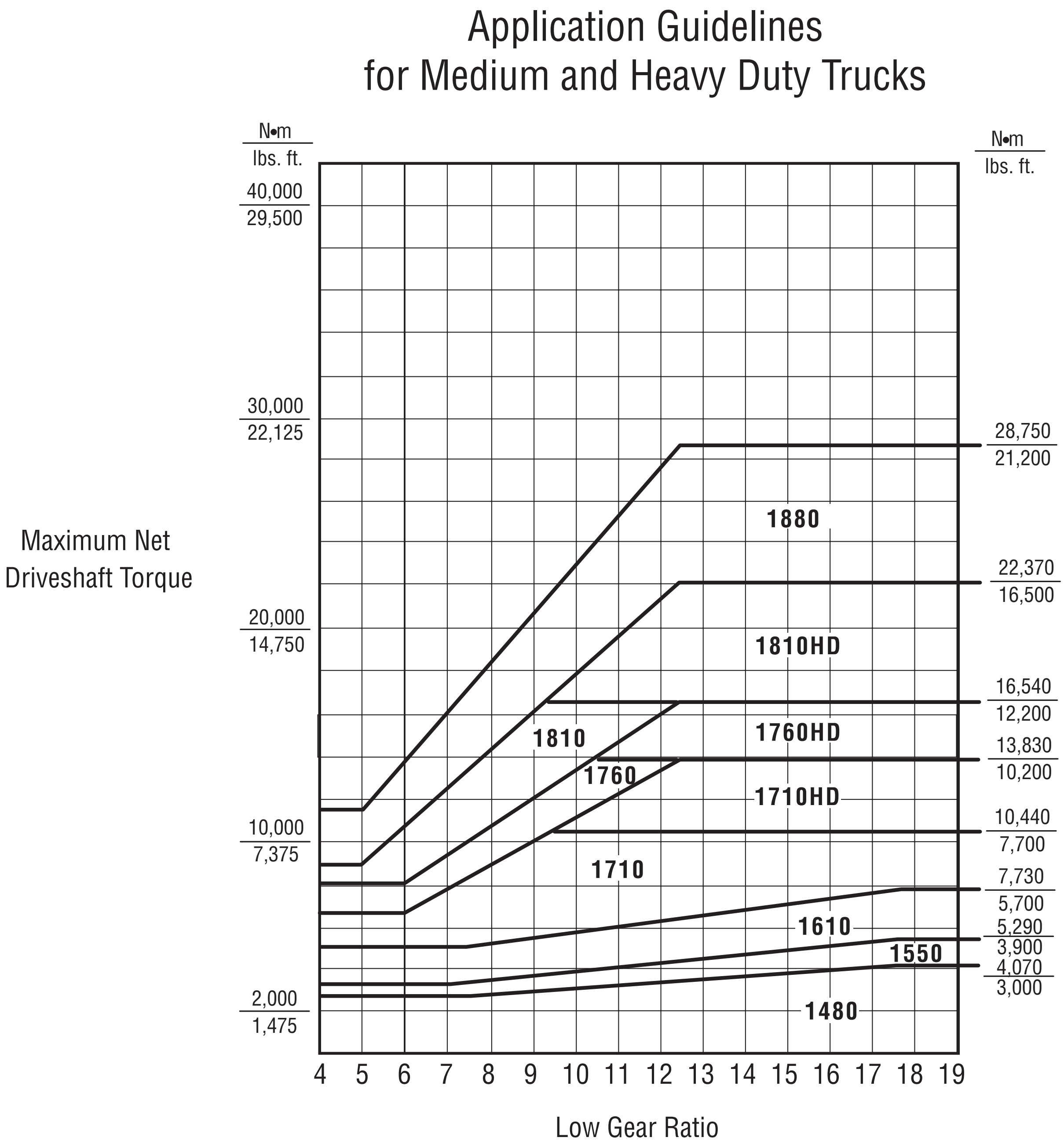
To specify the interaxle driveline, use:

1. 60% of the Driveline Series Selection torque from Step 3 and the OLGR from Step 2.
2. Find the appropriate interaxle driveline series for SPL or Ten Series using the “Application Guidelines” on page 6 & 7.

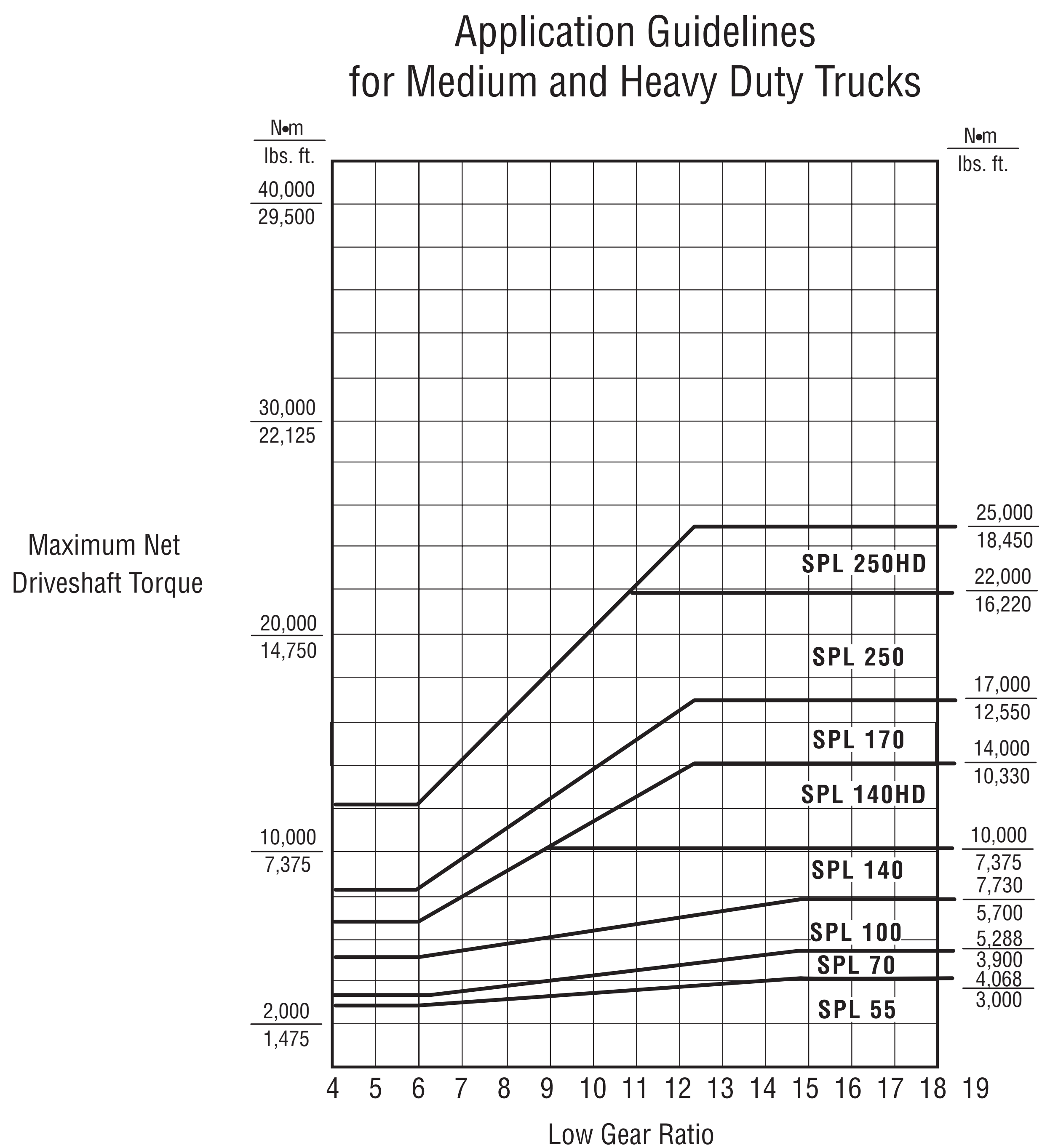
Note: High angle (45°) interaxle driveshafts are available in SPL-170 and 1710 Series only.

Application Guidelines

10 Series Graph



SPL Graph


Application Guidelines
for Medium and Heavy Duty Trucks
N•m
lbs. ft.
40,000
29,500
30,000
22,125
20,000
14,750
10,000
7,375
2,000
1,475
Maximum Net
Driveshaft Torque
25,000
18,450
SPL 250HD
22,000
16,220
SPL 250
17,000
12,550
SPL 170
14,000
10,330
SPL 140HD
10,000
7,375
SPL 140
7,730
5,700
SPL 100
5,288
3,900
SPL 70
4,068
3,000
SPL 55
4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Low Gear Ratio

Critical Speed

Critical speed is defined as: The speed at which the rotational speed of the driveshaft coincides with the natural frequency of the shaft.

Standard Equation

$$CS = 30\pi \sqrt{\frac{E \times 386.4\,(O^2 + I^2)}{P \times L^4 \times 16}}$$

CS = Critical Speed

E = Modulus of tubing material (psi)

O* = Outside Diameter of Tubing (in)

I* = Inside Diameter of Tubing (in)

P = Density of Tubing Material (lbs/in^3)

L = Distance Between Journal Cross Centers (in)

* Refer to “Spicer Standard Tube Sizes” on page 19 for tube dimensions.

Material Properties

Material	Modulus	Density	E/P x 386.4
Steel	30.00×10^6	0.2830	41.0×10^9
Aluminum	10.30×10^6	0.0980	39.4×10^9

Simplified Equations

Steel:

$$CS = \frac{4.769 \times 10^6}{L^2} \sqrt{O^2 + I^2}$$

Aluminum:

$$CS = \frac{4.748 \times 10^6}{L^2} \sqrt{O^2 + I^2}$$

CS = Critical Speed

L = Distance Between Journal Cross Centers (in)

O = Outside Diameter of Tubing (in)

I = Inside Diameter of Tubing (in)

Note: The theoretical values and the simplified equation values are the same for the material constants provided.

Adjusted Critical Speed

ACS = TC x CF x SF

ACS = Adjusted Critical Speed

TC = Theoretical Critical

CF = Correction Factor

SF = Safety Factor

Suggested factors for Adjusted Critical Speed:

Safety Factor = 0.75

Correction Factor

Outboard Slip = 0.92

Inboard Slip = 0.75

Maximum Driveshaft Length

Refer to the TMC Recommended Practice RP610A Chart 3 for maximum driveshaft length vs. RPM guidelines.

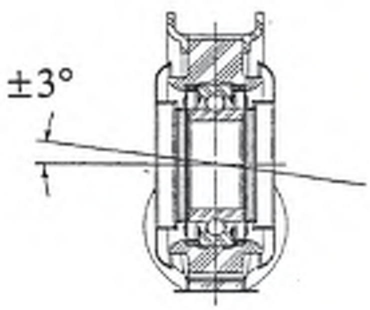
The general length limitations are as follows:

Tube O.D.	Maximum Length
3.0 in.	60 in.
3.5 in.	65 in.
4.0 in.	70 in.
4.2 in.	72 in.
4.3 in.	73 in.
4.5 in.	75 in.
5.0 in.	80 in.

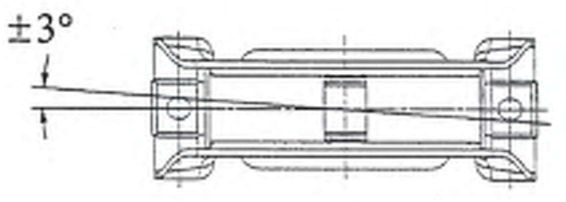
Center Bearing Mounting

Spicer heavy duty center bearings must be mounted within 3° of perpendicular to the coupling shaft centerline as shown in Figure 1 below **OR** the center bearing assembly must not operate at a linear offset greater than 1/8" as shown in Figure 2.

Figure 1

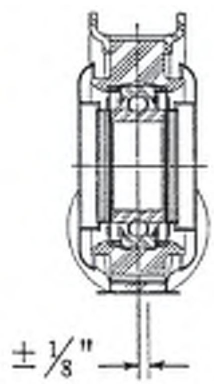


Side View



Top View

Figure 2



Side View

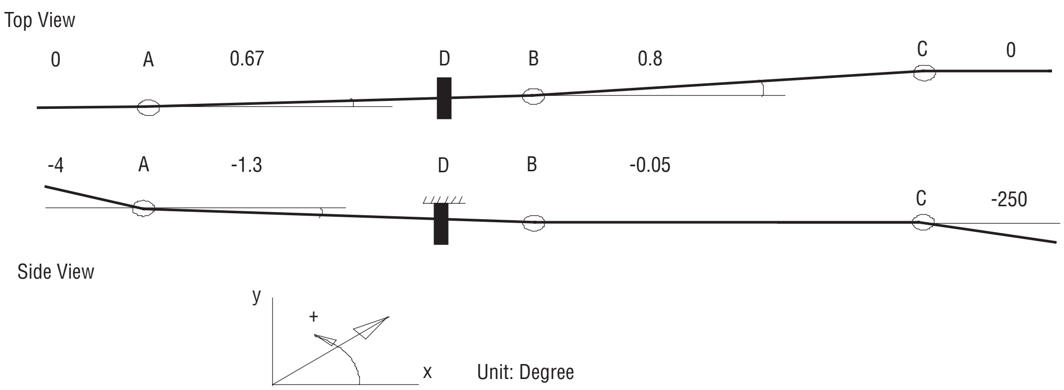
Driveline Analysis

Design Criteria

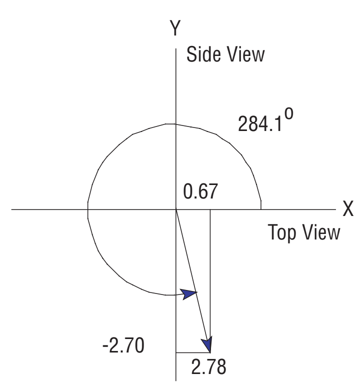
- Torsional Vibration
- Inertial Vibration
- Center Bearing Loading

Torsional and Inertial Excitation

Driveline Layout



Calculate Joint Angles



View from Rear of Driveline

To find the true joint angle of each joint, first find the top-view and side-view angles of each joint. The top-view angle of Joint A is equal to 0.67 - 0.00 = 0.67 and the side-view joint angle of Joint A is equal to (-4.0) - (-1.3) = -2.70. By putting the top-view angle (0.67) to the X-axis and the side-view angle (-2.70) to the Y-axis, the true joint angle of Joint A is equal to 2.78 $\angle$ 284.1 degrees.

Note: The true joint angle is a vector: the 2.78 degrees is the magnitude and the 284.1 degree is the argument. The true joint angles of joints A, B, and C are shown in the following chart.

	Trans U-joint (A) degrees	U-joint (B) degrees	Axle U-joint (C) degrees
Joint Angle - Top View	0.67	0.13	-0.80
Joint Angle - Side View	-2.70	-1.25	2.45
True Joint Angle Θ	2.78	1.26	2.58
Plane of True Joint Angle ϕ	284.10	276.01	108.29

Calculate Torsional and Inertia Excitation

Calculate the torsional effect:

$$\Theta_{res} = \sqrt{(|\Theta_1|\_\phi_1)^2 + (|\Theta_2|\_(\phi_2 - 90° - \delta_1))^2 + (|\Theta_3|\_(\phi_3 - \delta_2 - \delta_1))^2}$$

(1) When δ_1= 0 deg, δ_2= 0 deg.

$$= \sqrt{(2.78\_284.1°)^2 + (1.26\_(276.01 - 90)°)^2 + (2.58\_108.29°)^2}$$
$$= \sqrt{(7.7284\_{-151.8°}) + (1.5876\_12.02°) + (6.6564\_{-143.42})}$$
$$= \sqrt{(12.8667\_{-145.4°})}$$
$$= 3.5870°\_{-72.75°}$$
$$3.3405x\ 10^{-6}(2368rpm)^2(3.5870°)^2 = 241.0154\frac{rad}{\sec^2}$$

(2) When δ_1= 0 deg, δ_2= 90 deg.

$$= \sqrt{(2.78\_284.1°)^2 + (1.26\_(276.01 - 90)°)^2 + (2.58\_(108.29 - 90)°)^2}$$
$$= \sqrt{(7.7284\_{-151.8°}) + (1.5876\_12.02°) + (6.6564\_36.58)}$$
$$= \sqrt{(0.65124\_82.32°)}$$
$$= 0.80699°\_41.162°$$
$$3.3405x\ 10^{-6}(2368rpm)^2(0.80699°)^2 = 12.1988\frac{rad}{\sec^2}$$

(3) When δ_1= 90 deg, δ_2= 90 deg.

$$= \sqrt{(2.78\_284.1°)^2 + (1.26\_(276.01 - 90 - 90)°)^2 + (2.58\_(108.29 - 90 - 90)°)^2}$$
$$= \sqrt{(7.7284\_{-151.8°}) + (1.5876\_{-167.98°}) + (6.6564\_{-143.42})}$$
$$= \sqrt{(15.847236\_149.89°)}$$
$$= 3.98085°\_{-74.94°}$$
$$3.3405x\ 10^{-6}(2368rpm)^2(3.98085°)^2 = 296.84\frac{rad}{\sec^2}$$

(4) When δ_1= 90 deg, δ_2= 0 deg.

$$= \sqrt{(2.78\_284.1^{\circ})^2 + (1.26\_(276.01 - 90 - 90)^{\circ})^2 + (2.58\_(108.29 - 90)^{\circ})^2}$$
$$= \sqrt{(7.7284\_-151.8^{\circ}) + (1.5876\_-167.98^{\circ}) + (6.6564\_36.58)}$$
$$= \sqrt{(3.018639\_-179.699^{\circ})}$$
$$= 1.737423^{\circ}\_-89.84^{\circ}$$
$$3.3405x\ 10^{-6}(2368rpm)^2(1.737423^{\circ})^2 = 56.54\frac{rad}{\sec^2}$$

Calculate the inertia drive effects:

$$\Theta_D = \sqrt{2(|\Theta_1|\_\phi_1)^2 + (|\Theta_2|\_(\phi_2 - 90^{\circ} - \delta_1))^2}$$

(1) When δ_1= 0 deg, δ_2= 0 deg or δ_1= 0 deg, δ_2= 90 deg.

$$= \sqrt{2(2.78\_284.1^{\circ})^2 + (1.26\_(276.01 - 90)^{\circ})^2}$$
$$= \sqrt{(15.4568\_-151.8^{\circ}) + (1.5876\_12.02^{\circ})}$$
$$= \sqrt{(13.939105\_-149.98^{\circ})}$$
$$= 3.733511^{\circ}\_-74.99^{\circ}$$
$$3.3405x\ 10^{-6}(2368rpm)^2(3.733511^{\circ})^2 = 261.10\frac{rad}{\sec^2}$$

(2) When δ_1= 90 deg, δ_2= 90 deg or δ_1= 90 deg, δ_2= 0 deg.

$$= \sqrt{2(2.78\_284.1^{\circ})^2 + (1.26\_(276.01 - 90 - 90)^{\circ})^2}$$
$$= \sqrt{(15.4568\_-151.8^{\circ}) + (1.5876\_-167.98^{\circ})}$$
$$= \sqrt{(16.987278\_-153.29^{\circ})}$$
$$= 4.12156^{\circ}\_-76.64^{\circ}$$
$$3.3405x\ 10^{-6}(2368rpm)^2(4.12156^{\circ})^2 = 318.19\frac{rad}{\sec^2}$$

Calculate the inertia coast effects:

$$\Theta_C = \sqrt{2(|\Theta_3|\_\phi_3)^2 + (|\Theta_2|\_(\phi_2 + 90^{\circ} + \delta_2))^2}$$

(1) When δ_1= 0 deg, δ_2= 0 deg or δ_1= 90 deg, δ_2= 0 deg.

$$= \sqrt{2(2.58\_108.29^{\circ})^2 + (1.26\_(276.01 + 90)^{\circ})^2}$$
$$= \sqrt{(13.3128\_-143.42^{\circ}) + (1.5876\_12.02^{\circ})}$$
$$= \sqrt{(11.887165\_-140.24^{\circ})}$$
$$= 3.44777\_-70.11^{\circ}$$
$$3.3405x\ 10^{-6}(2368rpm)^2(3.44777^{\circ})^2 = 222.66\frac{rad}{\sec^2}$$

(2) When δ_1= 0 deg, δ_2= 90 deg or δ_1= 90 deg, δ_2= 90 deg.

$$= \sqrt{2(2.58\_108.29°)^2 + (1.26\_(276.01+90+90)°)^2}$$
$$= \sqrt{(13.3128\_-143.42°) + (1.5876\_-167.98°)}$$
$$= \sqrt{(14.77151\_-145.98°)}$$
$$= 3.84337\_-72.99°$$
$$3.3405x\,10^{-6}(2368rpm)^2(3.84337°)^2 = 276.69\frac{rad}{\sec^2}$$

Note: The recommended torsional excitation level is 300 rad/sec^2 or less. The recommended inertia excitation level is 1000 rad/sec^2 or less.

Calculate the torque fluctuations:

The mass moment of inertia of the following items are approximately equal to:

	lbf-in-sec^2
Transmission	2.33
Axle	2.53
1760 Driveshaft	1.3

(1) The torque fluctuation at the axle end is:

$$T_{axle} = T_{torsional,axle} + T_{inertia,drive}$$
$$= J_{axle\ \ torsional} + J_{driveshaft\ \ drive}$$
$$= (2.53)(241.01) + (1.3)(261.10)$$
$$= 949.18 in\text{-}lb$$
$$= 79.1 ft\text{-}lb$$

(2) The torque fluctuation at the transmission end is:

$$T_{transmission} = T_{torsional,transmission} + T_{inertia,coast}$$
$$= J_{transmission\ \ torsional} + J_{driveshaft\ \ coast}$$
$$= (2.33)(241.01) + (1.3)(222.66)$$
$$= 851.01 in\text{-}lb$$
$$= 70.92 ft\text{-}lb$$

Center Bearing Loading

Calculate Static / Dynamic Center Bearing Load

Static

$$= \frac{1}{2}\frac{T}{AB-DB}\{\sin a° \_(\phi_a + 90)° + (\tan b° - \frac{AB}{BC}\sin b°)\_(\phi_b + 90)°$$

$$+ \frac{AB}{BC}\tan c° \_(\phi_c - 90)° \}$$

$$= \frac{1}{2}\frac{12214x12}{(40.-6.2)}\{\sin 2.78° \_(284.1 + 90)°$$

$$+ (\tan 1.26° - \frac{40.}{44.34}\sin 1.26°)\_(276.01 + 90)°$$

$$+ \frac{40.}{44.34}\tan 2.58° \_(108.29 - 90)° \}$$

$$= 2168.1657\{(0.0485\_374.1°) + (0.0022\_366.01°) + (0.0406\_18.29°)\}$$

$$= 2168.1657(0.0912\_15.77°)$$

$$= 197.7738 lbs \quad \_15.77°$$

Dynamic

$$= \frac{1}{2}\frac{T}{AB-DB}\{\sin a° \_(90 - \phi_a)° + (\tan b° + \frac{AB}{BC}\sin b)\_(90 - \phi_b + 2\delta_1)°$$

$$+ \frac{AB}{BC}\tan c° \_(90 - \phi_c + 2\delta_1 + 2\delta_2)° \}$$

(1) When δ_1= 0 deg, δ_2= 0 deg.

$$= \frac{1}{2}\frac{12214x12}{(40.-6.2)}\{\sin 2.78° \_(90 - 284.1)°$$

$$+ (\tan 1.26° + \frac{40.}{44.34}\sin 1.26°)\_(90 - 276.01)°$$

$$+ \frac{40.}{44.34}\tan 2.58° \_(90 - 108.29)° \}$$

$$= 2168.1657\{(0.0485\_-194.1°) + (0.0418\_-186.01°) + (0.0406\_-18.29°)\}$$

$$= 2168.1657(0.0502\_176.°)$$

$$= 108.7635 lbs \quad \_176.°$$

(2) When δ_1= 0 deg, δ_2= 90 deg.

$$= \frac{1}{2}\frac{12214x12}{(40.-6.2)}\{\sin 2.78° \_(90-284.1)°$$

$$+ \ (\tan 1.26° + \frac{40.}{44.34}\sin 1.26°)\_(90-276.01)°$$

$$+ \ \frac{40.}{44.34} \ \tan 2.58° \_(90-108.29+2x90)° \}$$

$$= \ 2168.1657\{(0.0485\_-194.1°)+(0.0418\_-186.01°)+(0.0406\_161.71°)\}$$

$$= \ 2168.1657(0.1305\_167.18°)$$

$$= \ 282.9240lbs \quad \_167.18°$$

(3) When δ_1= 90 deg, δ_2= 90 deg.

$$= \frac{1}{2}\frac{12214x12}{(40.-6.2)}\{\sin 2.78° \_(90-284.1)°$$

$$+ \ (\tan 1.26° + \frac{40.}{44.34}\sin 1.26°)\_(90-276.01+2x90)°$$

$$+ \ \frac{40.}{44.34} \ \tan 2.58° \_(90-108.29)° \}$$

$$= \ 2168.1657\{(0.0485\_-194.1°)+(0.0418\_-6.01°)+(0.0406\_-18.29°)\}$$

$$= \ 2168.1657(0.0336\_-9.11°)$$

$$= \ 72.8115lbs \quad \_-9.11°$$

(4) When δ_1= 90 deg, δ_2= 0 deg.

$$= \frac{1}{2}\frac{12214x12}{(40.-6.2)}\{\sin 2.78° \_(90-284.1)°$$

$$+ \ (\tan 1.26° + \frac{40.}{44.34}\sin 1.26°)\_(90-276.01+2x90)°$$

$$+ \ \frac{40.}{44.34} \ \tan 2.58° \_(90-108.29+2x90)° \}$$

$$= \ 2168.1657\{(0.0485\_-194.1°)+(0.0418\_-6.01°)+(0.0406\_-161.71°)\}$$

$$= \ 2168.1657(0.0484\_155.36°)$$

$$= \ 105.03326lbs \quad \_155.36°$$

Center Bearing Loads

Design	Static Load	Dynamic Load
Solid Rubber	500 lbs.	500 lbs.
Semi-Slotted Rubber	250 lbs.	250 lbs.
Slotted Rubber	100 lbs.	100 lbs.

Application Form

SPICER DRIVESHAFT DIVISION Heavy / Medium Duty Applications

Company: ______________________ Contact: ______________________

Email: ______________________ Date: ______________________

Phone: ______________________ Fax: ______________________

Vocation: ____________ Vehicle Make: ____________ Vehicle Model: ____________

Weight - Empty: ______________________ GVW Total: ______________________

GVW (Front): ________ GVW (Rear): ____________ GCW: ______________________

Tires - Size: ____________ Make: ____________ Rolling Radius: ____________

Engine - Make: ________ Model: ____________ Displacement: ____________

Net Torque: ________ At Speed: ________ Net H.P.: ________ At Speed: ________

Gross Torque: ________ At Speed: ________ Gross H.P.: ________ At Speed: ________

Maximum Operating Speed (including engine over speed): ______________________

Trans - Make: ______________________ Model: ______________________

Ratios - Forward (including overdrive): ____________ Reverse: ____________

Torque Converter - Make: ________ Model: ____________ Stall Ratio: ____________

Auxiliary - Make: ____________ Model: ____________ Ratios: ____________

Transfer Case - Make: ____________ Model: ____________ Ratios: ____________

Torque Split Ratio - Front: ______________________ Rear: ______________________

Axle Make - Front: ____________ Model: ____________ Ratios: ____________

Make - Front: ____________ Model: ____________ Ratios: ____________

B_{10} Life Expectancy: ____

Vehicle Duty Cycle: ____

Description of Vehicle Function: ____

____

____

Signed: ______________________

Title: ______________________

Spicer Engineer: ______________________ Phone: ______________________

Email: ______________________ Fax: ______________________

SPICER DRIVESHAFT DIVISION Heavy / Medium Duty Applications

APPLICATION PROPOSAL

Vehicle Position	Series	Dana Part Number
Transmission to Rear Axle		
Transmission to Auxiliary		
Auxiliary to Rear Axle		
Transmission to Mid Bearing		
Mid Bearing to Rear Axle		
Interaxle		
Wheel Drive		

Vehicle Application Sketch

Plan View

Side View

People Finding A Better Way™

SPICER®

Proposed By: ______________________

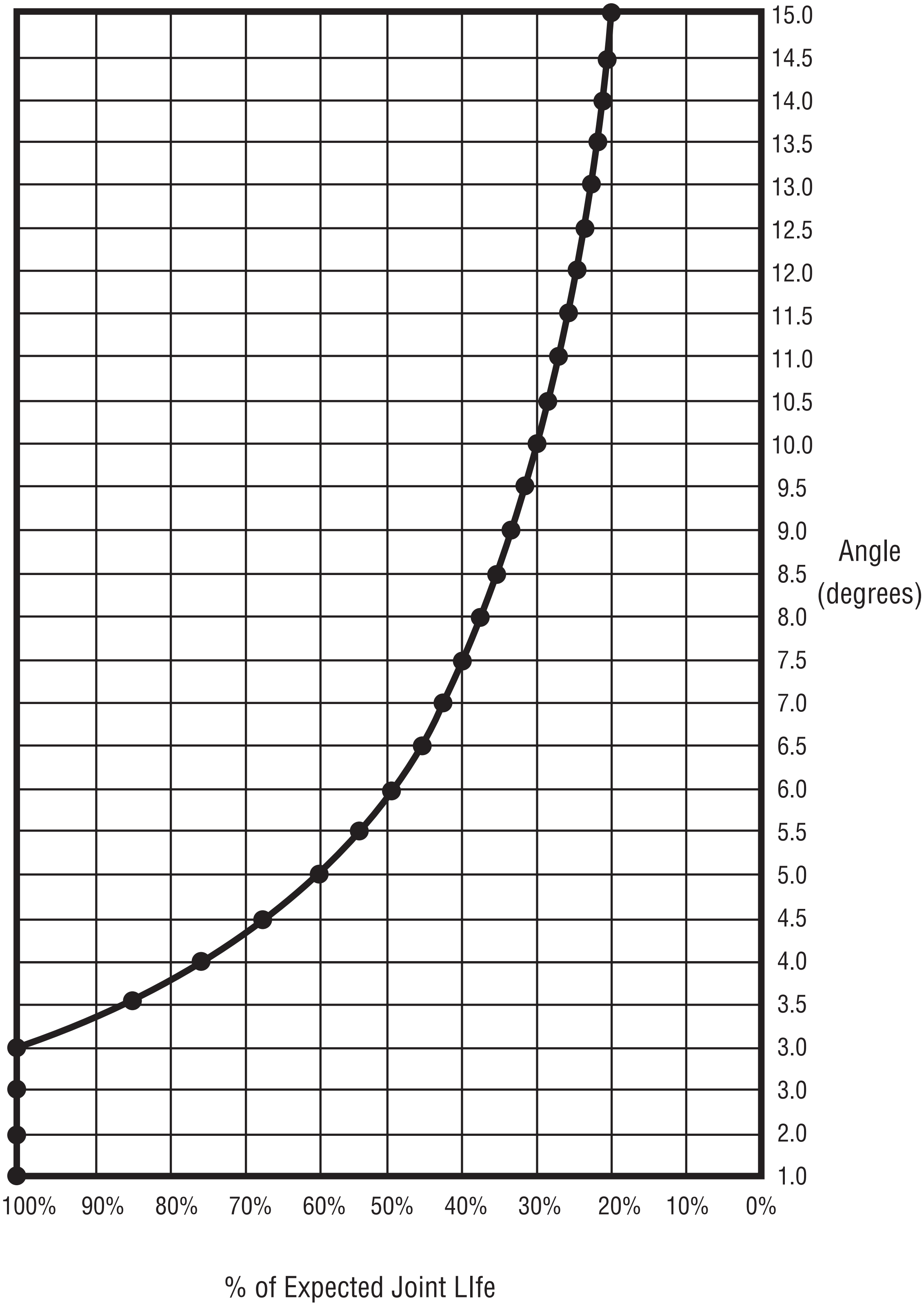
Signed: ______________________

Title: ______________________

Spicer Standard Tube Sizes

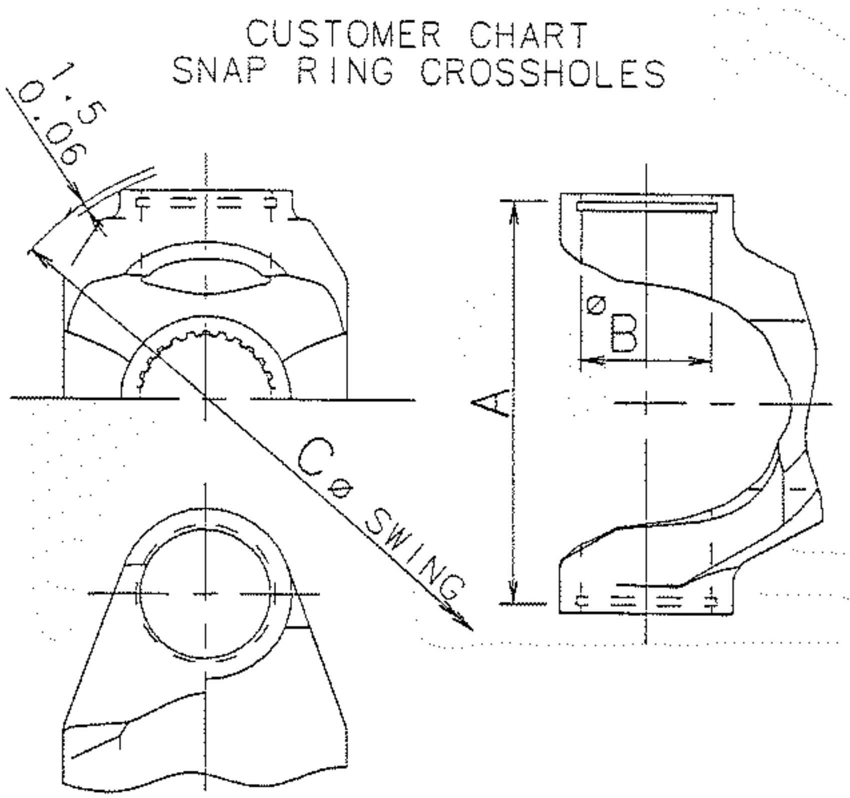
Series	Tube Size (in)	Dana Part Number	Torque Rating (lbs. ft.)	Tube Jael (lbs. ft.)
1610	4.00 x .134	32-30-52	5,700	8,600
1710	4.00 x .134	32-30-52	7,700	8,600
1710 HD	4.09 x .180	32-30-72	10,200	13,925
1760	4.00 x .134	32-30-92	10,200	10,435
1760 HD	4.09 x .180	32-30-72	12,200	13,925
1810	4.50 x .134	36-30-62	12,200	13,065
1810 HD	4.59 x .180	36-30-102	16,500	17,935
SPL 90	4.00 x .095	32-30-12	4,900	6,300
SPL 140	4.21 x .138	100-30-3	10,325	11,010
SPL 140 HD	4.33 x .197	100-30-5	10,325	16,519
SPL 170	4.96 x .118	120-30-3	12,550	13,185
SPL 170 HD	5.06 x .167	120-30-4	12,550	19,617
SPL 170 I/A	4.72 x .197	110-30-5	12,550	19,875
SPL 250	5.06 x .167	120-30-4	16,225	19,617
SPL 250 HD	5.12 x .197	120-30-5	18,450	23,555

Joint Life vs. Joint Angle



Charts

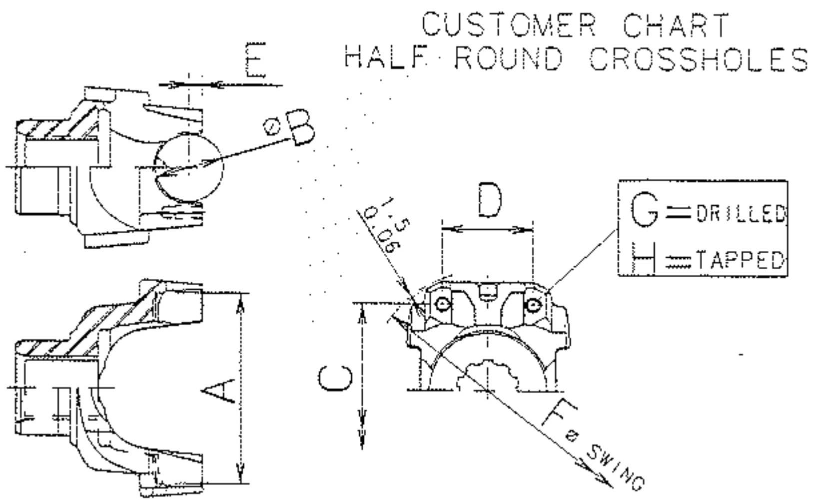
Snap Ring Cross Holes



Type	Series	A (mm / in)	B (mm / in)	C* (mm / in)
Snap Ring Construction	1210	65.0 / 2.56	26.9 / 1.06	79.2 / 3.12
	1280 / 1310	84.8 / 3.34	26.9 / 1.06	96.8 / 3.81
	1330	95.0 / 3.74	26.9 / 1.06	106.4 / 4.19
	1350	95.0 / 3.74	30.2 / 1.19	108.0 / 4.25
	1410	109.2 / 4.30	30.2 / 1.19	124.0 / 4.88
	1480	109.2 / 4.30	34.8 / 1.37	124.0 / 4.88
	1550	129.0 / 5.08	34.8 / 1.37	144.5 / 5.69
	SPL 90	130.6 / 5.14	41.1 / 1.62	149.4 / 5.88
	1650	146.8 / 5.78	41.1 / 1.62	165.1 / 6.50

* Swing diameter clears yoke by 1.5 mm / 0.06 in.

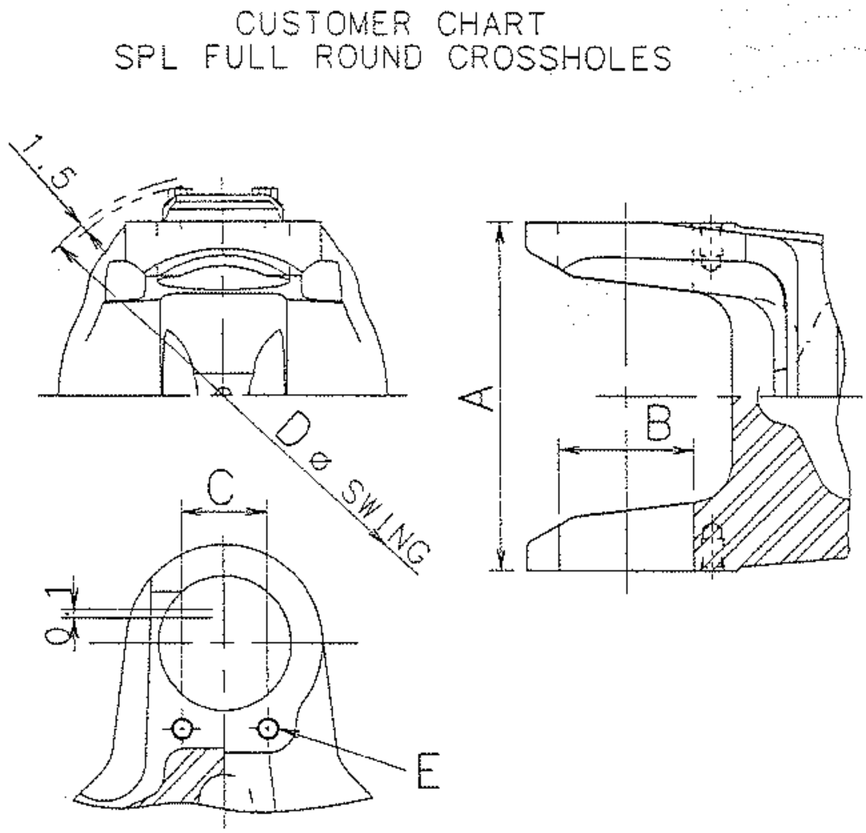
Half Round Cross Holes



Type	Series	A (mm / in)	B (mm / in)	C (mm / in)	D (mm / in)	E (mm / in)	F* (mm / in)	G (mm / in)	H
	1210	62.0 / 2.44	26.9 / 1.06	56.4 / 2.22	35.8 / 1.41	0.8 / 0.03	87.4 / 3.44	8.4 / 0.33	-
	1280/1310	81.8 / 3.22	26.9 / 1.06	73.9 / 2.91	35.8 / 1.41	0.8 / 0.03	101.6 / 4.00	8.4 / 0.33	-
U-bolt	1330	91.9 / 3.62	26.9 / 1.06	84.1 / 3.31	35.8 / 1.41	0.8 / 0.03	115.8 / 4.56	8.4 / 0.33	-
Design	1350	91.9 / 3.62	30.2 / 1.19	81.0 / 3.19	42.2 / 1.66	0.8 / 0.03	115.8 / 4.56	9.9 / 0.39	-
	1410	106.4 / 4.19	30.2 / 1.19	95.2 / 3.75	42.2 / 1.66	0.8 / 0.03	125.5 / 4.94	9.9 / 0.39	-
	1480	106.4 / 4.19	35.1 / 1.38	93.7 / 3.69	48.5 / 1.91	0.8 / 0.03	134.9 / 5.31	11.7 / 0.46	-
	1550	126.2 / 4.97	35.1 / 1.38	113.5 / 4.47	48.5 / 1.91	0.8 / 0.03	152.4 / 6.00	11.7 / 0.46	-
	1210	62.0 / 2.44	26.9 / 1.06	53.8 / 2.12	40.1 / 1.58	0.8 / 0.03	87.4 / 3.44	-	0.25 - 28
	1280/1310	81.8 / 3.22	26.9 / 1.06	73.9 / 2.91	40.1 / 1.58	0.8 / 0.03	101.6 / 4.00	-	0.25 - 28
Bearing	1330	91.9 / 3.62	26.9 / 1.06	84.1 / 3.31	40.1 / 1.58	0.8 / 0.03	115.8 / 4.56	-	0.25 - 28
Strap	1350	91.9 / 3.62	30.2 / 1.19	81.0 / 3.19	45.7 / 1.80	0.8 / 0.03	115.8 / 4.56	-	0.312 - 24
Tapped	1410	106.4 / 4.19	30.2 / 1.19	95.2 / 3.75	45.7 / 1.80	0.8 / 0.03	125.5 / 4.94	-	0.312 - 24
Hole	1480	106.4 / 4.19	35.1 / 1.38	93.7 / 3.69	53.8 / 2.12	0.8 / 0.03	134.9 / 5.31	-	0.375 - 24
	1550	126.2 / 4.97	35.1 / 1.38	113.5 / 4.47	53.8 / 2.12	0.8 / 0.03	152.4 / 6.00	-	0.375 - 24
	1610	134.9 / 5.31	47.8 / 1.88	122.2 / 4.81	63.5 / 2.50	9.7 / 0.38	171.4 / 6.75	-	0.375 - 24
	1710	157.2 / 6.19	49.3 / 1.94	142.0 / 5.59	71.4 / 2.81	7.9 / 0.31	190.5 / 7.50	-	0.50 - 20
	1760	180.1 / 7.09	49.3 / 1.94	165.1 / 6.50	71.4 / 2.81	7.9 / 0.31	212.9 / 8.38	-	0.50 - 20
	1810	194.1 / 7.64	49.3 / 1.94	179.1 / 7.05	71.4 / 2.81	7.9 / 0.31	228.6 / 9.00	-	0.50 - 20
Bearing	1410	106.4 / 4.19	30.2 / 1.19	95.2 / 3.75	45.7 / 1.80	0.8 / 0.03	125.5 / 4.94	8.4 / 0.33	-
Strap	1480	106.4 / 4.19	35.1 / 1.38	93.7 / 3.69	53.8 / 2.12	0.8 / 0.03	134.9 / 5.31	9.9 / 0.39	-
Thru-Hole	1550	126.2 / 4.97	35.1 / 1.38	113.5 / 4.47	53.8 / 2.12	0.8 / 0.03	152.4 / 6.00	9.9 / 0.39	-

* Swing diameter clears yoke by 1.5 mm / 0.06 in.

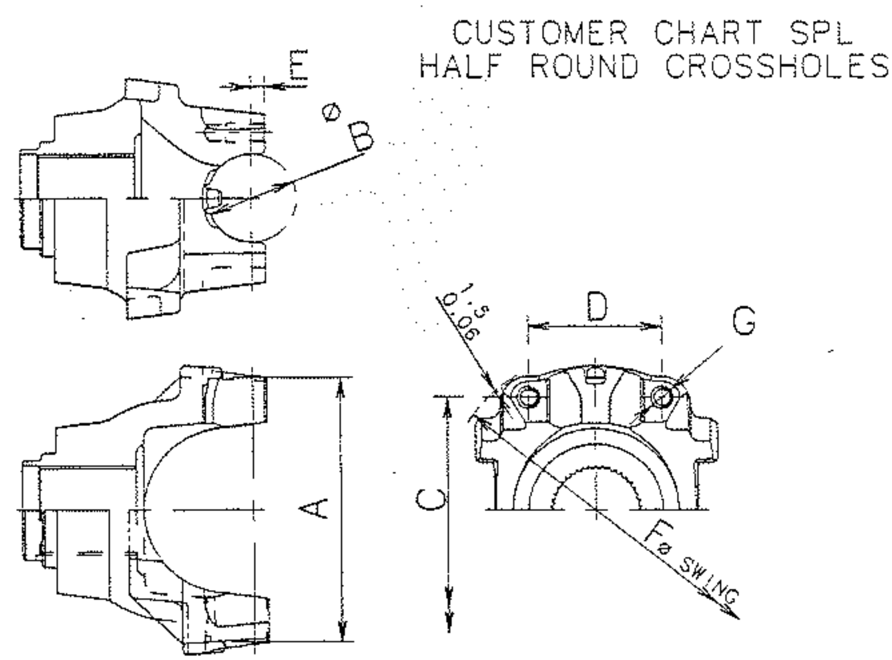
SPL Full Round Cross Holes



Type	Series	A (mm)	B (mm)	C (mm)	D * (mm)	E (mm)
SPL	SPL 140	128	49	32	160	M8 x 1.00
Full	SPL 170	153	55	32	185	M8 x 1.00
Round	SPL 250	152	60	32	184	M8 x 1.00

* Swing diameter clears yoke by 1.5 mm.

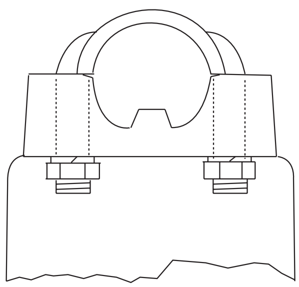
SPL Half Round Cross Holes



Type	Series	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F * (mm)	G (mm)
Bearing	SPL 90	126	41	115	59	6	154	0.375 x 24 UNF
Strap	SPL 140	139	49	113	76	8	164	12 x 1.25
Tapped	SPL 170	164	55	140	82	8	193	12 x 1.25
Hole	SPL 250	163	60	135	88	10	193	12 x 1.25

Joint Kit Attaching Hardware and Torque Specifications

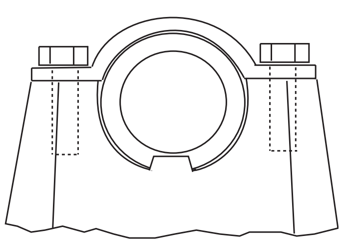
U-bolts



Series	Spicer Kit No	Assemblies	Recommended Nut Torque
1210	5-443X	-	-
1310, SPL22	5-153X, 5-785X, SPL22-1X	2-94-28X	14-17 lbs. ft.
1330, SPL25	5-213X, 5-790X, SPL25-1X	2-94-28X	14-17 lbs. ft.
1350, SPL30	5-178X, 5-799X, SPL30-1X	3-94-18X	20-24 lbs. ft.
1410, SPL36	5-160X, 5-801X, SPL36-1X	3-94-18X	20-24 lbs. ft.
1480, SPL55	5-188X, 5-803X, SPL55X	3-94-28X	32-37 lbs. ft.
1550, SPL70	5-155X, 5-808X, SPL70X	3-94-28X	32-37 lbs. ft.
3R	5-3147X, 5-795X, SPL25-6X	2-94-58X	17-24 lbs. ft.

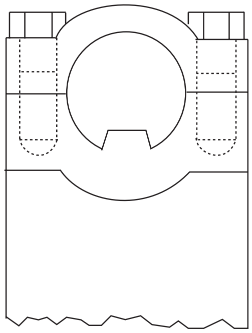
Bearing Strap

WARNING: Bearing strap retaining bolts should not be reused.



Series	Spicer Kit No	Assemblies	Recommended Bolt Torque
SPL90	SPL90-1X	90-70-28X	45-60 lbs. ft.
SPL100	SPL100X, SPL100-1X	90-70-28X	45-60 lbs. ft.
1210	5-443X	2-70-18X	13-18 lbs. ft.
1310, SPL22	5-153X, 5-785X, SPL22-1X	2-70-18X	13-18 lbs. ft.
1330, SPL25	5-213X, 5-790X, SPL25-1X	2-70-18X	13-18 lbs. ft.
1350, SPL30	5-178X, 5-799X, SPL30-1X	3-70-28X	30-35 lbs. ft.
1410, SPL36	5-160X, 5-801X, SPL36-1X	3-70-28X	30-35 lbs. ft.
1480, SPL55	5-188X, 5-803X, SPL55X	3-70-28X	30-35 lbs. ft.
1550, SPL70	5-155X, 5-808X, SPL70X	3-70-28X	30-35 lbs. ft.
1610	5-438X, 5-674X	5-70-28X	45-60 lbs. ft.
1710	5-515X, 5-675X	6.5-70-18X	115-135 lbs. ft.
1760	5-469X, 5-677X	6.5-70-18X	115-135 lbs. ft.
1810	5-510X, 5-676X	6.5-70-18X	115-135 lbs. ft.
3R	5-3147X, 5-795X, SPL25-6X	2-70-48X	30-35 lbs. ft.
7260	5-1306X, 5-789X, SPL22-8X	2-70-38X	13-18 lbs. ft.

Cap and Bolts



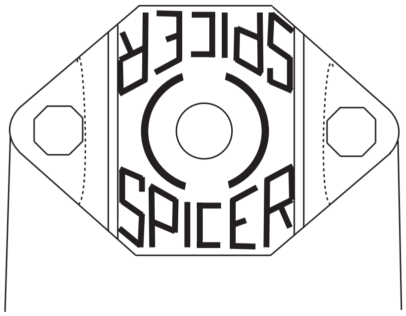
Series	Spicer Kit No	Assemblies	Recommended Bolt Torque
1650	5-165X	5-70-18X	77-103 lbs. ft.
1850	5-185X	8-70-18X	110-147 lbs. ft.
1950	5-339X	9-70-18X	271-362 lbs. ft.
2050	5-340X	9-70-28X	744-844 lbs. ft.

Bearing Plate

WARNING: Self locking bolts should not be reused.

Serrated Bolts with Lock Patch / No Lock Strap (Models after Spring 1994)

Series	Bolt Part No	Thread Size	Recommended Bolt Torque
1610	5-73-709	.312-24	26-35 lbs. ft.
1710	6-73-209	.375-24	38-48 lbs. ft.
1760	6-73-209	.375-24	38-48 lbs. ft.
1810	6-73-209	.375-24	38-48 lbs. ft.
1880	7-73-315	.438-20	60-70 lbs. ft.



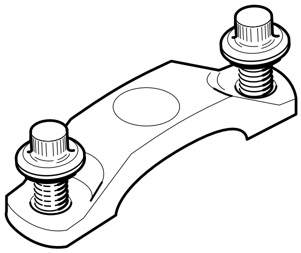
Bolt with Lock Strap (Pre-Spring 1994 Models)

Series	Bolt Part No	Thread Size	Recommended Bolt Torque
1610	5-73-109	.312-24	26-35 lbs. ft.
1710	6-73-109	.375-24	38-48 lbs. ft.
1760	6-73-109	.375-24	38-48 lbs. ft.
1810	6-73-109	.375-24	38-48 lbs. ft.
1880	7-73-115	.438-20	60-70 lbs. ft.

Quick Disconnect (Half Round)

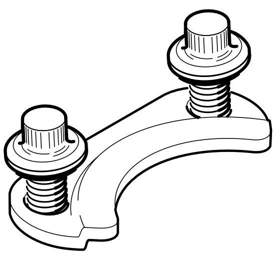
Series	Bolt Part No	Thread Size	Recommended Bolt Torque
SPL90	6-73-412	.375-24	45-60 lbs. ft.
1610	6-73-412	.375-24	45-60 lbs. ft.
1710	8-73-316	.500-20	115-135 lbs. ft.
1760	8-73-316	.500-20	115-135 lbs. ft.
1810	8-73-316	.500-20	115-135 lbs. ft.

Bearing Retainer

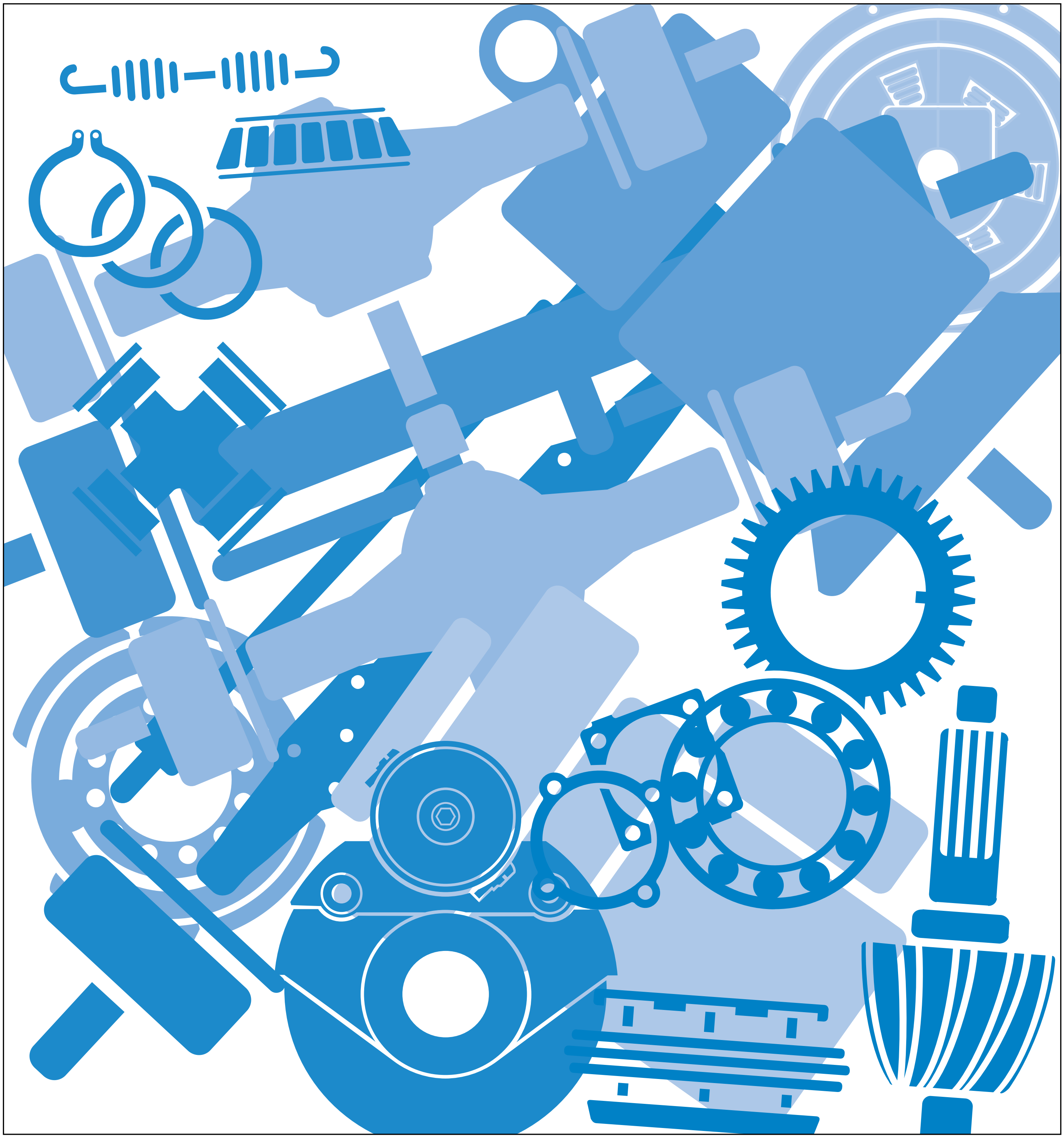


Series	Spicer Kit No	Retainer Kit No	Bolt Part No	Recommended Bolt Torque
SPL140	SPL140X	140-70-18X	12-73-125M	100-102 lbs. ft.
SPL170	SPL170X	170-70-18X	12-73-125M	100-102 lbs. ft.
SPL250	SPL250X	250-70-18X	12-73-125M	100-102 lbs. ft.

Spring Tab



Series	Spicer Kit No	Spring Tab Kit No	Bolt Part No	Recommended Bolt Torque
SPL140	SPL140X	211941X	8-73-114M	25-30 lbs. ft.
SPL170	SPL170X	211941X	8-73-114M	25-30 lbs. ft.
SPL250	SPL250X	211941X	8-73-114M	25-30 lbs. ft.



National Institute for AUTOMOTIVE SERVICE EXCELLENCE

SPICER® DRIVETRAIN COMPONENTS

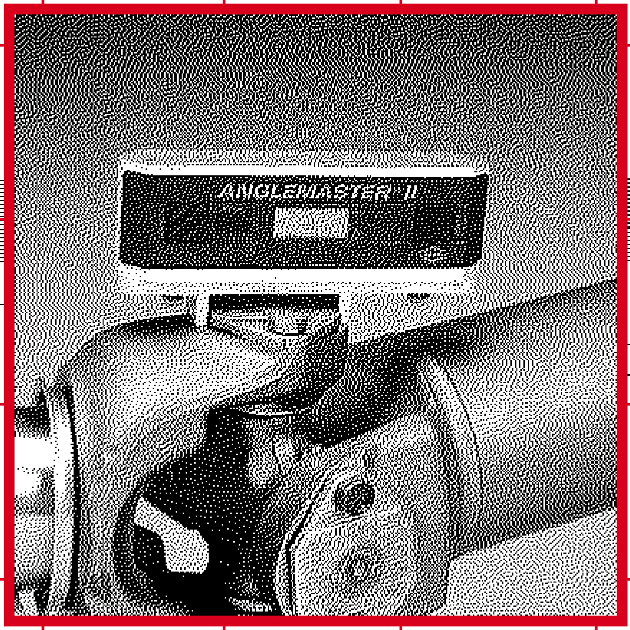
DANA

DSAG-0200
05/04 PDF
Printed in USA

SPICER®
DRIVETRAIN COMPONENTS

J3311-1-HVTSS
February 2005

Supersedes J3311-DSD
May 1994



Driveshaft Installation

DANA

People Finding A Better Way®

General Safety Information

To prevent injury to yourself and /or damage to the equipment:

- Read carefully all owners manuals, service manuals, and/or other instructions.
- Always follow proper procedures and use proper tools and safety equipment.
- Be sure to receive proper training.
- Never work alone while under a vehicle or while repairing or maintaining equipment.
- Always use proper components in applications for which they are approved.
- Be sure to assemble components properly.
- Never use worn-out or damaged components.
- Always block any raised or moving device that may injure a person working on or under a vehicle.
- Never operate the controls of the power take-off or other driven equipment from any position that could result in getting caught in the moving machinery.

WARNING: ROTATING DRIVESHAFTS

- Rotating auxiliary driveshafts are dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.
- Do not go under the vehicle when the engine is running.
- Do not work on or near an exposed shaft when engine is running.
- Shut off engine before working on power take-off or driven equipment.
- Exposed rotating driveshafts must be guarded.

WARNING: GUARDING AUXILIARY DRIVESHAFTS

We strongly recommend that a power take-off and a directly mounted pump be used to eliminate the auxiliary driveshaft whenever possible. If an auxiliary driveshaft is used and remains exposed after installation, it is the responsibility of the vehicle designer and PTO installer to install a guard.

WARNING: USING SET SCREWS

Auxiliary driveshafts may be installed with either recessed or protruding set screws. If you choose a square head set screw, you should be aware that it will protrude above the hub of the yoke and may be a point where clothes, skin, hair, hands, etc. could be snagged. A socket head set screw, which may not protrude above the hub of the yoke, does not permit the same amount of torquing as does a square head set screw. Also a square head set screw, if used with a lock wire, will prevent loosening of the screw caused by vibration. Regardless of the choice made with respect to a set screw, an exposed rotating auxiliary driveshaft must be guarded.

WARNING: THIS SYMBOL WARNS OF POSSIBLE PERSONAL INJURY.

Introduction

This brochure is intended for:

- Installers who install Spicer driveshafts into an application where the transmission and axle are not in direct line with each other, causing the driveshaft universal joints to operate at an angle.
- Anyone experiencing vibration problems with their application or their vehicle that driveshaft assembly balancing will not correct.
- Truck Equipment Distributors who:
    - Re-work a chassis to change the wheel base.
    - Install a midship mounted power take-off or fire pump.
    - Mount any other PTO-driven device such as a blower, hydraulic pump, or hydraulic motor.

Universal joint failures, as a rule, are of a progressive nature, which, when they occur, generally accelerate rapidly resulting in a mass of melted trunnions and bearings.

Some recognizable signs of universal joint deterioration are:

1. Vibrations - Driver should report to maintenance.
2. Universal joint looseness - End play across bearings.
3. Universal joint discoloration due to excessive heat build-up.
4. Inability to purge all four trunnion seals when re-lubing universal joint.

Items 2) thru 4) should be checked at re-lube cycle and, if detected, reported to the maintenance supervisor for investigation.

Experience with universal joint failures has shown that a significant majority are related to lubricating film breakdown. This may be caused by a lack of lubricant, inadequate lube quality for the application, inadequate initial lubrication, or failure to lubricate properly and often enough.

Failures which are not the result of lubrication film breakdown are associated with the installation, angles and speeds, and manufacturing discrepancies.

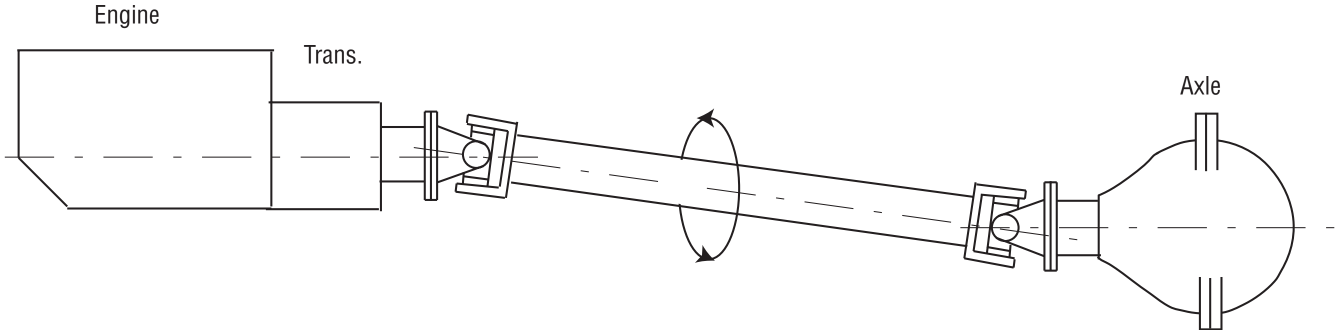
Driveshaft failures through torque, fatigue, and bending are associated with overload, excessively high universal joint angles, and drive shaft lengths excessive for operating speeds.

Driveshaft Torque

The following problems are usually a result of torque overloads:

- Twisted driveshaft tube
- Broken yoke shaft, slip yoke, tube yoke, flange yoke, end yoke
- Broken journal cross

How much torque can be generated in your application?



How to Calculate Torque:

LGT = T x TLGR x TE x SR x TCR x C

LGT = Maximum Driveshaft Low Gear Torque

T = Net Engine Torque or 95% of the Gross Engine Torque

TLGR = Transmission Low Gear Ratio (forward)*

TE = Transmission Efficiency (automatic = 0.8; manual = 0.85)

SR = Torque Converter Stall Ratio (if applicable)

TCR = Transfer Case Ratio (if applicable)

C = Transfer Case Efficiency (if applicable, 0.95)

How to Calculate Wheel Slip:

WST = (.71 x W x RR) / (11.4 x AR)

WST = Wheel Slip Torque Applied to the Driveshaft

W = Axle Capacity (lbs)

RR = Tire Rolling Radius (in)

AR = Axle Ratio

For On Road Applications

Relate the lesser of above to Spicer universal joint ratings. If your torque exceeds the Spicer rating for the universal joint used in your application, switch to a size with a rating compatible to your calculation. However, the series selected cannot be more than one series below the series called for by the LGT calculation.

For Off Road or On-Off Road Applications

Use Low Gear Torque value only to verify or switch to a size with a rating compatible to your calculation.

Common Causes of Vibrations

The three most common causes of driveshaft vibration are: Driveshaft Imbalance, Critical Speed, and Universal Joint Operating Angles.

Driveshaft Imbalance

Eliminate the potential for balance problems before you undertake any other measures.

A driveshaft on a vehicle usually rotates at a higher rate of speed than the tire. For that reason, like tires, driveshafts should be balanced.

Any time you build or rework a driveshaft, make sure it is dynamically balanced at, 3000 RPM for Light Duty or 2500 RPM for Heavy Duty, to the following specifications:

Series	Specification
1310, 1330	.375 oz-in total at each end of shaft *
1350, 1410	.500 oz-in total at each end of shaft *
1480 - 1880	1.00 oz-in for each ten pounds of driveshaft weight divided proportionally at each end of shaft
* Passenger Car, Light Truck, Van, and SUV only. Industrial, Mobile Off-Highway, PTO, etc. same as 1480 - 1880.	

Critical Speed

Every driveshaft has a critical speed. Critical speed is the point at which a rotating driveshaft begins to bow off its normal rotating centerline.

Driveshafts begin to vibrate as they approach critical speed. If they are operated at near critical speed for an extended period, they often fail. This can damage the vehicle and possibly injure persons nearby.

As a driveshaft fabricator or installer, you are responsible for checking the safe operating speed of any driveshaft you fabricate or specify into an application. Make sure it will not operate at a speed higher than Spicer's recommended safe operating speed. Use Spicer Calculator (P/N J 3253) to determine safe operating speed.

Checking for a Possible Critical Speed Problem

Here is what you must do to make sure you won't have a critical speed problem:

- Determine the safe operating speed of the driveshaft you want to use in your application. Insert the tube diameter and center-to-center installed length of the shaft you want to use into a Spicer Safe Operating Speed Calculator (P/N. J3253). The calculator will tell you the safe operating speed of the shaft you have chosen.
- Determine the NORMAL and MAXIMUM POSSIBLE operating speed of the driveshaft.
  REMEMBER:
  - On vehicles with a standard transmission that have a 1:1 direct drive high gear and no overdrive, MAXIMUM POSSIBLE driveshaft RPM is the same as the maximum possible ENGINE RPM.
  - On vehicles that have an overdrive transmission, MAXIMUM POSSIBLE driveshaft RPM is higher than maximum possible ENGINE RPM.

Maximum Possible Driveshaft RPM

To calculate the maximum possible driveshaft RPM in vehicles having an overdrive transmission, divide the maximum possible engine RPM by the overdrive ratio. (See examples below.)

Example 1:
Max. engine RPM: 2100
Overdrive ratio: .79
2100/.79 = 2658 maximum possible driveshaft RPM

Example 2:
Max. engine RPM 6000
Overdrive ratio: .66
6000/.66 - 9091 maximum possible driveshaft RPM

Compare the maximum possible driveshaft RPM with the safe operating speed determined from the Safe Operating Speed Calculator. If the maximum possible driveshaft RPM meets or exceeds the safe operating speed determined from the calculator, you must do whatever is required to raise the critical speed of the driveshaft you have chosen for the application.

Sample Specification:

To specify a driveshaft for the application described in Example 1 above, compare the safe operating speed for the driveshaft selected with the maximum possible driveshaft RPM calculated (2658 RPM). Make sure the safe operating speed of the driveshaft is greater than 2658 RPM.

Changing the Safe Operating Speed of a Driveshaft

A driveshaft's safe operating speed can be raised by increasing its tube diameter or by shortening the installed center-to-center length of the driveshaft. Changing the installed length of a driveshaft will require the use of multiple driveshafts with center bearings.

Important: The critical speed of an assembly can be affected by driveshaft imbalance, improper universal joint operating angles, or improperly phased driveshafts. (A properly phased driveshaft has the in-board yokes of the shaft in line with each other.) Each of the above items will tend to lower the true critical speed from the values shown on the calculator.

Since critical speed can ultimately cause driveshaft failure, it is extremely important to be very precise in all applications.

Universal Joint Operating Angles

Every Universal Joint that Operates at an Angle Creates a Vibration

Universal joint operating angles are probably the most common causes of driveline vibration in vehicles that have been reworked, or in vehicles that have had auxiliary equipment installed.

Universal joint operating angles are a primary source of problems contributing to:

- Vibrations
- Reduced universal joint life
- Problems with other drivetrain components that may include:
  - Transmission gear failures
  - Synchronizer failures
  - Differential problems
  - Premature seal failures in axles, transmissions, pumps, or blowers
  - Premature failure of gears, seals, and shafts in Power Take-Offs

When you rework a chassis or install a new driveshaft in a vehicle, make sure that you follow the basic rules that apply to universal joint operating angles:

RULE 1: UNIVERSAL JOINT OPERATING ANGLES AT EACH END OF A DRIVESHAFT SHOULD ALWAYS BE AT LEAST 1 DEGREE.

RULE 2: UNIVERSAL JOINT OPERATING ANGLES ON EACH END OF A DRIVESHAFT SHOULD ALWAYS BE EQUAL WITHIN 1 DEGREE OF EACH OTHER (ONE HALF DEGREE FOR MOTOR HOMES AND SHAFTS IN FRONT OF TRANSFER CASE OR AUXILIARY DEVICE).

RULE 3: FOR VIRTUAL VIBRATION FREE PERFORMANCE, UNIVERSAL JOINT OPERATING ANGLES SHOULD NOT BE LARGER THAN 3 DEGREES. IF THEY ARE, MAKE SURE THEY DO NOT EXCEED THE MAXIMUM RECOMMENDED ANGLES.

A universal joint operating angle is the angle that occurs at each end of a driveshaft when the output shaft of the transmission and driveshaft and the input shaft of the axle and driveshaft are not in line. (See Fig 1)

The connecting driveshaft operates with an angle at each universal joint. It is that angle that creates a vibration.

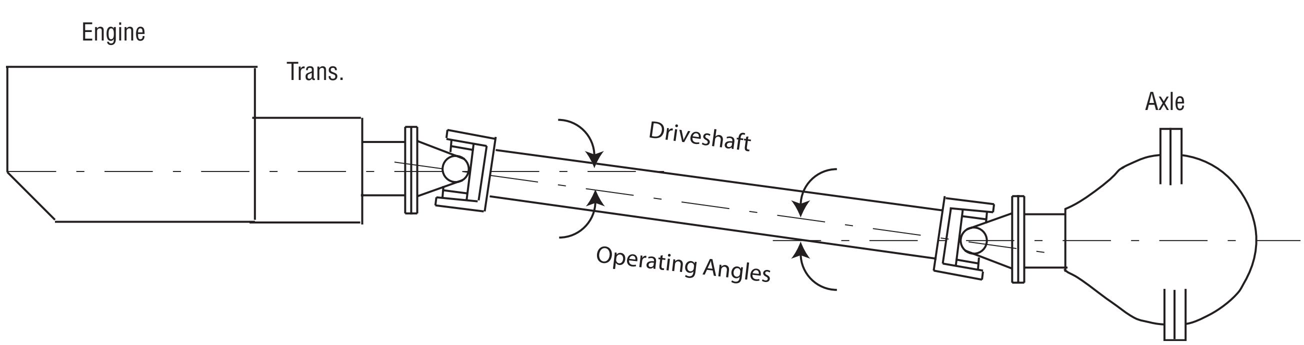


Figure 1

Reducing and Canceling Vibration

A key point to remember about universal joint operating angles: To reduce the amount of vibration, the angles on each end of a driveshaft should always be SMALL.

To cancel an angle vibration, the universal joint operating angles need to be EQUAL within 1 degree at each end of a driveshaft. On motor home applications and auxiliary transmission installations, the tolerance is 1/2 degree. (See Fig 2)

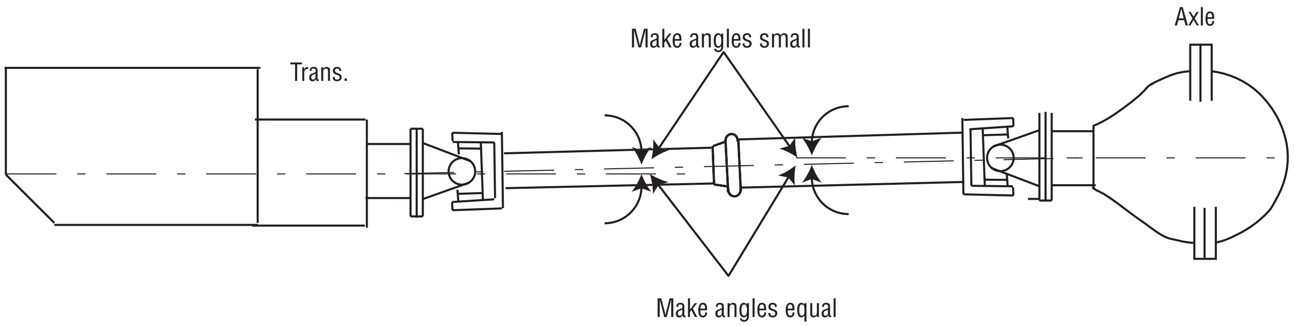


Figure 2

Single Plane and Compound Universal Joint Operating Angles

There are two types of universal joint operating angles: Single Plane and Compound.

Single Plane

Single Plane angles occur when the transmission and axle components are in line when viewed from either the top or side, but not both.

Determining the universal joint operating angle in an application where the components are in line when viewed from the top, but not in line when viewed from the side, is as simple as measuring the slope of the components in the side view, and adding or subtracting those slopes to determine the angle. (See Fig. 3)

These angles should be **small** and **equal** within 1 degree.

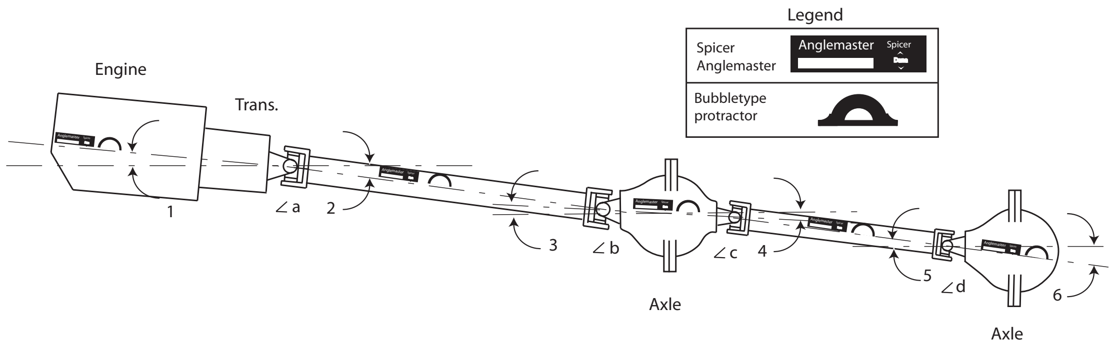


Figure 3

The most convenient way to determine universal joint angles in the side view is through the use of a Spicer Anglemaster™ or a bubble type protractor.

Using an Anglemaster or a bubble protractor, record inclination angles of drivetrain components. Set Anglemaster or protractor on machined surfaces of engine, transmission, axle, or on machined lugs of transmission and axle yoke(s).

Note: Universal joint angles can change significantly in a loaded situation. Therefore, check vehicle loaded and unloaded to achieve the accepted angle cancellation.

Example:

Engine-Transmission Output	4°30’ Down (1)
Main Driveshaft	7°00’ Down (2)
Input 1st Rear Axle	4°00’ Up (Input Shaft Nose Up) (3)
Output 1st Rear Axle	4°00’ Down (4)
Inter-axle Shaft	7°00’ Down (5)
Input 2nd Rear Axle	4°15’ Up (Pinion Shaft Nose Up) (6)
Note: If inclination of driveshaft is opposite connecting component, add angles to obtain the universal joint operating angle.	
Angle a = (2) - (1) = 7°00’ - 4°30’ = 2°30’ (2.50°)	
Angle b = (2) - (3) = 7°00’ - 4°00’ = 3°00’ (3.00°)	
Angle c = (5) - (4) = 7°00’ - 4°00’ = 3°00’ (3.00°)	
Angle d = (5) - (6) = 7°00’ - 4°15’ = 2°45’ (2.75°)	

Determining the universal joint operating angles on a driveshaft that is straight when viewed from the side and offset when viewed from the top requires the use of a special chart (See Angle Chart). In this type of application, the centerlines of the connected components **must be parallel** when viewed from the top as shown. These angles also should be **small** and **equal** within 1 degree. (See Fig. 4)

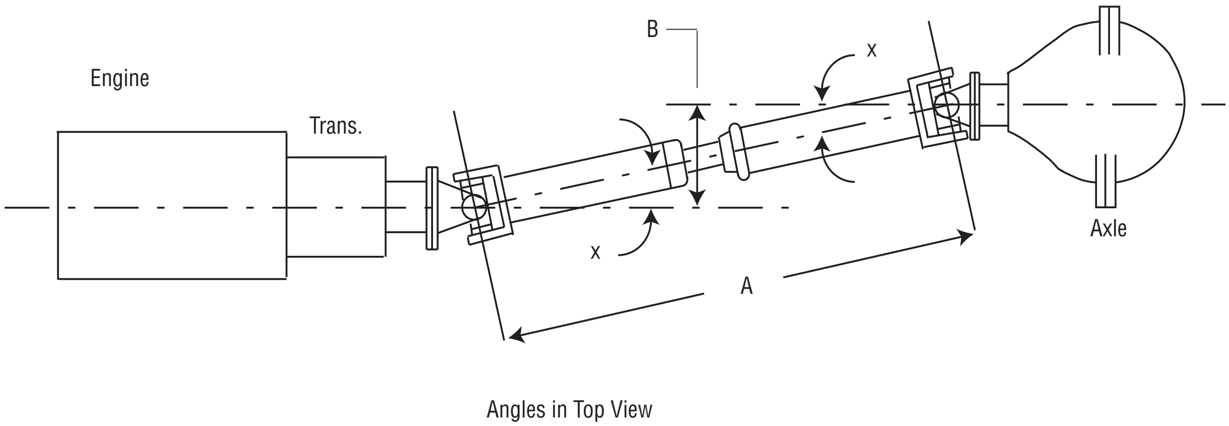


Figure 4

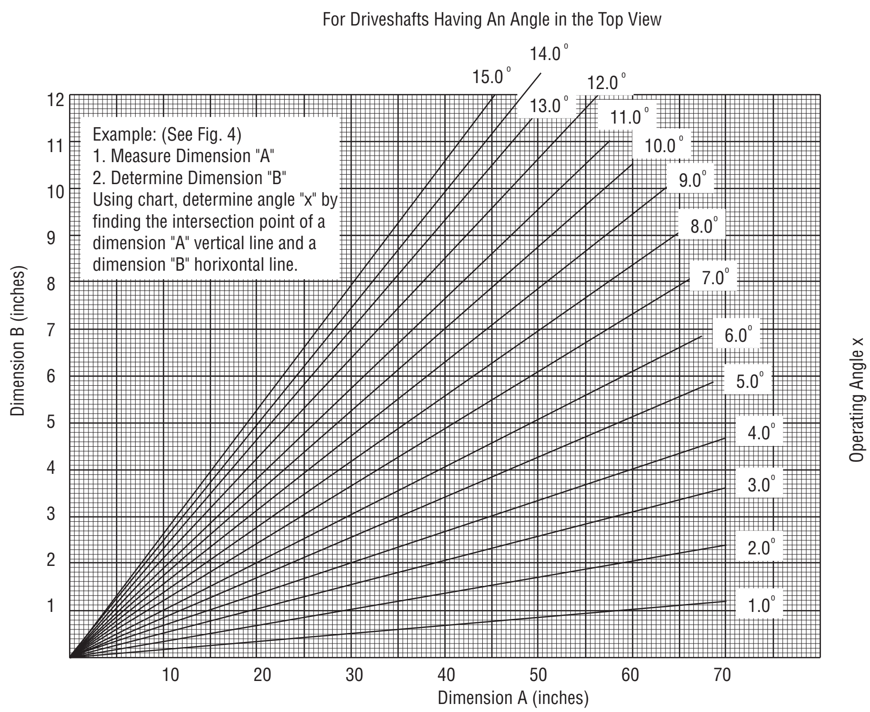
Measure dimensions "A" and "B" shown in figure 4. Use the instructions in the angle chart below to determine the size of the angle.

Look at the Angle Chart and note that the smaller the offset, the smaller the resultant angle.

To reduce the possibility of vibration, keep any offset between connected points to a minimum.

There are two things you can do to always make sure Single Plane angles are SMALL and EQUAL: Make sure the transmission and axle are mounted so their centerlines are parallel when viewed from both the side and the top. Make sure the offset between them is small in both views.

ANGLE CHART



U-Joint Operating Angles

Compound Angles

Compound universal joint operating angles occur when the transmission and axle are not in line when viewed from BOTH the top and side. Their centerlines, however, are parallel in both views. (See Fig. 5)

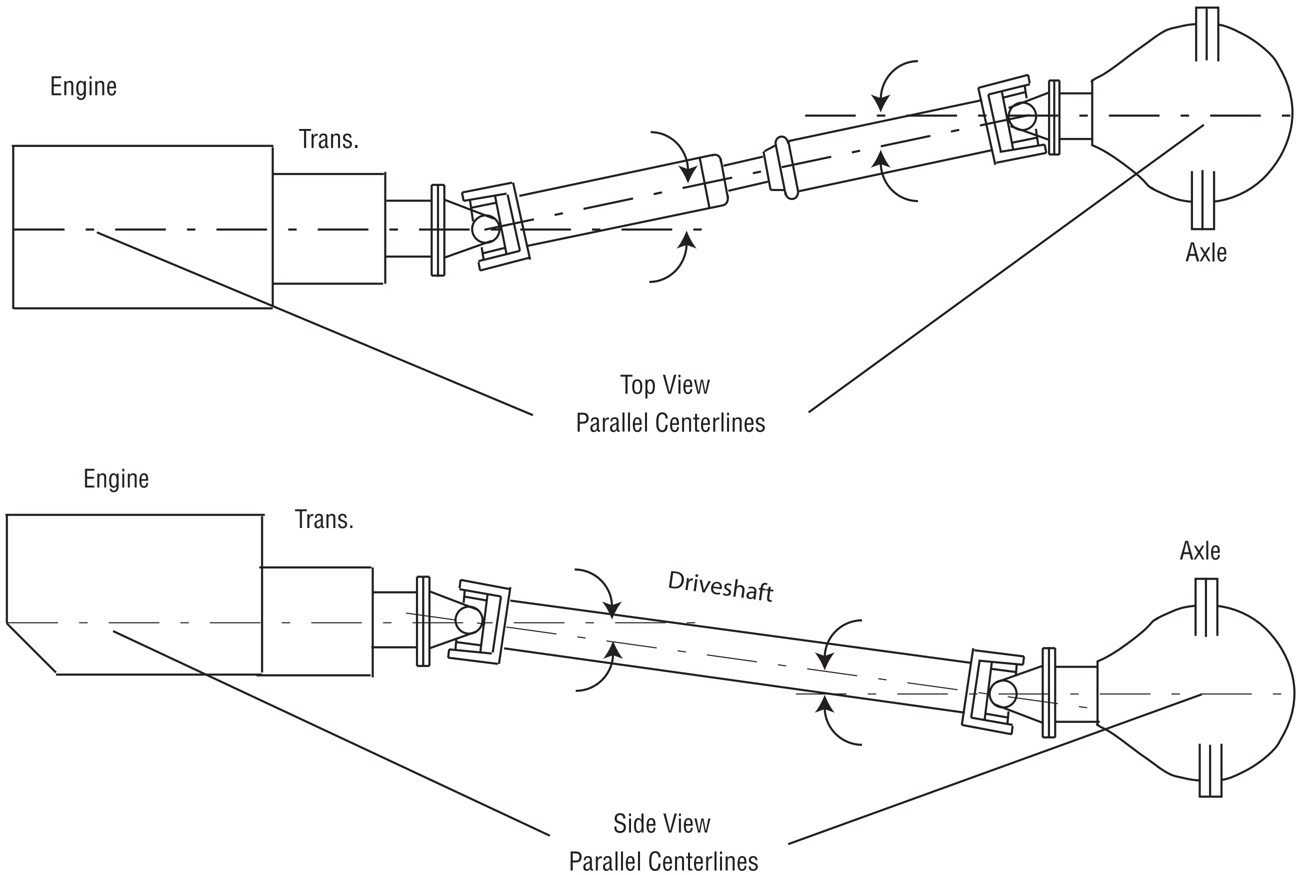


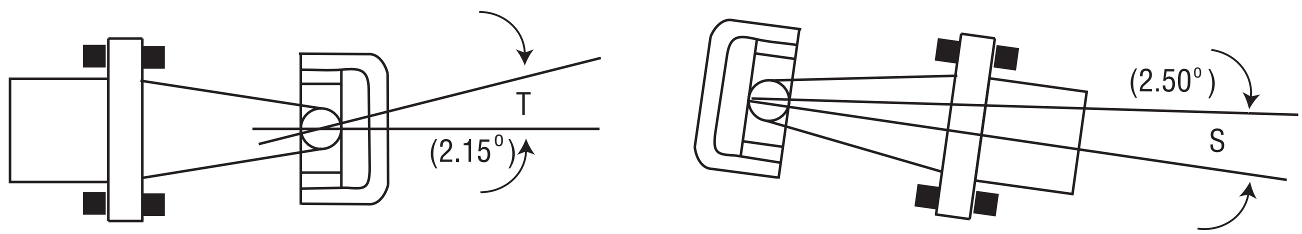
Figure 5

When you have a compound angle, you have to calculate the "True Universal Joint Operating Angle" of each universal joint. It is the True Universal Joint Operating Angle that must meet the three rules shown on page 5.

True Universal Joint Operating Angle

The True Universal Joint Operating Angle, which must be calculated for each end of the shaft with compound angles, is a combination of the universal joint operating angle in the top view, as determined from the chart, and the measured universal joint operating angle in the side view.

To determine the true universal joint operating angle for one end of a shaft, (compound angle C° in the formula shown in Fig. 6) insert the universal joint operating angle measurement obtained in the side view and the universal joint operating angle obtained from the chart into the formula.



Angle in Top View (from Chart)

SideView

$$\text{Compound Angle } (C^{\circ}) = \sqrt{T^2 + S^2}$$

$T = 2.15^{\circ}$ (A calculated angle)

$S = 2.5^{\circ}$ (The measured angle)

$$C = \sqrt{2.15^2 + 2.5^2}$$

$$C = \sqrt{10.873}$$

$C = 3.3^{\circ}$ (True operating angle)

Figure 6

Do the same for the other end of the shaft. Compare the resultant calculated universal joint operating angle for each end. They should be EQUAL within 1 degree. If they're not, the driveshaft will vibrate.

Eliminating Compound Angle Induced Vibrations

Compound universal joint operating angles are one of the most common causes of driveline vibration. To avoid theses problems, remember these important points:

- When setting up an application that requires compound universal joint operating angles, always keep the centerlines of the transmission and axle parallel in both views.
- Always keep the offset between their horizontal and vertical centerlines small.

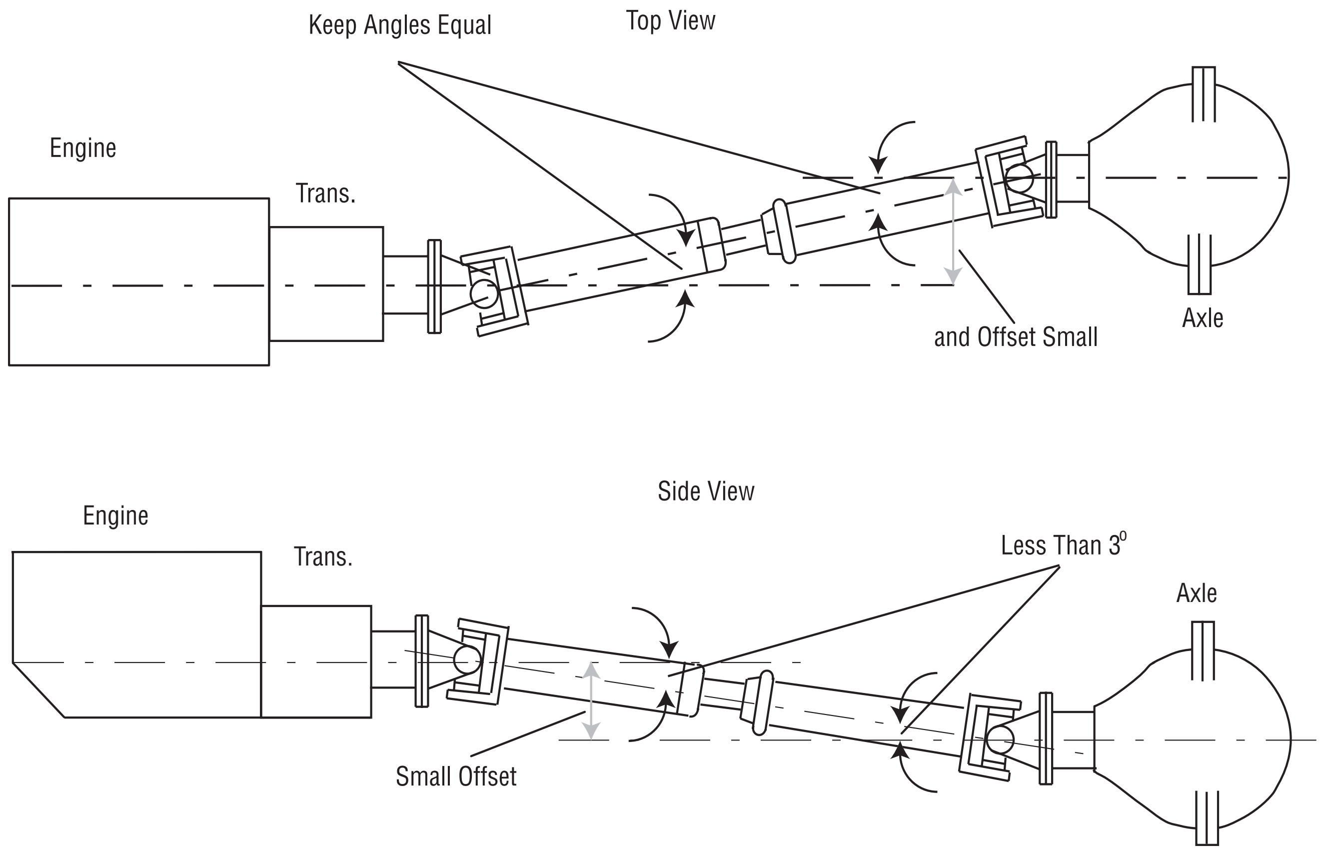


Figure 7

Note: Centerlines of transmission and axle must be parallel in both top and side views to use this method of determining true universal joint operating angle. Please contact Spicer Driveshaft Engineering if you have an application where the components cannot be installed with their centerlines parallel.

If adjustments must be made to the system:

- Install shims between the axle housing and springs to rotate the axle input yoke to change operating angles.
- Change operating angle on torque arm type suspensions by lengthening or shortening torque arms.
- Raise, lower, or shift side-to-side a pump, blower, or other piece of auxiliary equipment to change operating angles.

Note: It is important to remember to keep the centerlines of two components that are connected by a driveshaft parallel in both the top and side views, so the operating angles will ALWAYS be equal.

Angle Size

The magnitude of a vibration created by a universal joint operating angle is proportional to the size of the universal joint operating angle. Spicer Engineers recommend true universal joint operating angles of 3 degrees or less.

Obtain the true universal joint operating angle, as explained above, and if it is greater than 3 degrees, compare it to this chart.

Driveshaft RPM	Maximum Operating Angle	Interaxle	
		Parallel	Intersecting
5000	3.2°	-	-
4500	3.7°	-	-
4000	4.2°	3.8°	3.8°
3500	5.0°	4.4°	4.4°
3000	5.8°	5.1°	4.8°
2500	7.0°	6.0°	4.8°
2000	8.7°	6.0°	4.8°
1500	11.5°	6.0°	4.8°

The angles shown on this chart are the maximum universal joint operating angles recommended by Spicer Engineers and are directly related to the speed of the driveshaft. Any universal joint operating angle greater than 3 degrees will lower universal joint life and may cause a vibration. Remember to check maximum safe driveshaft RPM by using the Spicer Safe Operating Speed Calculator.

Multiple Shaft Installations

Multiple Shaft Set Up Recommendations

In general, multiple shaft installations follow the same guidelines, except there are different recommendations for setting up the driveline:

- For a 2-shaft application, set up the first coupling shaft (sometimes called a jackshaft) so that the universal joint operating angle that occurs at the transmission end is 1 to 1-1/2 degrees. (See Fig. 8)

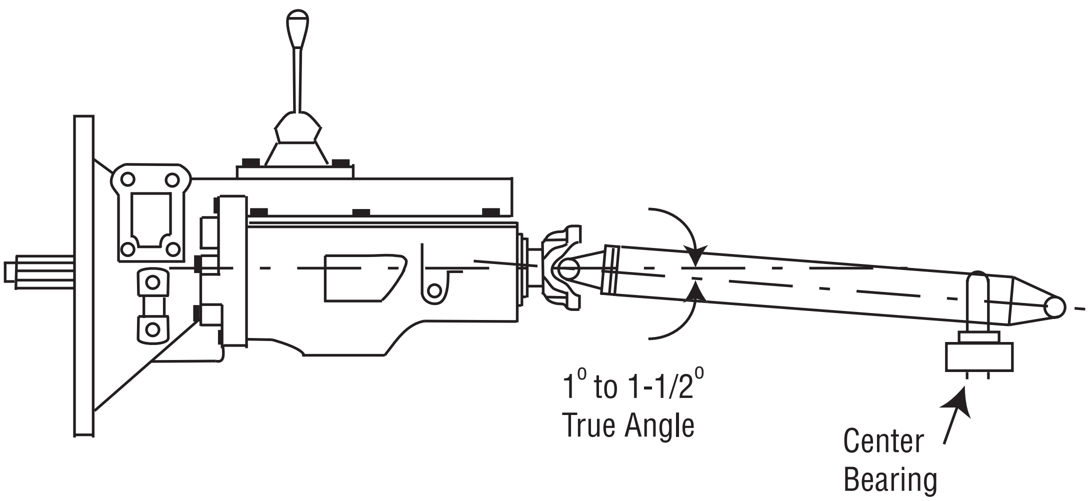


Figure 8

- Try to avoid building a compound universal joint operating angle into the first coupling shaft by installing it in line with the transmission.
- If it ends up being compound, make sure the true universal joint operating angle, determined by using the information mentioned earlier, is 1 to 1-1/2 degrees.

Install or tilt the axle so it is mounted on the same angle as the first coupling shaft (the centerlines of the axle and the first coupling shaft will be parallel).

Note: BY FOLLOWING THIS PROCEDURE, THE UNIVERSAL JOINT OPERATING ANGLE AT EACH END OF THE LAST SHAFT WILL AUTOMATICALLY BE EQUAL. (See Fig. 9)

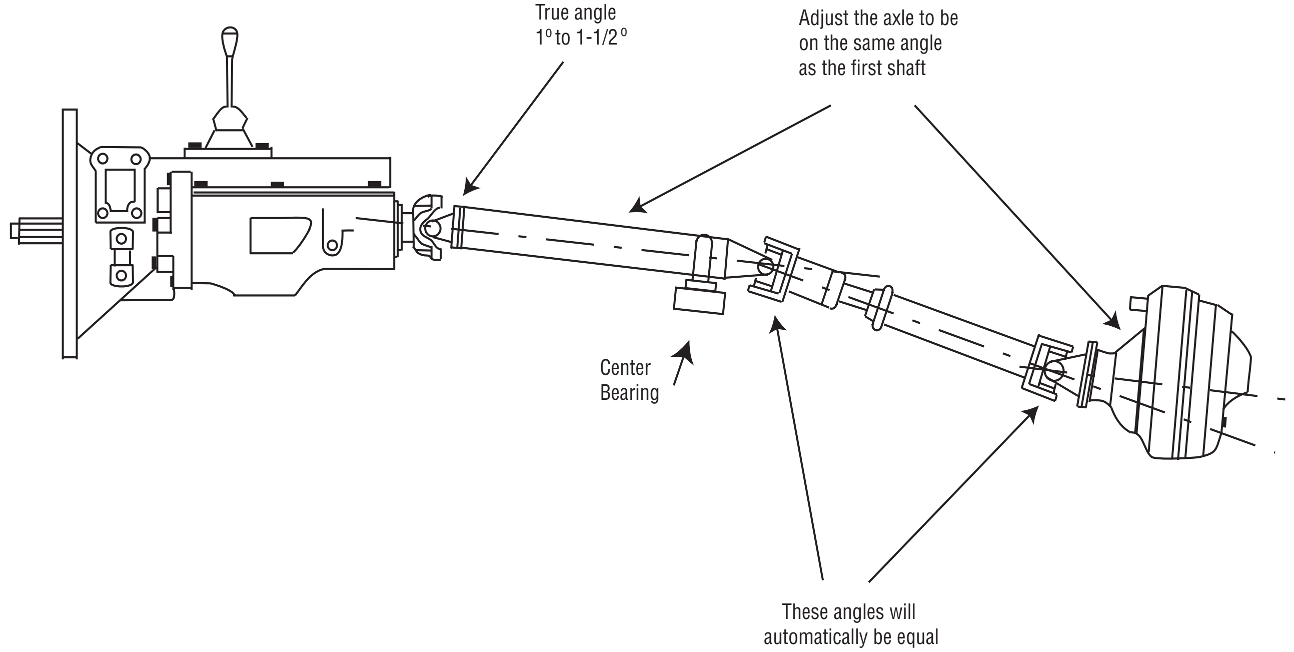


Figure 9

If there is an offset in the installation of the axle, make sure it does not create too large of a compound universal joint operating angle. Whenever possible, mount the axle directly in line with the first coupling shaft (when viewed from the top).

Check the actual universal joint operating angle at the rear of the first coupling shaft. If it is less than 1º and the transmission universal joint operating angle is greater than 1.5º, rotate the end yoke at the center bearing position so that the ears of the yoke are 90º to the ears of the tube yoke on the transmission end of the coupling shaft. (See Fig. 10) As an alternative, rotate the slip yoke on the driveshaft 90º if the slip spline has 16 teeth.

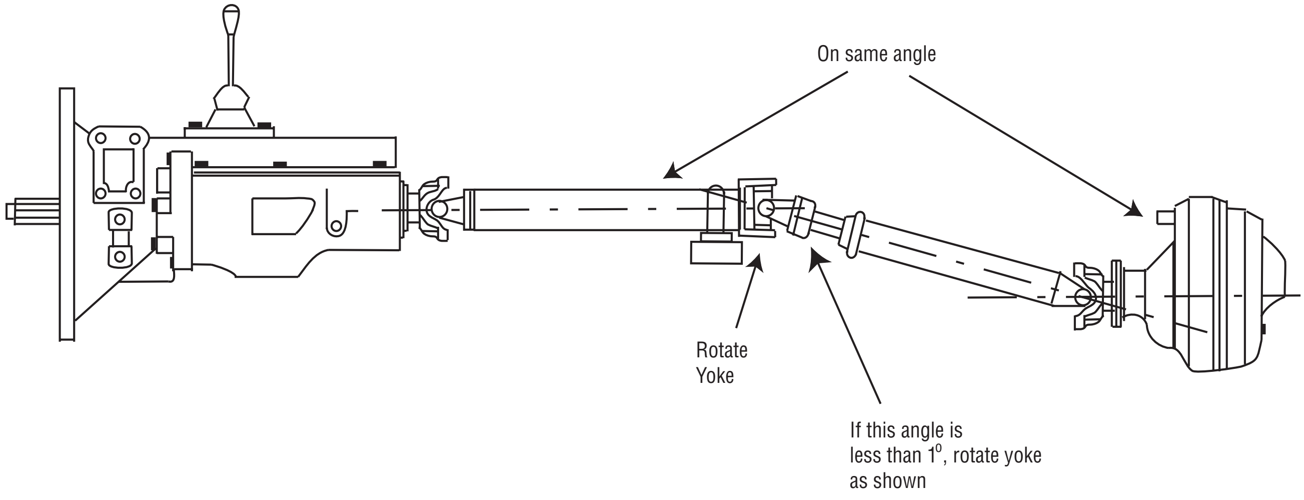


Figure 10

On applications having more than two shafts, mount the first coupling shaft as outlined in the preceding example, and each additional coupling shaft at a 1 to 1-1/2 degree universal joint operating angle to the previous coupling shaft.

Install or tilt the axle to the same angle as the last fixed coupling shaft so the centerline of the axle and the last fixed coupling shaft are parallel.

Note: THIS ASSURES THE UNIVERSAL JOINT OPEARTING ANGLE AT EACH END OF THE LAST SHAFT WILL AUTOMATICALLY BE EQUAL (See Fig. 11).

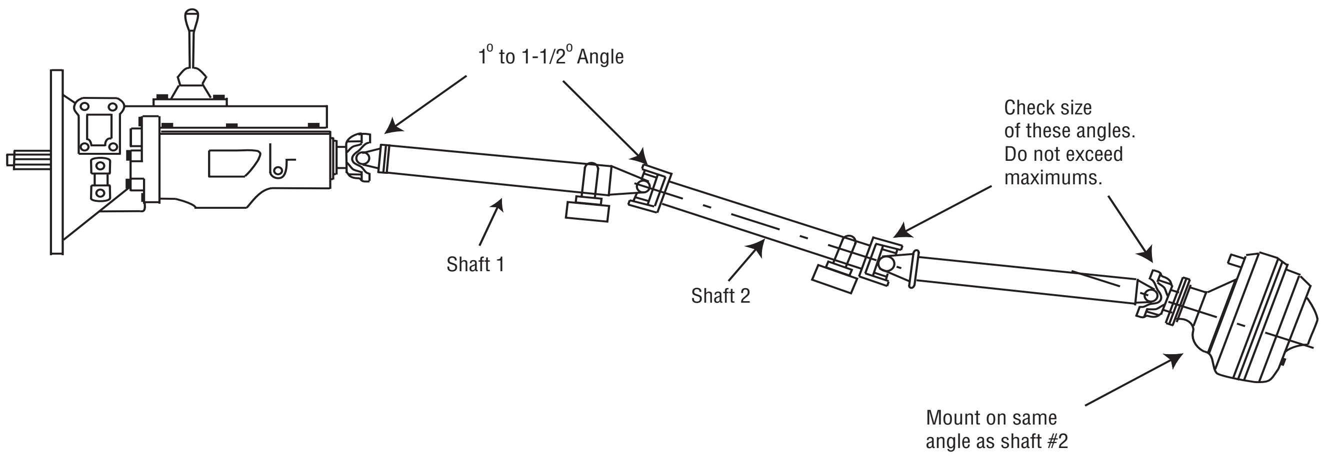


Figure 11

Mounting a Midship-Mounted PTO, Pump, or Auxiliary Transmission

When installing a midship-mounted PTO, auxiliary transmission, or midship-mounted pump into the main driveline of a vehicle, install it at the same angle as the transmission. Keep the offset to a minimum to reduce universal joint operating angles.

Note: Do not make the universal joint operating angle less than 1/2 degree.

Before bolting the device in place, check the universal joint operating angles that occur at each end of the driveshaft. They must be 1 to 1-1/2 degrees and they must be equal to within 1/2 degree for this type of application.

If the device ends up being installed in direct line with the transmission, with little or no universal joint operating angle on the joints, raise or lower it so there is enough offset to create the required 1 to 1-1/2 degree universal joint operating angle on each end of the driveshaft. (See Fig. 12)

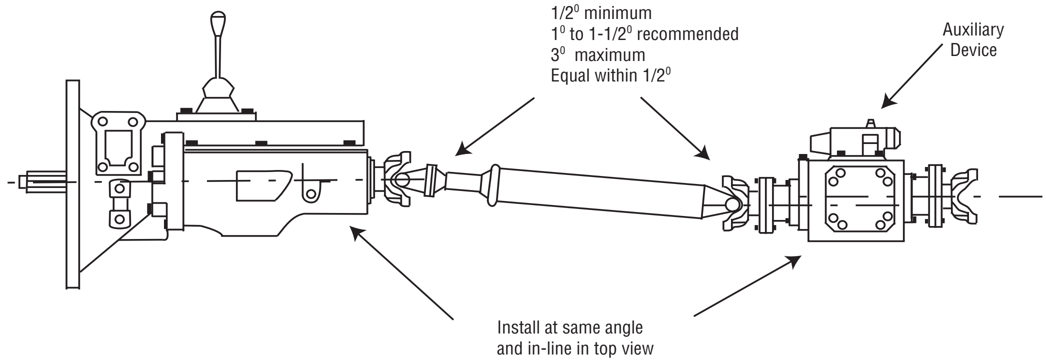


Figure 12

If there is only one driveshaft between the device and the rear axle, rotate the rear axle (using shims in the appropriate place) so it is the same angle as the device. This makes the universal joint operating angle at each end of the driveshaft equal (See Fig. 13). Check the size of the universal joint operating angles to determine if they meet recommendations.

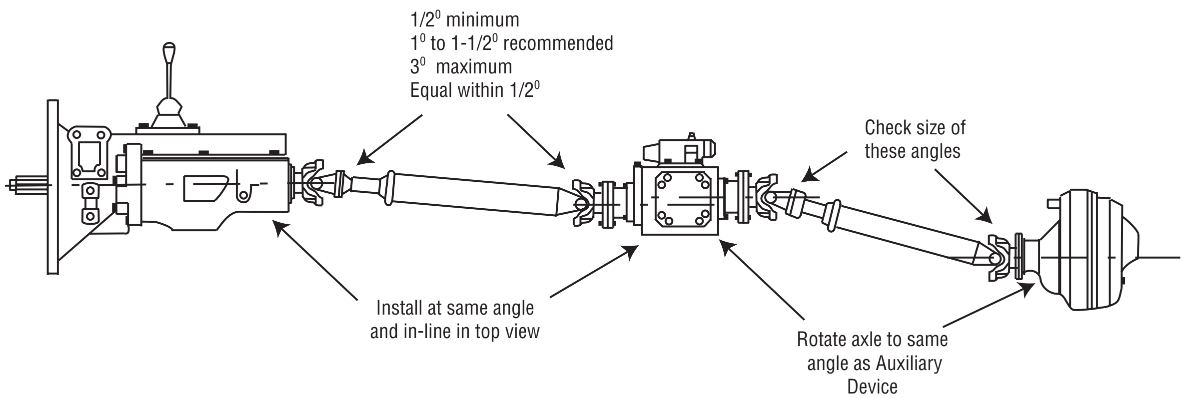


Figure 13

If there is more than one driveshaft between the device and the rear axle, install the driveshaft as outlined earlier with a 1 to 1-1/2 degree universal joint operating angle on the input end of each shaft. Then rotate the axle so it is on the same angle as the last fixed shaft. The universal joint operating angle on each end of the last shaft will automatically be equal. (See Fig. 14)

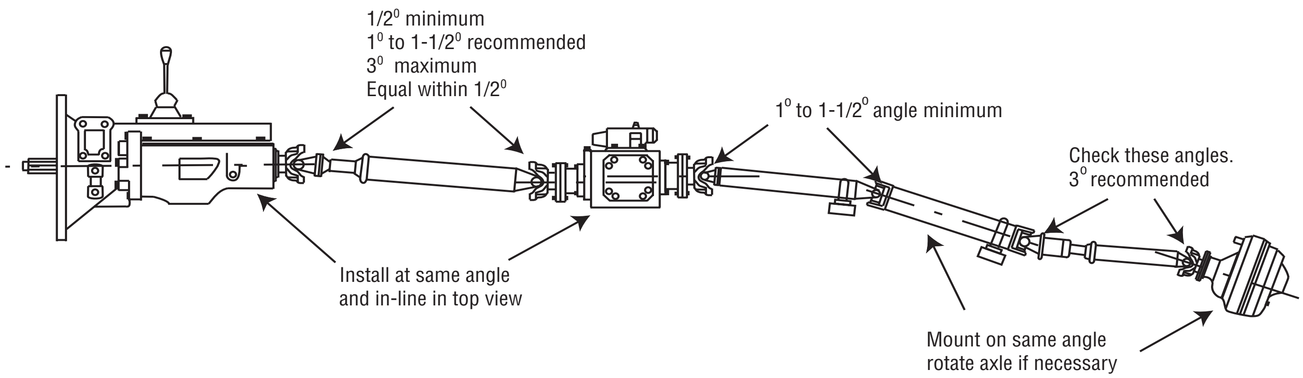


Figure 14

Mounting a Remote-Driven Pump, Blower, or Similar Device

Remote mounted-pumps, blowers, or similar devices are usually driven by a side, top, or bottom-mounted PTO and use an auxiliary driveshaft.

Many times these devices are mounted to the vehicle frame or cross member. The usual method of mounting, where the driven device is mounted parallel with the ground without regard to the mounted angle of the PTO, will produce a vibration that may cause failure of the PTO, pump, blower, or other driven device.

Any remote driven device must be mounted parallel and in line, if possible, with the PTO.

To select the appropriate auxiliary driveshaft for these types of applications, you should consider proper torque, safe operating speed (which is different than the critical speed for tubular driveshafts), and angularity. (See Maximum Safe Operating Speed Chart on page 18).

An auxiliary driveshaft must be capable of transmitting the maximum torque and RPM required by the driven equipment. For most low-torque applications operating at less than 1200 RPM, solid bar-stock constructed driveshafts are adequate. For applications requiring additional torque or RPMs, tubular shafts should be fabricated.

Maximum Safe Operating Speed

MAXIMUM OPERATING SPEED* BY TUBE SIZE, SOLID SHAFT SIZE, AND LENGTH *(For speeds over 6000 RPM, contact Spicer Universal Joint Division Engineering)											
TUBING	MAXIMUM INSTALLED LENGTH (IN INCHES) FOR GIVEN RPM										
Diameter & Wall Thickness W - Welded S - Seamless	Centerline to Centerline of Joints for a Two Joint Assembly or Centerline of Joint to Centerline of Center Bearing for a Joint and Shaft										
	RPM - Revolutions Per Minute										
	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
1.750" x .065" W	82"	67"	58"	52"	-	-	-	-	-	-	-
1.250" x .095" S	64"	52"	45"	40"	37"	34"	32"	-	-	-	-
2.500" x .083" W	87"	70"	62"	55"	50"	45"	43"	41"	39"	37"	35"
3.000" x .083" W	-	-	85"	76"	70"	64"	60"	57"	54"	51"	49"
SOLID SHAFT DIAMETER											
.750"	42"	35"	30"	27"	25"	-	-	-	-	-	-
.812"	44"	36"	31"	28"	26"	-	-	-	-	-	-
.875"	46"	37"	32"	29"	27"	-	-	-	-	-	-
1.000"	49"	40"	35"	31"	28"	-	-	-	-	-	-
1.250"	55"	45"	39"	35"	32"	-	-	-	-	-	-

To prevent premature wear, auxiliary driveshaft breakage, and possible injury to people or equipment, be aware of the critical speed of these types of driveshafts. Critical speed, explained earlier in this guide, is different for these solid shaft and small tube driveshafts.

Refer to the chart above for maximum safe operating speed information on these types of shafts.

If the chart indicates that the critical speed may be a problem, use multiple shafts. Be sure to use support bearings where necessary and set up the true universal joint operating angles as indicated earlier in this guide.

As with all driveshafts, auxiliary driveshafts should be:

- Carefully installed to minimize vibrations caused by incorrect universal joint operating angles
- Capable of absorbing shock loads
- Capable of changing length as needed
- Guarded so as to prevent inadvertent entanglement

Special Notes Regarding Auxiliary Driveshafts

WARNING: Working on or near an auxiliary driveshaft when the engine is running is extremely dangerous and should be avoided. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.

- Shut off engine before working on power take-off or driven equipment.
- Do not go under the vehicle when the engine is running.
- Do not engage or disengage driven equipment by hand from under the vehicle when the engine is running.
- Fasteners should be properly selected and torqued to the manufacturer's specifications.
- If a setscrew protrudes above the hub of an end yoke, you may want to replace it with a recessed (Allen-type) setscrew.
- If you decide that a recessed setscrew does not have enough holding power for your application and you must use a protruding setscrew, be sure no one can come in contact with the rotating driveshaft or the protruding setscrew.
- **Exposed rotating driveshafts must be guarded!**
- Lubricate auxiliary driveshafts according to manufacturer's specifications.

Contact Information:

Dana Corporation
Heavy Vehicle Technologies and
Systems Service
P.O. Box 321
Toledo, OH 43697-0321
1-800-SAY-DANA (729-3262)

www.dana.com
www2.dana.com/expert

Dana Corporation
Heavy Vehicle Technologies and
Systems Service – Canada
5095 South Service Road
Beamsville, Ontario, Canada L0R 1B0
Tech Service: 1-905-563-4991

Dana Corporation
Heavy Vehicle Technologies and
Systems Service – International
419-861-6325

People Finding A Better Way®

J3311-1-HVTSS
2/05
Printed in U.S.A.

Service Data

Bendix® AD-9™ Air Dryer

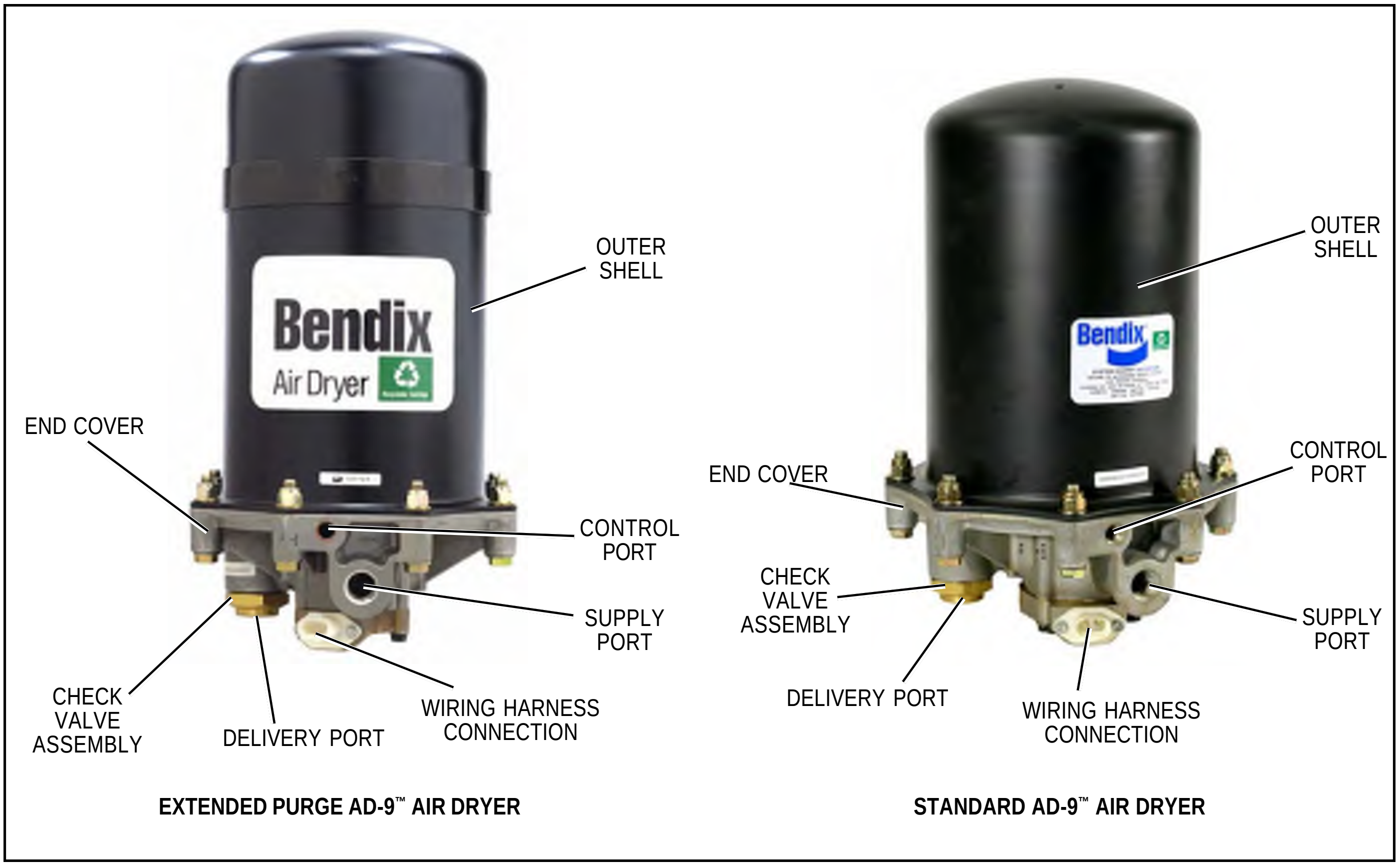


*FIGURE 1 - **AD-9™ AIR DRYER MODELS***

DESCRIPTION

The function of the AD-9™ air dryer is to collect and remove air system contaminants in solid, liquid and vapor form before they enter the brake system. It provides clean, dry air to the components of the brake system which increases the life of the system and reduces maintenance costs. Daily manual draining of the reservoirs is eliminated.

The AD-9™ air dryer consists of a desiccant cartridge and a die cast aluminum end cover secured to a cylindrical steel outer shell with eight cap screws and nuts. The end cover contains a check valve assembly, a safety valve, three threaded air connections and the purge valve housing assembly. The removable purge valve housing assembly incorporates a purge valve mechanism and a turbo charger cut-off feature that is designed to prevent loss of engine "turbo" boost pressure during the purge cycle of the AD-9™ air dryer. For ease of serviceability, the desiccant cartridge and discharge check valve assembly are screw in type. The purge valve housing assembly, which includes the heater and thermostat assembly, and the discharge check valve assembly, is serviceable from the exterior of the air dryer, while servicing the screw-in desiccant cartridge requires removal of the air dryer assembly from the vehicle.

The AD-9™ air dryer has three female pipe thread air connections and each is identified as follows:

Port I.D.	Function/Connection
CON 4...............	Control Port (purge valve control and turbo cut-off).
SUP 11	Supply Port (air in).
DEL 2	Delivery Port (air out).

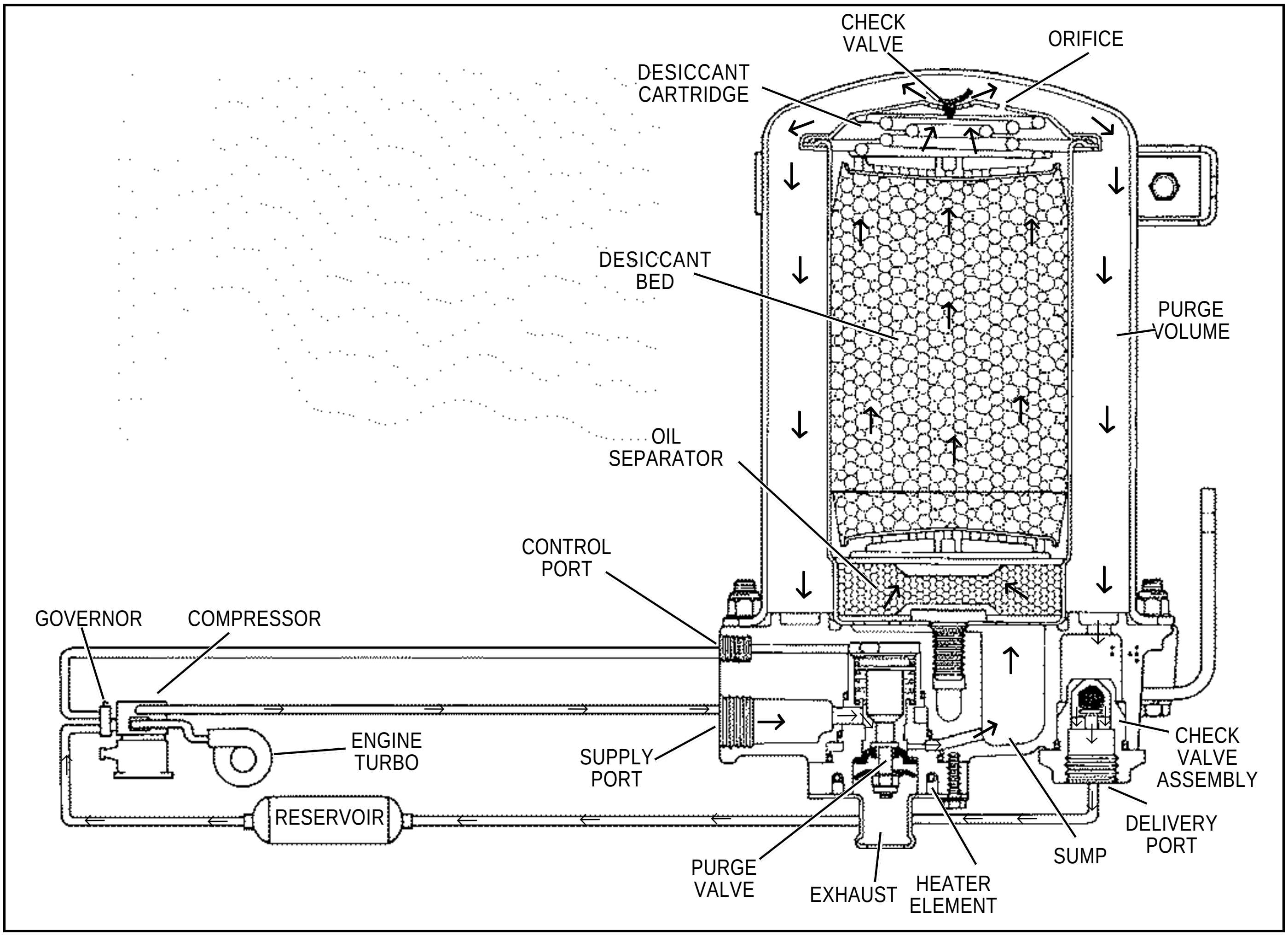


*FIGURE 2 - **AD-9™ AIR DRYER CHARGE CYCLE***

OPERATION OF THE AD-9™ AIR DRYER

The AD-9™ air dryer alternates between two operational modes or "cycles" during operation: the *charge cycle* and the *purge cycle*. The following description of operation is separated into these "cycles" of operation.

CHARGE CYCLE (refer to Figure 2)

When the compressor is loaded (compressing air) compressed air, along with oil, oil vapor, water and water vapor flows through the compressor discharge line to the supply port of the air dryer end cover. As air travels through the end cover assembly, its direction of flow changes several times, reducing the temperature, causing contaminants to condense and drop to the bottom or sump of the air dryer end cover.

After exiting the end cover, the air flows into the desiccant cartridge. Once in the desiccant cartridge air first flows through an oil separator which removes water in liquid form as well as oil and solid contaminants.

Air exits the oil separator and enters the desiccant drying bed. Air flowing through the column of desiccant becomes progressively dryer as water vapor adheres to the desiccant material in a process known as *"adsorption"*. The desiccant cartridge using the adsorption process typically removes 95% of the water vapor from the pressurized air.

The majority of dry air exits the desiccant cartridge through its integral single check valve to fill the purge volume between the desiccant cartridge and outer shell. Some air will also exit the desiccant cartridge through the purge orifice adjacent to the check valve.

Dry air flows out of the purge volume through the single check valve assembly and out the delivery port to the first (supply) reservoir of the air system.

The air dryer will remain in the charge cycle until air brake system pressure builds to the governor cutout setting.

PURGE CYCLE (refer to Figure 3)

When air brake system pressure reaches the cutout setting of the governor, the compressor unloads (air compression stopped) and the purge cycle of the air dryer begins. When the governor unloads the compressor, it pressurizes the compressor unloader mechanism and line connecting the

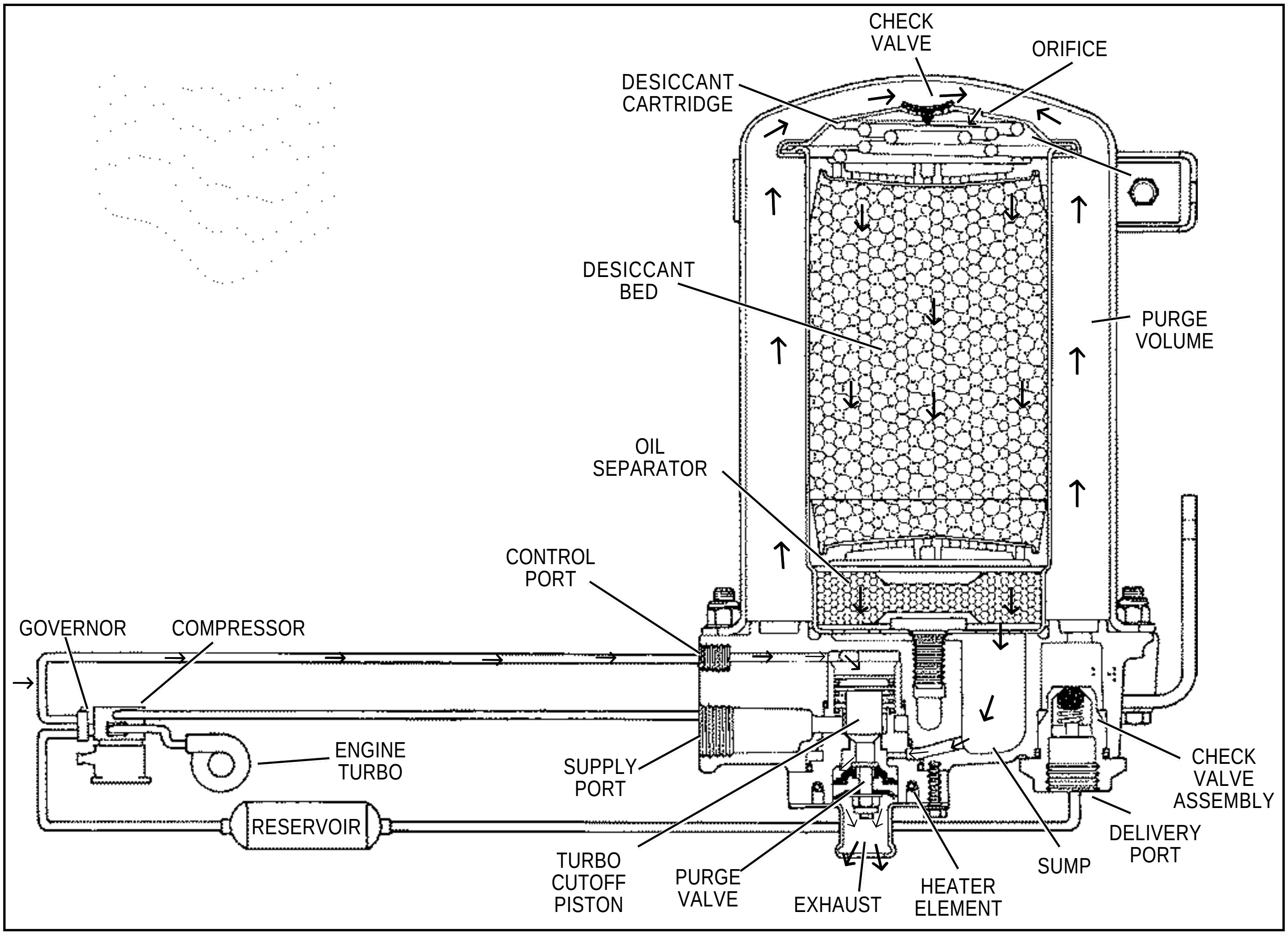


*FIGURE 3 - **AD-9™ AIR DRYER PURGE CYCLE***

governor unloader port to the AD-9™ air dryer end cover control port. The purge piston moves in response to air pressure causing the purge valve to open to atmosphere and (partially) closing off the supply of air from the compressor, this will be further discussed in the section covering the turbo cut-off feature. Contaminants in the end cover sump are expelled immediately when the purge valve opens. Also, air which was flowing through the desiccant cartridge changes direction and begins to flow toward the open purge valve. Oil and solid contaminants collected by the oil separator are removed by air flowing from the desiccant drying bed to the open purge valve.

The initial purge and desiccant cartridge decompression lasts only a few seconds and is evidenced by an audible burst of air at the AD-9™ air dryer exhaust.

The actual reactivation of the desiccant drying bed begins as dry air flows from the purge volume through the desiccant cartridge purge orifice and into the desiccant drying bed. Pressurized air from the purge volume expands after passing through the purge orifice; its pressure is lowered and its volume increased. The flow of dry air through the drying bed reactivates the desiccant material by removing the water vapor adhering to it. Generally 15-30 seconds are required for the entire purge volume of a standard AD-9™ air dryer to flow through the desiccant drying bed.

The end cover single check valve assembly prevents air pressure in the brake system from returning to the air dryer during the purge cycle. After the 30 second purge cycle is complete, the air dryer is ready for the next charge cycle to begin.

The purge valve will remain open after the purge cycle is complete and will not close until air brake system pressure is reduced and the governor signals the compressor to charge.

TURBO CUT-OFF FEATURE (Refer to Figure 4)

The primary function of the turbo cut-off valve is to prevent loss of engine turbocharger air pressure through the AD-9™ air dryer in systems where the compressor intake is connected to the engine turbocharger. The turbo cut-off valve also reduces the “puffing” of air out the open exhaust when a naturally aspirated, single cylinder compressor equipped with an inlet check valve is in use.

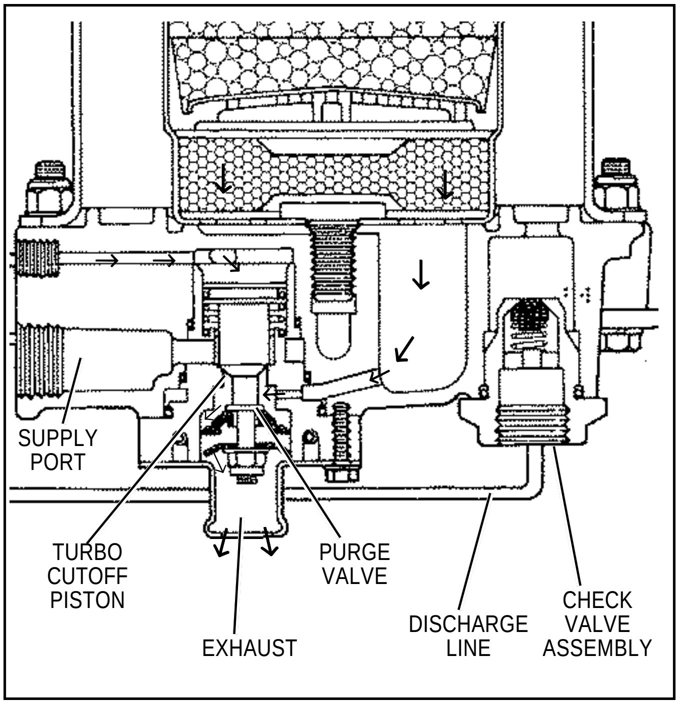


*FIGURE 4 - **AD-9™ AIR DRYER TURBO CUTOFF***

At the onset of the purge cycle, the downward travel of the purge piston is stopped when the turbo cut-off valve (tapered portion of purge piston) contacts its mating metal seat in the purge valve housing. With the turbo cut-off valve seated (closed position), air in the discharge line and AD-9™ air dryer inlet port is restricted from entering the air dryer. While the turbo cut-off effectively prevents loss of turbo charger boost pressure to the engine, some "seepage" of air may be detected under certain conditions of compressor engine and turbo charger operation, even so there will always be low pressure trapped in the discharge line.

PREVENTIVE MAINTENANCE

Important: Review the warranty policy before performing any intrusive maintenance procedures. An extended warranty may be voided if intrusive maintenance is performed during this period.

Because no two vehicles operate under identical conditions, maintenance and maintenance intervals will vary. Experience is a valuable guide in determining the best maintenance interval for any one particular operation.

Every 900 operating hours or 25,000 miles or every three (3) months:

1. Check for moisture in the air brake system by opening reservoirs, drain cocks, or valves and checking for presence of water. If moisture is present, the desiccant may require replacement; however, the following conditions can also cause water accumulation and should be considered before replacing the desiccant:
   - A. An outside air source has been used to charge the system. This air did not pass through the drying bed.

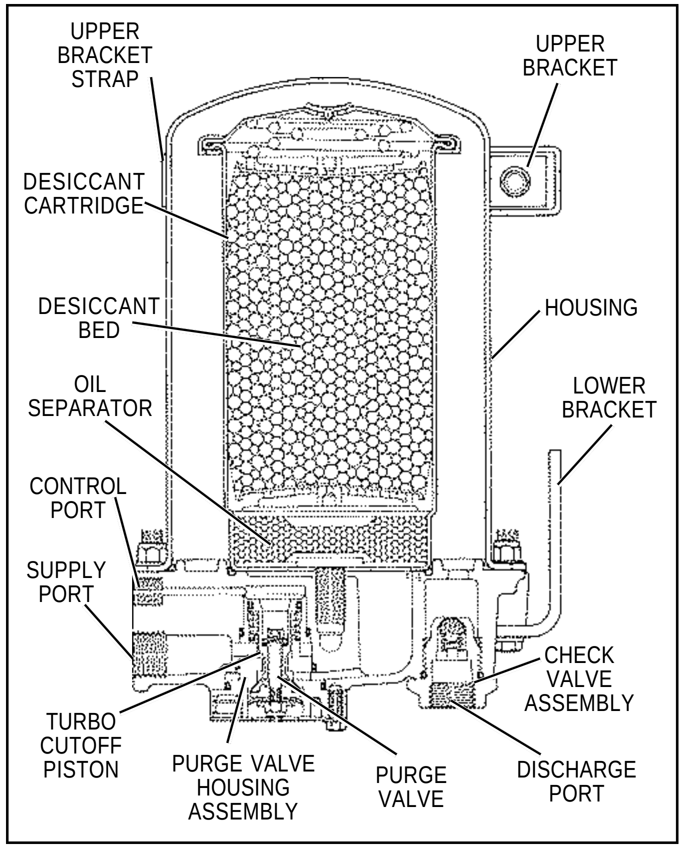


*FIGURE 5 - **AD-9™ AIR DRYER SECTIONAL VIEW***

   - B. Air usage is exceptionally high and not normal for a highway vehicle. This may be due to accessory air demands or some unusual air requirement that does not allow the compressor to load and unload (compressing and non-compressing cycle) in a normal fashion. Check for high air system leakage. If the vehicle vocation has changed it may be necessary to upgrade the compressor size. Refer to Appendix A, Table A and the column entitled Vehicle Vocation.
   - C. The air dryer has been installed in a system that has been previously used without an air dryer. This type system will be saturated with moisture and several weeks of operation may be required to dry it out.
   - D. Location of the air dryer is too close to the air compressor. Refer to *Locating AD-9™ Air Dryer On Vehicle* section and Appendix A, Table A, column 2 for discharge line length.
   - E. In areas where more than a 30 degree range of temperature occurs in one day, small amounts of water can accumulate in the air brake system due to condensation. Under these conditions, the presence of small amounts of moisture is normal and should not be considered as an indication that the dryer is not performing properly.

Note: A small amount of oil in the system may be normal and should not, in itself, be considered a reason to replace the desiccant; oil stained desiccant can function adequately.

2. Check mounting bolts for tightness. Retorque to 270-385 inch pounds.
3. Perform the *Operation & Leakage Tests* listed in this publication.

Every 10,800 hours; 300,000 miles or 36 months:

1. Rebuild the air dryer including the desiccant cartridge.

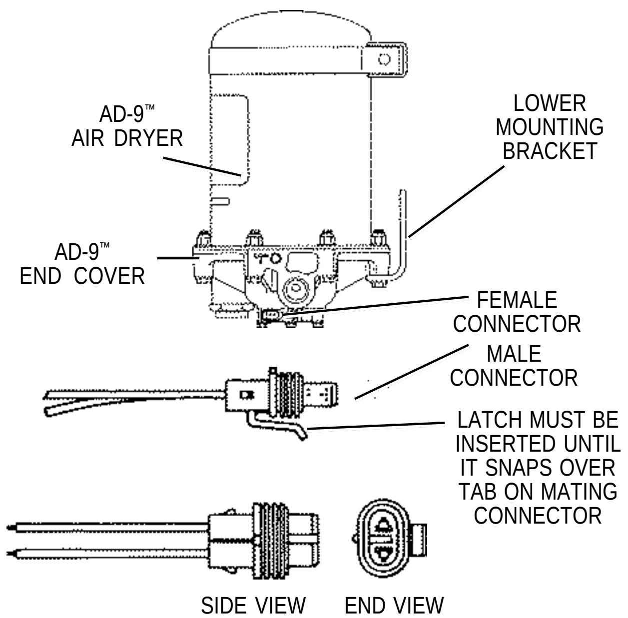
Note: The desiccant change interval may vary from vehicle to vehicle. Although typical desiccant cartridge life is three years, many will perform adequately for a longer period of time. In order to take maximum advantage of desiccant life and assure that replacement occurs only when necessary, it is important that *Operation & Leakage Tests* be performed.

WARNING!

This air dryer is intended to remove moisture and other contaminants normally found in the air brake system. Do not inject alcohol, anti-freeze, or other de-icing substances into or upstream of the air dryer. Alcohol is removed by the dryer, but reduces the effectiveness of the device to dry air. Use of other substances can damage the air dryer and may void the warranty.

OPERATION & LEAKAGE TESTS

1. Test the outlet port check valve assembly by building the air system to governor cut-out and observing a test air gauge installed in the #1 reservoir. A rapid loss of pressure could indicate a failed outlet port check valve. This can be confirmed by bleeding the system down, removing the check valve assembly from the end cover, subject air pressure to the unit and apply a soap solution to the check valve side. Leakage should not exceed a 1" bubble in 1 second.
2. Check for excessive leakage around the purge valve. With the compressor in loaded mode (compressing air), apply a soap solution to the purge valve housing assembly exhaust port and observe that leakage does not exceed a 1" bubble in 1 second. If the leakage exceeds the maximum specified, service the purge valve housing assembly.
3. Close all reservoir drain cocks. Build up system pressure to governor cut-out and note that AD-9™ air dryer purges with an audible escape of air. "Fan" the service brakes to reduce system air pressure to governor cut-in. Note that the system once again builds to full pressure and is followed by an AD-9™ air dryer purge.
4. Check the operation of the safety valve by pulling the exposed stem while the compressor is loaded (compressing air). There must be an exhaust of air while the stem is held and the valve should reseat when the stem is released.



A two lead, 12 inch, wire harness with attached weather resistant connector is supplied with all retrofit and replacement AD-9™ air dryers. Connect one of the two leads of the wire harness to the engine kill or ignition switch. The remaining lead of the wire harness must be connected to a good vehicle ground. A fuse should be installed in the power carrying wire; install a 10 amp fuse for 12 volt heaters and a 5 amp fuse for a 24 volt heater. Use 14 AWG wire if it is necessary to lengthen the wire harness provided.
Make certain all wire splices are waterproofed.
Tie wrap or support all electrical wire leading to the AD-9™ air dryer.

*FIGURE 6 - **HEATER AND THERMOSTAT CONNECTOR***

5. Check all lines and fittings leading to and from the air dryer for leakage and integrity.
6. Check the operation of the end cover heater and thermostat assembly during cold weather operation as follows:

   A. Electric Power to the Dryer

   With the ignition or engine kill switch in the ON position, check for voltage to the heater and thermostat assembly using a voltmeter or test light. Unplug the electrical connector at the air dryer and place the test leads on each of the pins of the male connector. If there is no voltage, look for a blown fuse, broken wires, or corrosion in the vehicle wiring harness. Check to see if a good ground path exists.

   B. Thermostat and Heater Operation

   Turn off the ignition switch and cool the end cover assembly to below 40 degrees Fahrenheit. Using an ohmmeter, check the resistance between the electrical pins in the female connector. The resistance should be 1.5 to 3.0 ohms for the 12 volt heater assembly and 6.8 to 9.0 ohms for the 24 volt heater assembly. **Note**: *Some early models of the AD-9™ air dryer will have resistance readings of 1.0 to 2.5 ohms for the 12 volt heater assembly and 4.8 to 7.2 ohms for the 24 volt heater assembly. If the resistance is higher than the maximum stated, replace the purge valve housing assembly, which includes the heater and thermostat assembly.*

Warm the end cover assembly to over 90 degrees Fahrenheit and again check the resistance. The resistance should exceed 1000 ohms. If the resistance values obtained are within the stated limits, the thermostat and heater assembly is operating properly. If the resistance values obtained are outside the stated limits, replace the purge valve housing assembly, which includes the heater and thermostat assembly.

REBUILDING THE AD-9™ AIR DRYER

GENERAL

If, after completing the routine operation and leakage tests, it has been determined that one or more components of the air dryer requires replacement or maintenance, refer to the following list to find the appropriate kit(s).

When rebuilding or replacing components of the air dryer use only genuine Bendix parts. For ease in servicing the AD-9™ air dryer desiccant cartridge assembly, it is recommended that the air dryer be removed from the vehicle.

MAINTENANCE KITS AVAILABLE:

500503 Hard Seat Purge Valve Housing Maintenance Kit

5005893 Soft Seat Purge Valve Housing Maintenance Kit

These kits contain the parts necessary to rebuild the air portion of the purge valve housing and do not include the heater and thermostat.

107794 Desiccant Cartridge Replacement Kit

This kit contains the parts necessary to change the desiccant cartridge only.

107796 Remanufactured Desiccant Cartridge Replacement Kit

This kit contains the parts necessary to change the desiccant cartridge only.

107799 End Cover Check Valve Assembly Replacement

3/4 inch thread size.

107800 End Cover Check Valve Assembly Replacement

1/2 inch thread size.

800405 Service New or Remanufactured Exchange Purge Valve Housing Assembly - Soft Seat (w/heater and thermo.) 12 volt system.

5004479 Service New or Remanufactured Exchange Purge Valve Housing Assembly - Hard Seat (w/heater and thermo.) 12 volt system.

5004339 Service New or Remanufactured Exchange Purge Valve Housing Assembly - DLU (w/heater and thermo.) 12 volt system.

5004338 Service New or Remanufactured Exchange Purge Valve Housing Assembly - Soft Seat (w/heater and thermo.) 24 volt system.

5004480 Service New or Remanufactured Exchange Purge Valve Housing Assembly - Hard Seat (w/heater and thermo.) 24 volt system.

5004340 Service New or Remanufactured Exchange Purge Valve Housing Assembly - DLU (w/heater and thermo.) 24 volt system.

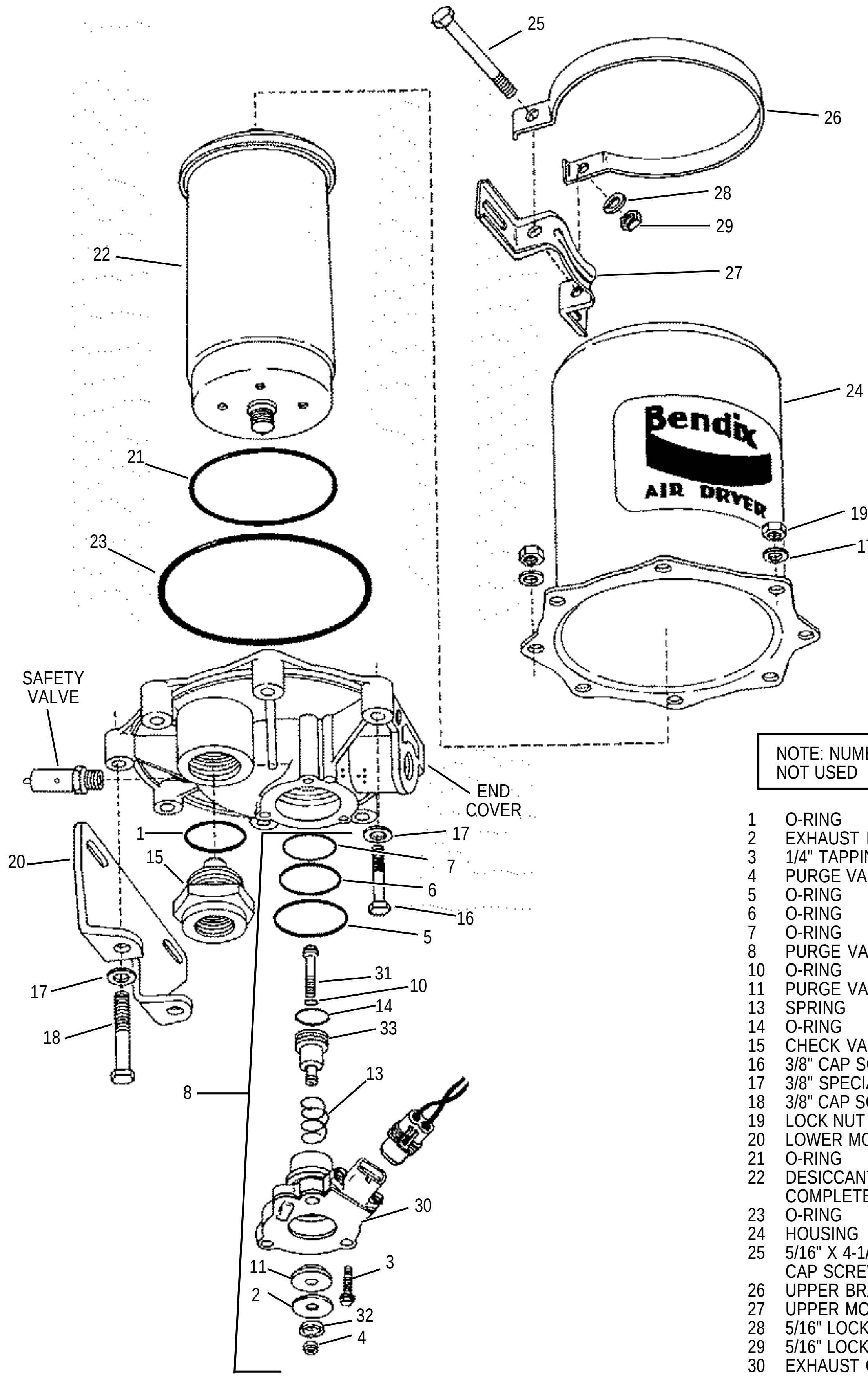
107695 Complete Mounting Bracket Kit

This kit contains the upper and lower brackets as well as the necessary hardware items to mount them.

WARNING! PLEASE READ AND FOLLOW THESE INSTRUCTIONS TO AVOID PERSONAL INJURY OR DEATH:

When working on or around a vehicle, the following general precautions should be observed at all times.

1. **Park the vehicle on a level surface, apply the parking brakes, and always block the wheels. Always wear safety glasses.**
2. **Stop the engine and remove ignition key when working under or around the vehicle. When working in the engine compartment, the engine should be shut off and the ignition key should be removed. Where circumstances require that the engine be in operation, EXTREME CAUTION should be used to prevent personal injury resulting from contact with moving, rotating, leaking, heated or electrically charged components.**
3. **Do not attempt to install, remove, disassemble or assemble a component until you have read and thoroughly understand the recommended procedures. Use only the proper tools and observe all precautions pertaining to use of those tools.**
4. **If the work is being performed on the vehicle's air brake system, or any auxiliary pressurized air systems, make certain to drain the air pressure from all reservoirs before beginning ANY work on the vehicle. If the vehicle is equipped with an AD-IS™ air dryer system or a dryer reservoir module, be sure to drain the purge reservoir.**
5. **Following the vehicle manufacturer's recommended procedures, deactivate the electrical system in a manner that safely removes all electrical power from the vehicle.**
6. **Never exceed manufacturer's recommended pressures.**
7. **Never connect or disconnect a hose or line containing pressure; it may whip. Never remove a component or plug unless you are certain all system pressure has been depleted.**



NOTE: NUMBERS 9 AND 12 NOT USED

1	O-RING
2	EXHAUST DIAPHRAGM
3	1/4" TAPPING SCREW
4	PURGE VALVE LOCK NUT
5	O-RING
6	O-RING
7	O-RING
8	PURGE VALVE ASSEMBLY
10	O-RING
11	PURGE VALVE
13	SPRING
14	O-RING
15	CHECK VALVE ASSEMBLY
16	3/8" CAP SCREW
17	3/8" SPECIAL WASHER
18	3/8" CAP SCREW (LONG)
19	LOCK NUT
20	LOWER MOUNTING BRACKET
21	O-RING
22	DESICCANT CARTRIDGE COMPLETE
23	O-RING
24	HOUSING
25	5/16" X 4-1/2" UPPER BRACKET CAP SCREW
26	UPPER BRACKET STRAP
27	UPPER MOUNTING BRACKET
28	5/16" LOCK WASHER
29	5/16" LOCK NUT
30	EXHAUST COVER
31	TORX HEAD BOLT
32	EXHAUST DIAPHRAGM WASHER
33	PURGE PISTON

*FIGURE 7 - **AD-9™ AIR DRYER ASSEMBLY***

8. **Use only genuine Bendix® replacement parts, components and kits. Replacement hardware, tubing, hose, fittings, etc. must be of equivalent size, type and strength as original equipment and be designed specifically for such applications and systems.**
9. **Components with stripped threads or damaged parts should be replaced rather than repaired. Do not attempt repairs requiring machining or welding unless specifically stated and approved by the vehicle and component manufacturer.**
10. **Prior to returning the vehicle to service, make certain all components and systems are restored to their proper operating condition.**
11. **For vehicles with Antilock Traction Control (ATC), the ATC function must be disabled (ATC indicator lamp should be ON) prior to performing any vehicle maintenance where one or more wheels on a drive axle are lifted off the ground and moving.**

AD-9™ AIR DRYER REMOVAL

1. Park the vehicle on a level surface and prevent movement by means other than the brakes.
2. Drain all reservoirs to 0 p.s.i. (0 kPa).— Caution: Compressor discharge line may still contain residual pressure.
3. Identify and disconnect the three air lines from the end cover and note the position of end cover ports relative to the vehicle.
4. Unplug the vehicle wiring harness from the heater and thermostat assembly connector on the purge valve housing assembly.
5. Loosen the 5/16" X 4-1/2" hex bolt securing the upper mounting strap.
6. Remove, retain and mark the two 3/8" end cover cap screws, lock nuts and four special washers that retain the lower mounting bracket to the end cover, also mark these two holes of the end cover. (These bolts are longer than the other 6 bolts.)
7. Remove the AD-9™ air dryer from its mounting brackets on the vehicle.

DISASSEMBLY

The following disassembly and assembly procedure is presented for reference purposes and presupposes that a major rebuild of the AD-9™ air dryer is being undertaken. Several replacement parts and maintenance kits are available which do not require full disassembly. The instructions provided with these parts and kits should be followed in lieu of the instructions presented here. Refer to Figure 7 during disassembly.

Caution: While performing service on the AD-9™ air dryer, it is <u>not</u> recommended that a clamping device (vise, C-clamp, etc.) be used to hold any die cast aluminum component as damage may result. To hold the end cover, install a pipe nipple in the supply port and clamp the nipple into a vise.

1. Using an adjustable wrench or an 1-3/4" socket, remove the delivery, check valve assembly (15) and o-ring. Remove the o-ring from the check valve assembly.
2. Remove the three 1/4" self tapping screws (3) that secure the purge valve housing assembly to the end cover assembly. Pull the purge valve housing assembly out of the end cover assembly. Remove the three o-rings (5,6 & 7) from the exterior of the purge valve housing assembly. **Note:** O-rings 5 and 6 may be lodged in the end cover bores, if so, they must be removed
3. Purge Valve Disassembly:

   Note: In most cases a flat (non-extended) exhaust cover (30) is used. This cover should be left intact while servicing the purge valve housing assembly. However, if an extended type exhaust cover is in use to accommodate the attachment of an exhaust hose, the exhaust cover must be carefully peeled off the purge valve housing. **Use a thin flat blade to pry the exhaust cover off, taking care not to damage the potting material (RTV sealant) under the cover.** To remove the piston from the purge valve housing assembly requires a special Torx head socket or a twelve point 1/4" socket to hold the head of the purge valve bolt (31).

   A. Remove the 1/4" nut (4) from the bottom of the purge valve housing assembly using a 9/16" socket wrench and a Torx head socket to hold the head of the bolt (31). Remove the diaphragm washer (32) (if present), and the diaphragm (2) (if present), and the purge valve (11) from the purge valve housing.

   B. Remove the 1/4" Torx head bolt (31) from the opposite end, then the purge piston (33), the return spring (13) and two o-rings (10 & 14); one on the O.D. and the other in the inside of the purge piston.

   C. Heater and Thermostat Assembly Replacement.

   Caution: Do not attempt to remove this assembly, as it will be damaged during the removal process and is **not available as a service part**. If the heater and thermostat are defective, replace the entire purge valve housing assembly which includes these items.
4. Remove the remaining six 3/8" cap screws (16), lock nuts (19) and twelve special washers (17) that secure the end cover to the housing (24). Separate the end cover and desiccant cartridge (22) from the housing (24).
5. Remove the end cover to outer housing o-ring (23).
6. Do not remove the safety valve from the end cover unless it has been proven defective. If replacement is required, apply thread sealant or teflon tape on the threads of the replacement valve and torque to 120-400 in. lbs.
7. Place a strap or chain wrench around the desiccant cartridge (22) so that it is approximately 2-3 inches away from the end cover. Rotate the cartridge counterclockwise until it completely separates from the end cover. **Note:** *A substantial torque (up to 50 lb. ft.) may be required to perform this disassembly.*

8. Remove the desiccant cartridge o-ring (21) from the end cover.

CLEANING & INSPECTION

1. Using mineral spirits or an equivalent solvent, clean and thoroughly dry all metal parts.
2. Inspect the interior and exterior of all metal parts that will be reused for severe corrosion, pitting and cracks. Superficial corrosion and or pitting on the exterior portion of the upper and lower body halves is acceptable.
3. Inspect the bores of both the end cover and the purge valve housing for deep scuffing or gouges.
4. Make certain that all purge valve housing and end cover passages are open and free of obstructions.
5. Inspect the pipe threads in the end cover. Make certain they are clean and free of thread sealant.
6. Inspect the purge valve housing bore and seats for excessive wear and scuffing.
7. Inspect the purge valve piston seat for excessive wear.
8. Inspect all air line fittings for corrosion. Clean all old thread sealant from the pipe threads.
9. All o-rings removed should be discarded and replaced with new o-rings provided in appropriate kit(s).

Any component exhibiting a condition described in step 1 to 8 should be replaced.

ASSEMBLY

Prior to assembly, coat all o-rings, o-ring grooves, and bores with a generous amount of barium base lubricant. Refer to Figure 7 during assembly unless otherwise advised.

1. Purge Valve Housing Assembly
   A. Install the o-ring (14) in its groove on the O.D. of the purge piston. Place the return spring (13) in the bore of the purge valve housing. Place the o-ring (10) into its recess in the bore of the purge piston. Install the 1/4" Torx head bolt (31) into the I.D. of the purge piston. Insert the purge piston (33) into the I.D. of the spring (13). Using a Torx head wrench, push the purge piston into the piston housing until it bottoms.
   B. While depressing the purge piston with the Torx head wrench, install the following parts over the purge valve bolt (31) from the opposite end of the purge valve housing; the purge valve (11) with its rubber side first, followed by the diaphragm (2) (if present), the diaphragm washer (32) (if present) or the flat washer and finally the 1/4" hex nut (4). Torque the purge valve nut and bolt (4 & 31) to between 60-80 in. lbs.
   C. Install the three o-rings (5, 6 & 7) on the purge valve housing placing each in its appropriate location. If the exhaust cover (30) was removed during disassembly, install it on the purge valve housing assembly making certain the "bubble" portion is positioned over the thermostat. Install the assembled purge valve housing in the end cover making certain to orient both parts such that the connector is approximately 10 degrees clockwise from the supply port, while making certain the purge valve housing is fully seated against the end cover. Secure the purge valve housing to the end cover using the three 1/4" self-tapping screws (3). Start all three screws by hand then torque to 50-80 in. lbs.
2. Install the o-ring on the check valve assembly (15), then install the assembly in the end cover.
3. Install the desiccant cartridge o-ring (21) in its groove in the end cover. Using a light coat of barium grease, lubricate the bottom of the desiccant cartridge in the area that will contact the o-ring (21) and end cover. Screw the desiccant cartridge into the end cover until contact is made between it and the o-ring. Using a strap or chain wrench positioned 2-3" from the bottom of the cartridge, turn the desiccant cartridge clockwise 180-225 degrees beyond the position where initial contact was made between the cartridge and end cover o-ring. Torque should not exceed 50 ft. lbs.

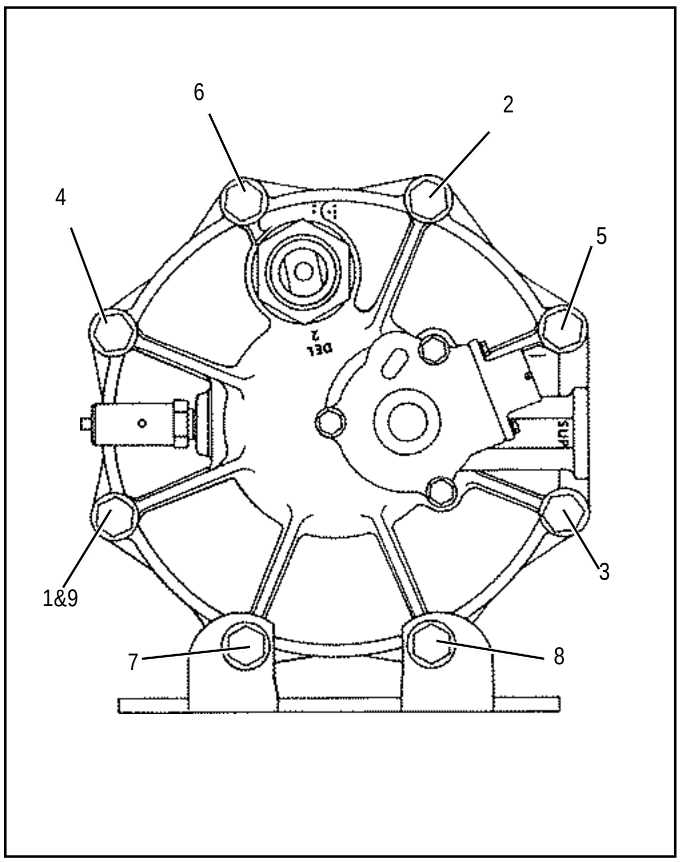


*FIGURE 8 - **END COVER TO HOUSING TORQUE PATTERN***

4. Install the end cover outer housing o-ring (23) on the shoulder in the end cover. Place the housing (24) over the desiccant cartridge and align the holes. Install the six 3/8" cap screws (16), lock nuts (19) and twelve special washers (17) making certain they are in the proper position as marked during disassembly. The two longer 3/8" cap screws (18) will be used to secure the AD-9™ air dryer to its mounting bracket. Tighten the six cap screws and nuts in a star pattern in a fashion similar to Figure 8; depending on lower bracket location. Torque to 270-385 in. lbs. (Refer to Fig. 8.) **Note:** The two remaining bolt holes in the end cover and two 3/8" cap screws must be the ones marked during disassembly to assure proper orientation of the ports and adequate length of the cap screws.

INSTALLATION

1. Install the assembled AD-9™ air dryer back onto the vehicle by slipping it into the upper mounting bracket. Align the two unused holes in the end cover with the bottom mounting bracket such that the bottom bracket supports air dryer. The AD-9™ air dryer end cover should rest on the bracket. Using the remaining two 3/8" cap screws (18), four special washers (17), and two lock nuts (19), secure the air dryer to the lower bracket. Tighten, then torque the two remaining cap screws to 270-385 in. lbs.
2. Tighten the 5/16" X 4-1/2" bolt and nut on the upper mounting bracket. Torque to 80-120 in. lbs.
3. Reconnect the three airlines to the proper ports on the end cover (identified during disassembly).
4. Reconnect the vehicle wiring harness to the AD-9™ air dryer heater and thermostat assembly connector by plugging it into the air dryer connector until its lock tab snaps in place.
5. Before placing vehicle back into service, perform the *Operation and Leakage Tests* stated elsewhere in this manual.

RETROFITTING THE AD-9™ AIR DRYER

GENERAL

The following retrofit instructions are presented for reference purposes only since Bendix aftermarket retrofit and replacement air dryers are packaged with the most up-to-date installation instructions. The instructions packaged with the AD-9™ air dryer should be followed in lieu of those presented here.

The preceding portion of this manual deals with “in-service” repair and or replacement of the AD-9™ air dryer. The portion of the manual that follows is concerned with installing an AD-9™ air dryer on a vehicle not previously equipped with one.

VEHICLE APPLICATION REQUIREMENTS

The basic application requirements presented here apply to a standard air dryer installation. The majority of highway vehicles in use today will meet these basic requirements however, some may not. Examples of vehicles that may not meet the requirements include, bulk trailer unloading operations and other high air consumption/continuous flow systems. While the AD-9™ air dryer can be used on these vehicles the standard installation procedure presented in this manual may require modification to assure proper operation and service life. Consult your local authorized Bendix parts outlet or sales representative for additional information.

1. Charge Cycle Time - The AD-9™ air dryer is designed to provide clean, dry air for the brake system. When a vehicle’s air system is used to operate non-brake air accessories it is necessary to determine that during normal, daily operation the compressor should recover from governor “cut-in” to governor “cut-out” (usually 100 psi to 120 psi) in 90 seconds or less at engine RPMs commensurate with the vehicle vocation. If the recovery time consistently exceeds this limit, it may be necessary to “bypass” the air accessory responsible for the high air usage. Consult your local authorized Bendix parts outlet or sales representative for additional information.
2. Purge Cycle Time - During normal vehicle operation, the air compressor **must remain unloaded for a minimum of 20 seconds for the standard AD-9™ air dryer or 30 seconds for the Extended Purge model.** These minimum purge times are required to ensure complete regeneration of the desiccant material. If the purge time is occasionally shorter than the times specified, no permanent ill effect should be expected, however, if the purge time is consistently less than the minimum, an accessory by-pass system must be installed.
3. European Air Brake Systems - Brake systems that incorporate compressors without integral unloading mechanisms and/or utilize a compressor discharge line unloader valve have special AD-9™ air dryer installation requirements. Consult your local authorized Bendix parts outlet or sales representative for additional information.
4. Air Compressor Size - Although the AD-9™ air dryer can be used in conjunction with larger compressors, it was designed primarily for units rated for up to 17 CFM. It is recommended that when using the AD-9™ air dryer with a compressor which has a rated displacement exceeding 17 CFM that an authorized Bendix parts outlet or Bendix marketing representative be contacted for assistance.
5. Holset “E or QE” Type Air Compressors - In order for the AD-9™ air dryer to function properly when installed with the Holset Type “E or QE” compressor, several specialized Holset components are required. Consult

your local authorized Holset parts outlet or sales representative for additional information.

6. Use of Standard or Extended Purge AD-9™ Air Dryer - Use the following guidelines:

Total Vehicle Reservoir Volume	Requirement
Less than 9,000 cu. in.	Standard AD-9™ Air Dryer
9,000 - 12,500 cu. in.	Extended Purge AD-9™ Air Dryer
Greater than 12,500 cu. in.	Contact Bendix Rep. or Bendix Engineering

VEHICLE PREPARATION

1. Park the vehicle on a level surface and prevent movement by means other than the brakes.
2. Drain all reservoirs to 0 p.s.i. (0 kPa).

LOCATING AD-9™ AIR DRYER ON VEHICLE

1. The AD-9™ air dryer must be mounted vertically (purge exhaust toward road surface) outside the engine compartment in an area of air flow while the vehicle is in motion. The AD-9™ air dryer must not be exposed to direct wheel splash (located behind axle mud flap is acceptable).
2. Locate the AD-9™ air dryer as close to the first (supply) reservoir as possible.
3. Do not locate the AD-9™ air dryer near heat producing components such as the vehicle exhaust and make certain adequate clearance from moving components (e.g. drive shaft, suspension, pitman arm, etc.) is provided.

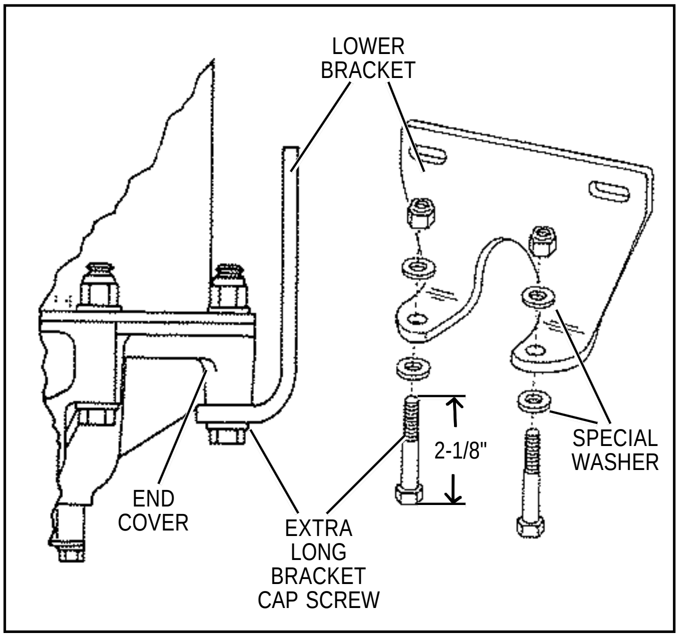


*FIGURE 9 - **LOWER BRACKET INSTALLATION***

4. Locate the AD-9™ air dryer on vehicle so that a minimum of 11 inches (28 CM) clearance below the end cover is available to allow servicing. Alternatively, provide access to the bracket bolts so the unit may be removed for servicing.
5. When choosing the mounting location for the AD-9™ air dryer, note the discharge line length requirements stated under the heading *Connecting the Air Lines*, elsewhere in this instruction sheet.

   Important Note: Under normal operating conditions, the maximum inlet air temperature for the AD-9™ air dryer is 160 degrees Fahrenheit.

MOUNTING THE AD-9™ AIR DRYER

1. To install the lower mounting bracket on the AD-9™ air dryer, it will be necessary to remove and discard two of the end cover bolts and lock nuts. To determine which end cover bolts to utilize to attach the lower bracket, take into consideration the piping connections required to install the AD-9™ air dryer and use those that will best position the unit for ease of installation. Locate the bracket such that it cradles the end cover as shown in Figure 2. Utilizing the two 2-3/8" long cap screws, lock nuts and special washers provided with the AD-9™ air dryer retrofit unit, attach the lower mounting bracket and torque to 270-385 in. lbs.
2. Assemble the mounting strap and upper mounting bracket as illustrated in Figure 4, by utilizing the 5/16" cap screw, 5/16" lockwasher and 5/16" nut provided.
3. Place the upper bracket assembly onto the shell of the AD-9™ air dryer and orient it so that it bears entirely on the cylindrical surface and does not extend onto the domed top. The slot spacing between the upper and lower bracket should be a minimum of 5.5 inches apart. Do not tighten strap onto the shell at this time.

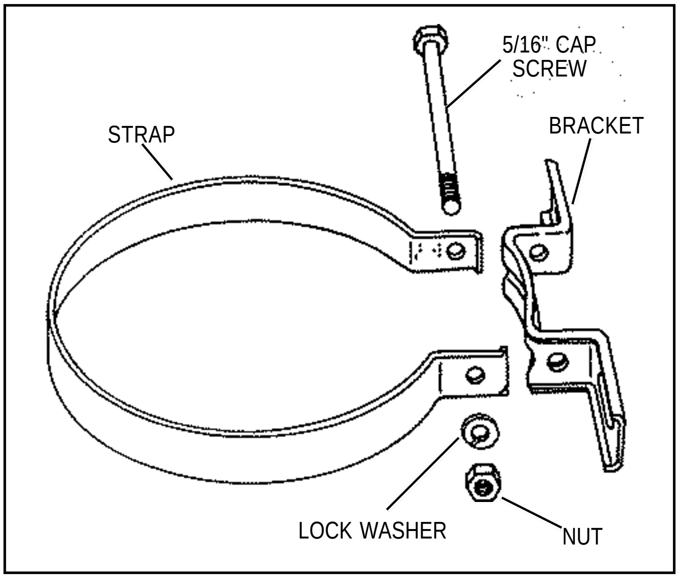


*FIGURE 10 - **UPPER MOUNTING BRACKET AND STRAP***

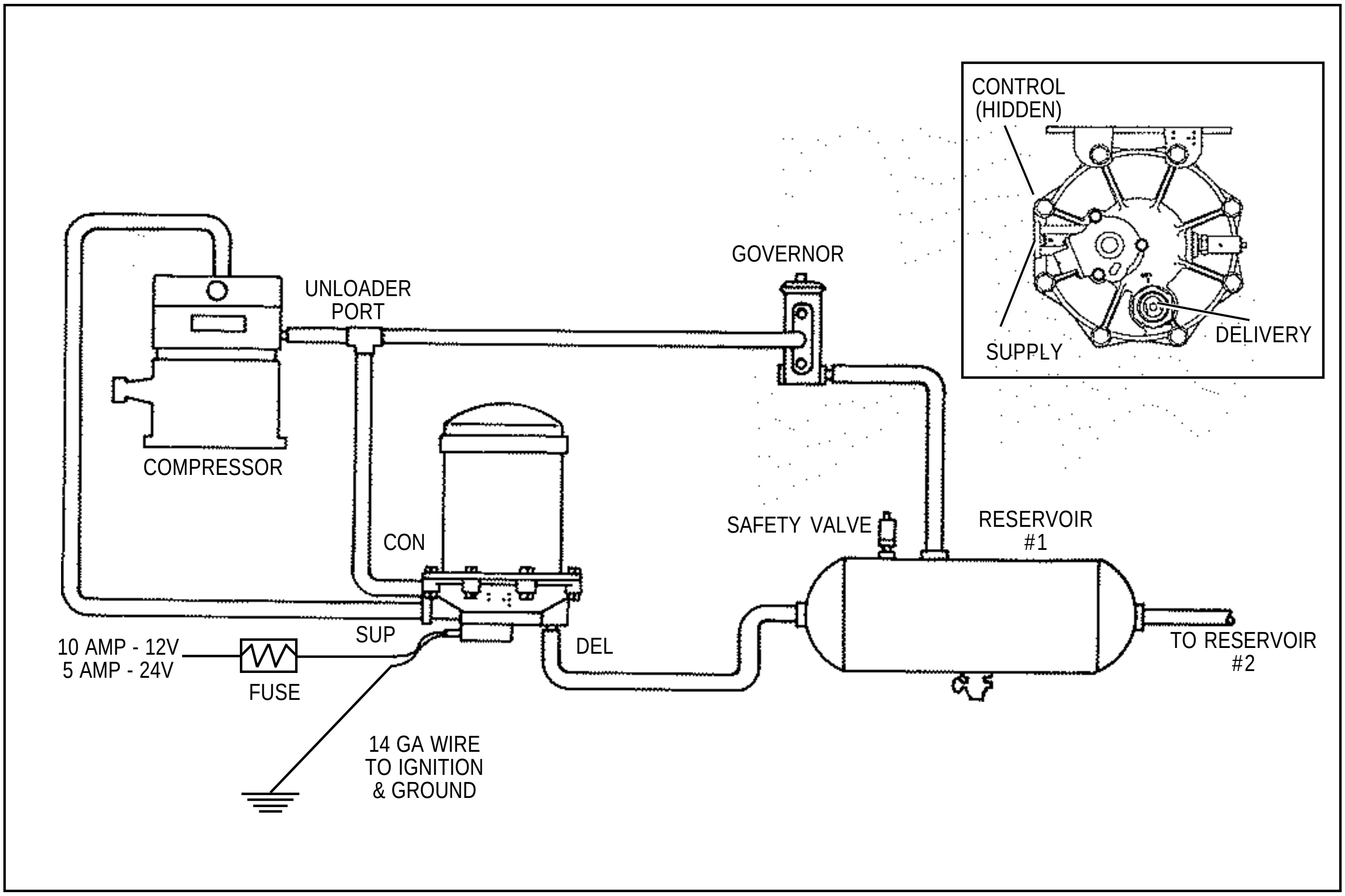


*FIGURE 2 - **AD-9™ AIR DRYER CHARGE CYCLE***

4. A universal mounting plate (Pc. No. 248478) is available to facilitate the mounting of the AD-9™ air dryer to the vehicle. It can be obtained through an authorized Bendix parts outlet.
5. Mount the AD-9™ air dryer on the vehicle using 3/8" bolts (grade 5 min.) and washers. Torque to 25 ft. Ibs. (300 inch pounds.) After positioning and mounting the upper bracket assembly according to the installation requirements, torque the 5/16" nut to 80120 in. Ibs. to tighten strap onto the shell.

CONNECTING THE AIR LINES

PURGE CONTROL LINE

1. Install a purge control air line having a minimum inside diameter of 3/16 inches between the AD-9™ air dryer end cover control port and an unused unloader port on the governor. The control line must be plumbed direct to the governor and not in series with automatic drain valves, lubrication systems, etc.
2. The control line should slope downward to the end cover without forming potential water traps.

DISCHARGE LINE

General:

Refer to Appendix A, Table A for recommended discharge line lengths and sizes for various vehicle applications and vocations.

PURGE EXHAUST LINE

1. If it is necessary to direct AD-9™ air dryer discharge contaminants away from vehicle components it may be necessary to purchase a special exhaust cover for the AD-9™ air dryer (Pc. No. 5003838) to replace the standard exhaust cover furnished with the unit. A 1" (25.4 mm) I.D. hose can be clamped on the special AD-9™ air dryer exhaust cover.

WIRING THE HEATER/THERMOSTAT

1. Determine the vehicle's electrical system voltage and make certain that the AD-9™ air dryer that is to be installed contains the same voltage heater. Use the AD-9™ air dryer part number to confirm the proper voltage. The AD-9™ air dryer is available with either a 12 or 24 volt heater which uses 75 watts of power.

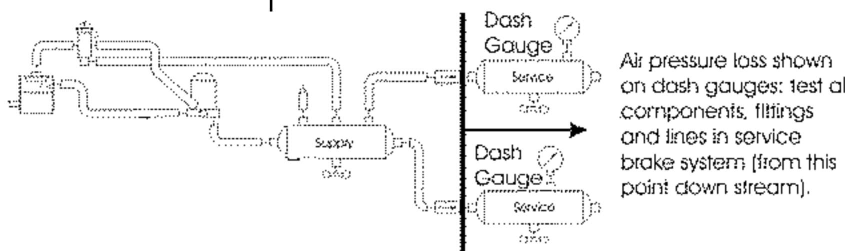
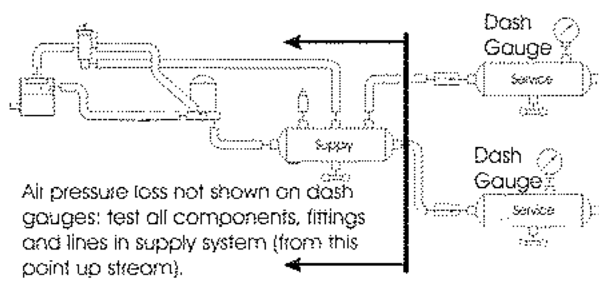
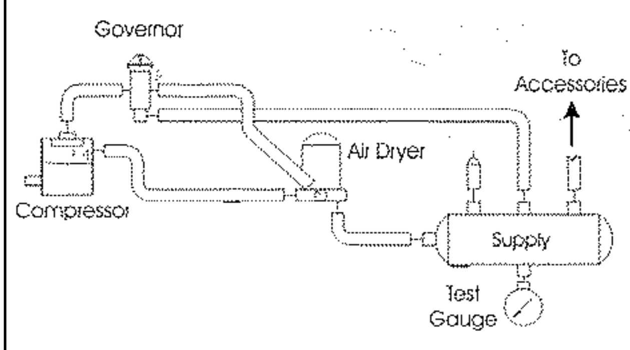
2. A two lead, 12 inch, wire harness with attached weather resistant connector is supplied with all retrofit and replacement AD-9™ air dryers. Connect one of the two leads of the wire harness to the engine kill or ignition switch. The remaining lead of the wire harness must be connected to a good vehicle ground (not to the air dryer or its mounting bracket). A fuse should be installed in the power carrying wire; install a 10 amp fuse for 12 volt heaters and a 5 amp fuse for a 24 volt heater.
3. Use 14 GA wire if it is necessary to lengthen the wire harness provided with the AD-9™ air dryer. Make certain all wire splices are waterproofed.
4. Tie wrap or support all electrical wire leading to the AD-9™ air dryer at 6 - 8 inch intervals. **Note:** Wires should have sufficient slack and not completely taught.

TESTING THE AD-9™ AIR DRYER

Before placing the vehicle in service, perform the following tests:

1. Close all reservoir drain cocks.
2. Build up system pressure to governor cut-out and note that the AD-9™ air dryer purges with an audible escape of air.
3. "Fan" the service brakes to reduce system air pressure to governor cut-in. Note that the system once again builds to full pressure and is followed by a purge at the AD-9™ air dryer exhaust.
4. It is recommended that the following items be tested for leakage to assure that the AD-9™ air dryer will not cycle excessively.
   (A) Total air system leakage (See Bendix publication BW-5057 "Air Brake Handbook").
   (B) Compressor unloader mechanism.
   (C) Governor.
   (D) Drain cock and safety valve in first (supply) reservoir.
   (E) All air connections leading to and from the first (supply) reservoir.

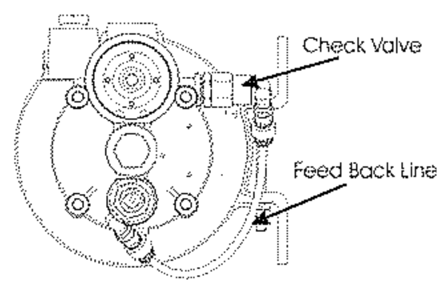
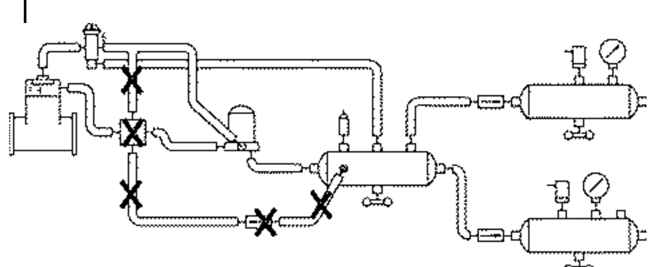
AD-9™ AIR DRYER TROUBLESHOOTING CHART

SYMPTOMS	CAUSE	REMEDY
1. Dryer is constantly "cycling" or purging. Dryer purges frequently (every 4 minutes or less while vehicle is idling).	A. Excessive system leakage. IMPORTANT: Note whether air pressure loss is shown on dash gauge(s). Pressure loss shown on gauges is caused by service brake system or component leakage. Pressure loss NOT SHOWN on gauges is caused by supply system or component leakage.	A. If leakage IS SHOWN on gauges test for excessive service brake system leakage. Allowable leakage: Pre-121 vehicles, single vehicles - 2 psi/ minute. Tractor trailer - 3 psi/minute. 121 vehicles, single vehicle - 1 psi/minute per service reservoir. Tractor trailer - 3 psi/minute per service reservoir. Repair and retest as required.  If <ins>leakage is NOT SHOWN on gauges</ins> test for excessive supply system leakage.  Remove drain cock or valve in supply reservoir (wet tank) and install air gauge. Build system pressure, allow air dryer to purge and observe air gauge in supply reservoir. Pressure drop should not exceed 1 psi per minute. Perform tests 1 to 6 in the order presented. 

AD-9™ AIR DRYER TROUBLESHOOTING CHART

SYMPTOMS	CAUSE	REMEDY
		1. **Test fittings, hoses, lines and connections.** Apply soap solution to detect excessive leakage. Tighten or replace as needed then repeat the air dryer charge-purge cycle and observe the gauge installed in the supply reservoir. If leakage is within limits remove gauge from reservoir and replace drain cock or valve. If excessive leakage is detected, continue testing. 2. **Test accessories connected to supply reservoir.** Drain all air pressure from system, disconnect all air lines leading to accessories (fan clutch, wipers, air seats, etc.) and plug the reservoir at disconnection point. Build air system pressure until air dryer purges and observe supply reservoir gauge. If leakage is no longer excessive, repair or replace leaking accessory. If excessive leakage is detected, continue testing. 3. **Test governor leakage.** Build system pressure to governor cut-out turn off engine and apply soap solution to governor exhaust port and around cap.). Leakage should not exceed a 1" bubble in 5 seconds. Reduce system pressure to 80 psi or less, and re-apply soap solution. Leakage should not exceed a 1" bubble in 5 seconds. If excessive leakage is detected in either test, repair or replace governor. 4. **Test compressor unloader leakage.** Drain all air pressure from system and remove the governor from the compressor. Temporarily plug the governor unloader port or air line that mated with, or connected to, the compressor. Build air system pressure until air dryer purges then IMMEDIATELY SHUT OFF THE ENGINE. Observe the air gauge in the supply reservoir. If leakage is within limits, replace the compressor unloaders. Re-connect the governor to the compressor (after removing plug installed in governor) and retest while observing supply reservoir gauge. If excessive leakage is detected, continue testing. 5. **Test air dryer purge valve and outlet (delivery) check valve.** Drain all air pressure from system, remove the control line connection at the air dryer and plug the end of the air line leading to the governor (not the air dryer control port). Build system pressure to governor cut-out and observe air gauge. If little or no pressure drop is observed replace the air dryer check valve. If pressure drop continues apply soap

AD-9™ AIR DRYER TROUBLESHOOTING CHART

SYMPTOMS	CAUSE	REMEDY
		solution to air dryer purge exhaust and purge control port (where the control line was removed). Leakage should not exceed a 1" bubble in 5 seconds. If leakage is excessive repair or replace purge valve assembly. 6. With gauge installed at RES port of governor, pressure should not drop below “Cut-In” pressure at the onset of the compressor “Unloaded” cycle. If pressure drops, check for “kinks” or restrictions in line connected to RES port. Line connected to RES port on governor must be same diameter, or preferably larger than, lines connected to UNL port(s) on governor.
	B. Leaking purge valve housing assembly and/or o-rings in AD-9™ air dryer end cover.	B. With the supply port open to atmosphere, apply 120 psi at the control port. Apply a soap solution to the supply port and exhaust port (purge valve seat area). Permissible leakage - 1" bubble in 5 seconds.
	C. Holset “E” type compressor.	C. Test the Holset E Compressor unloader system with feedback line and check valve for proper operation. Make certain Holset ECON is not in use with the drop-in version of the air dryer, if so, remove and retest.  Typical Drop-In Air Dryer End Cover When installing a Bendix Drop-In air dryer in a system equipped with a Holset E or QE compressor, remove the Holset ECON valve along with its feed back and governor control line. 

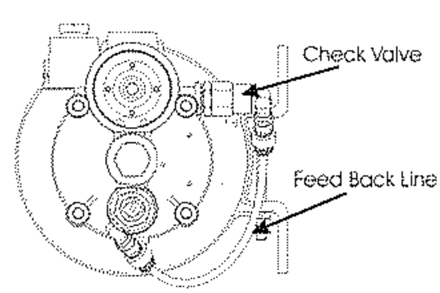
AD-9™ AIR DRYER TROUBLESHOOTING CHART

SYMPTOMS	CAUSE	REMEDY
2. Water in vehicle reservoir.	A. Desiccant requires replacement - excessive contaminants in desiccant cartridge assembly.	A. Replace desiccant cartridge.
	B. Improper discharge line length or improper line material. Maximum air dryer inlet temperature is exceeded.	B. Refer to section entitled "Connecting the Air Lines" as well as Appendix A, Table A columns 1 & 2 then check line size and length.
	C. Air system charged from outside air source (outside air not passing through air dryer).	C. If system must have outside air fill provision, outside air should pass through air dryer. This practice should be minimized.
	D. Air dryer not purging (see Symptom #5).	D. See Symptom #5.
	E. Purge (air exhaust) time insufficient due to excessive system leakage (see causes for Symptom #1).	E. Check causes and remedies for Symptom #1.
	F. Excessive air usage, duty cycle too high - Air dryer not compatible with vehicle air system requirement (Improper air dryer/vehicle application). **NOTE: Duty Cycle** is the ratio of time the compressor spends building air to total engine running time. Air compressors are designed to build air (run "loaded") up to 25% of the time. Higher duty cycles cause conditions that affect air brake charging system performance which may require additional maintenance. Factors that add to the duty cycle are: air suspension, additional air accessories, use of an undersized compressor, frequent stops, excessive leakage from fittings, connections, lines, chambers or valves, etc.	F. See Appendix A, Table A, column 1, for recommended compressor sizes. If the compressor is "too small" for the vehicle vocation (for example, where a vehicle's vocation has changed or service conditions exceed the original vehicle or engine OE spec's) then upgrade the compressor. Note: The costs incurred (e.g. installing a larger capacity compressor, etc.) are not covered under original compressor warranty. Charge Cycle Time - The AD-9™ air dryer is designed to provide clean, dry air for the brake system. When a vehicle's air system is used to operate non-brake air accessories it is necessary to determine that during normal, daily operation the compressor should recover from governor "cut-in" to governor "cut-out" (usually 100 psi to 120 psi) in 90 seconds or less at engine RPM's commensurate with the vehicle vocation. If the recovery time consistently exceeds this limit, it may be necessary to "bypass" the air accessory responsible for the high air usage. An example of where a by-pass system would be required is when the compressor is used to pressurize a tank trailer for purposes of off-loading product. Consult your local authorized Bendix parts outlet or sales representative for additional information.

AD-9™ AIR DRYER TROUBLESHOOTING CHART

SYMPTOMS	CAUSE	REMEDY
		Purge Cycle Time - During normal vehicle operation, the air compressor **must remain unloaded for a minimum of 20 seconds for the standard AD-9™ air dryer or 30 seconds for the Extended Purge Model.** These minimum purge times are required to ensure complete regeneration of the desiccant material. If the purge time is consistently less than the minimum, an accessory by-pass system must be installed. Consult your local authorized Bendix parts outlet or sales representative for additional information. European Air Brake Systems - Brake systems that incorporate compressors without integral unloading mechanisms and/or utilize a compressor discharge line unloader valve have special air dryer installation requirements. Consult your local authorized Bendix parts outlet or sales representative for additional information. Air Compressor Size - Although the AD-9™ air dryer can be used in conjunction with larger compressors, it was designed primarily for units rated for up to 17 CFM. It is recommended that when using the AD-9™ air dryer with a compressor which has a rated displacement exceeding 17 CFM that an authorized Bendix parts outlet or Bendix marketing representative be contacted for assistance.
	G. Air compressor discharge and/or air dryer inlet temperature too high.	G. **Restricted discharge line.** See Appendix A, Table A, column 1 & 2 for recommended sizes. If discharge line is restricted or more than 1/16" carbon build up is found, replace the discharge line. Replace as necessary. **Discharge Line Freeze-Up.** The discharge line must maintain a **constant slope** down from the compressor to the air dryer inlet fitting to avoid low points where ice may form and block the flow. If, instead, ice blockages occur at the air dryer inlet, insulation may be added here, or if the inlet fitting is a typical 90 degree fitting, it may be changed to a straight or 45 degree fitting. For more information on how to help prevent discharge line freeze-ups, see Bendix Bulletins TCH-08-21 and TCH-08-22. Shorter discharge line lengths or insulation may be required in cold climates. **Insufficient coolant flow through compressor.** Inspect coolant line. Replace as necessary (I.D. is 1/2" min.). Inspect the coolant lines for kinks and restrictions and fittings for restrictions. Replace as necessary. Verify coolant lines go from engine block to compressor and back to the water pump. Repair as necessary.

AD-9™ AIR DRYER TROUBLESHOOTING CHART

SYMPTOMS	CAUSE	REMEDY
		Restricted air inlet (not enough air to compressor). Check compressor air inlet line for restrictions, brittleness, soft or sagging hose conditions etc. Repair as necessary. Inlet line size is 3/4 ID. Maximum restriction requirement for compressors is 25 inches of water. Check the engine air filter and service if necessary (if possible, check the air filter usage indicator). **Poorly filtered inlet air (poor air quality to compressor).** Check for leaking, damaged or malfunctioning compressor air inlet components (e.g. induction line, fittings, gaskets, filter bodies, etc.). Repair inlet components as needed. Note: Dirt ingestion will damage compressor and is not covered under warranty. If you found excessive oil present in the service reservoir and you did not find any issues above, the compressor may be passing oil. Replace compressor. If still under warranty, follow normal warranty process.
	H. Compressor malfunction.	H. If you found excessive oil present in the service reservoir and you did not find any issues above, the compressor may be passing oil. Test the compressor using the BASIC cup method as described in the Bendix compressor service manual and referred to in Appendix A, Table A, column 5. Replace compressor. If still under warranty, follow normal warranty process.
	I. Air by-passes desiccant cartridge assembly.	I. If vehicle uses Holset compressor, inspect feedback check valve for proper installation and operation. When replacing the desiccant cartridge, make sure desiccant cartridge assembly is properly installed and sealing rings are in place on mounting surface of desiccant cartridge.  Typical Drop-In Air Dryer End Cover

AD-9™ AIR DRYER TROUBLESHOOTING CHART

SYMPTOMS	CAUSE	REMEDY
	J. Desiccant requires replacement.	J. Replace desiccant cartridge assembly. Refer to Appendix A, Table A columns 3 & 4 for recommended intervals.
3. Oil present at air dryer purge exhaust or cartridge during maintenance.	A. Air brake charging system is functioning normally.	A. Air dryers remove water and oil from the air brake charging system. A small amount of oil is normal. Check that regular maintenance is being performed and that the amount of oil in the air tanks (reservoirs) is within the acceptable range shown on the BASIC cup (see also column 5 of Appendix A, Table A. Replace the air dryer cartridge as needed and return the vehicle to service.
4. Safety valve on air dryer "popping off" or exhausting air.	A. Restriction between air dryer and supply (first) reservoir.	A. Check to determine if air is reaching supply reservoir. Inspect for kinked tubing or hose. Check for undrilled or restricted hose or tubing fittings and repair or replace as needed.
	B. Air dryer safety valve malfunction.	B. Verify relief pressure is at vehicle or component manufacturer specifications. Replace if malfunctioning.
	C. Desiccant cartridge maintenance required.	C. Refer to Appendix A Table A and column 3. Check compressor for excessive oil passing and/or correct compressor installation. Repair or replace as necessary. Replace desiccant cartridge.
	D. Malfunctioning Defective discharge check valve in end cover of the AD-IP™ air dryer.	D. Test to determine if air is passing through check valve. Repair or replace.
	E. Excessive pressure pulsations from compressor. (Typical single cylinder type).	E. Increase volume in discharge line by increasing length or diameter. Add a ping tank (small reservoir).
	F. Governor malfunction. Missing or restricted governor control line installation.	F. Test governor operation and/or inspect the control line leading from the governor UNL (unloader) port to the air dryer control port.
5. Constant exhaust of air at air dryer purge valve exhaust. (Charge mode.)	A. Air dryer purge valve leaking excessively.	A. With compressor loaded, apply soap solution on purge valve exhaust, to test for excessive leakage. Repair purge valve as necessary.
	B. Compressor fails to unload (stop compressing air) and air dryer purge exhaust makes "sputtering" or "popping" sound.	B. Confirm failure to unload by increasing & decreasing engine RPM and noting change in the rate of leakage and intensity of accompanying leakage sound. Repair/replace compressor unloaders.

AD-9™ AIR DRYER TROUBLESHOOTING CHART (Continued)

SYMPTOMS	CAUSE	REMEDY
	C. Purge control line connected to reservoir or exhaust port of governor.	C. Purge control line must be connected to unloader port of governor.
	D. Purge valve frozen open - malfunctioning heater and thermostat, wiring, blown fuse.	D. Test heater and thermostat as described in Preventative Maintenance Section.
	E. Excessive system leakage.	E. See Symptom #1.
	F. Purge valve stays open - supply air leaks to control side.	F. Repair purge valve and housing.
6. Can not build system air pressure.	A. Inlet and outlet air connections reversed.	A. Connect compressor discharge to air dryer supply port. Reconnect lines properly.
	B. Check valve between air dryer and first reservoir.	B. Test check valve for proper operation. Repair or replace as necessary.
	C. Kinked or blocked (plugged) discharge line.	C. Check to determine if air passes through discharge line. Check for kinks, bends, excessive carbon deposits, or ice blockage.
	D. Excessive bends in discharge line (water collects and freezes).	D. Discharge line should be constantly sloping from compressor to air dryer with as few bends as possible.
	E. Refer to Symptom 4, causes E & F.	E. Refer to Symptom #4, Remedies E & F.
7. Air dryer does not purge or exhaust air.	A. Missing, broken, kinked, frozen, plugged or disconnected purge control line.	A. Inspect control line from governor UNL (unloader) port to control port of air dryer. Test to determine air flows through purge control line when compressor unloaded. Check for undrilled fittings. (See Symptom #4, Remedy C.)
	B. Faulty air dryer purge valve.	B. After determining air reaches purge valve (Remedy A above), repair purge valve.
	C. See Causes B, E, G for Symptom #4.	C. See Causes, B, E, G for Symptom #4.
8. Desiccant material being expelled from air dryer purge valve exhaust (may look like whitish liquid or paste or small beads.) - OR - Unsatisfactory desiccant life.	A. This symptom is almost always accompanied by one or more of Symptoms 1, 2, 3, 4 and 5. See related causes for these Symptoms above.	A. See Causes and Remedies for Symptoms 1, 2, 3, 4 and 5.
	B. Air dryer not securely mounted. (Excessive vibration.)	B. Vibration should be held to minimum. Add bracket supports or change air dryer mounting location if necessary.
	C. Malfunctioning or saturated desiccant cartridge.	C. Replace desiccant cartridge assembly.
	D. Compressor passing excessive oil.	D. Check for proper compressor installation; if symptoms persist, replace compressor.

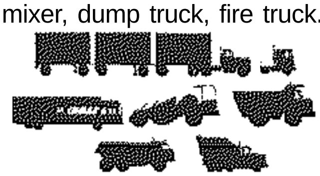
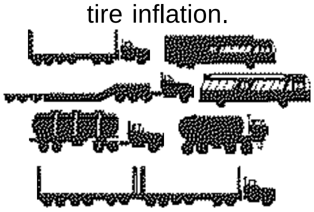
AD-9™ AIR DRYER TROUBLESHOOTING CHART (Continued)

SYMPTOMS	CAUSE	REMEDY
	E. Desiccant cartridge not assembled properly to end cover. (Loose attachment)	E. Check the torque on the desiccant cartridge to end cover attachment. Refer to assembly section of this data sheet.
9. "Pinging" noise excessive during compressor loaded cycle.	A. Defective check valve assembly in AD-IP™ air dryer end cover.	A. Refer to Remedy C, Symptom #1.
	B. Leaking Turbo Cutoff valve.	B. Repair or replace purge valve assembly.
	C. Leaking purge valve control piston o-ring.	C. Repair or replace purge valve assembly.
10. Constant seepage of air at air dryer purge valve exhaust (non-charging mode.)	A. Defective check valve assembly in AD-9™ air dryer end cover.	A. Refer to Remedy C, Symptom #1.
	B. Leaking Turbo Cutoff valve.	B. Repair or replace purge valve assembly.
	C. Leaking purge valve control piston o-ring.	C. Repair or replace purge valve assembly.
11. The air dryer purge piston cycles rapidly in the compressor unloaded (non-compressing) mode.	A. Compressor fails to "unload".	A. Faulty governor installation; no air line from governor to compressor or line is kinked or restricted. Install or repair air line.

Appendix A

Table A: Maintenance Schedule and Usage Guidelines

Regularly scheduled maintenance is the single most important factor in maintaining the air brake charging system.

Vehicle Used for:	**No. of Axles**	Column 1 **Typical Compressors Spec'd**	Column 2 **Discharge Line** **I.D.**	 **Length**	Column 3 **Recom-mended Air Dryer Cartridge Replacement[1]**	Column 4 **Recom-mended Reservoir Drain Schedule[2]**	Column 5 **Acceptable Reservoir Oil Contents[3] at Regular Drain Interval**
Low Air Use							
Compressor with less than 15% duty cycle e.g. Line haul single trailer w/o air suspension, air over hydraulic brakes. 	5 or less	Bendix® BA-921™ air compressor Bendix® Tu-Flo® 550 air compressor	1/2 in. For oil carry-over control[4] suggested upgrades: 5/8 in.	6 ft. 9 ft.	Every 3 Years	Recom-mended Every Month - Max of every 90 days	BASIC test acceptable range: 3 oil units per month. See appendix A.
Compressor with up to 25% duty cycle e.g. Line haul single trailer with air suspension, school bus. 	5 or less	Bendix® BA-921™ air compressor Bendix® Tu-Flo® 550 air compressor	1/2 in. For oil carry-over control[4] suggested upgrades: 5/8 in.	9 ft. 12 ft.			*For the BASIC Test Kit: Order Bendix P/N 5013711*
High Air Use							
Compressor with up to 25% duty cycle e.g. Double/triple trailer, open highway coach/RV, (most) pick-up & delivery, yard or terminal jockey, off-highway, construction, loggers, concrete mixer, dump truck, fire truck. 	8 or less	Bendix® Tu-Flo® 750 air compressor Bendix® BA-921™ air compressor Bendix® Tu-Flo® 550 air compressor Bendix® BA-922™, or DuraFlo™ 596 air compressor	1/2 in. For oil carry-over control[4] suggested upgrades: 5/8 in.	12 ft. 15 ft.	Every 2 Years	Every Month	BASIC test acceptable range: 5 oil units per month. See appendix A.
Compressor with up to 25% duty cycle e.g. City transit bus, refuse, bulk unloaders, low boys, urban region coach, central tire inflation. 	12 or less	Bendix® Tu-Flo® 750 air compressor Bendix® BA-922™, or DuraFlo™ 596 air compressor	5/8 in. For oil carry-over control[4] suggested upgrades: 3/4 in.	12 ft. 15 ft.	Every Year		

Footnotes:

1 With increased air demand the air dryer cartridge needs to be replaced more often.

2 Use the drain valves to slowly drain all reservoirs to zero psi.

3 Allow the oil/water mixture to fully settle before measuring oil quantity.

4 To counter above normal temperatures at the air dryer inlet, (and resultant oil-vapor passing upstream in the air system) replace the discharge line with one of a larger diameter and/or longer length. This helps reduce the air's temperature. If sufficient cooling occurs, the oil-vapor condenses and can be removed by the air dryer. Discharge line upgrades are not covered under warranty. Note: To help prevent discharge line freeze-ups, shorter discharge line lengths or insulation may be required in cold climates. (See Bendix Bulletins TCH-08-21 and TCH-08-22, included in Appendix B, for more information.)

5 For certain vehicles/applications, where turbo-charged inlet air is used, a smaller size compressor may be permissible.

Note: Compressor and/or air dryer upgrades are recommended in cases where duty cycle is greater than the normal range (for the examples above).

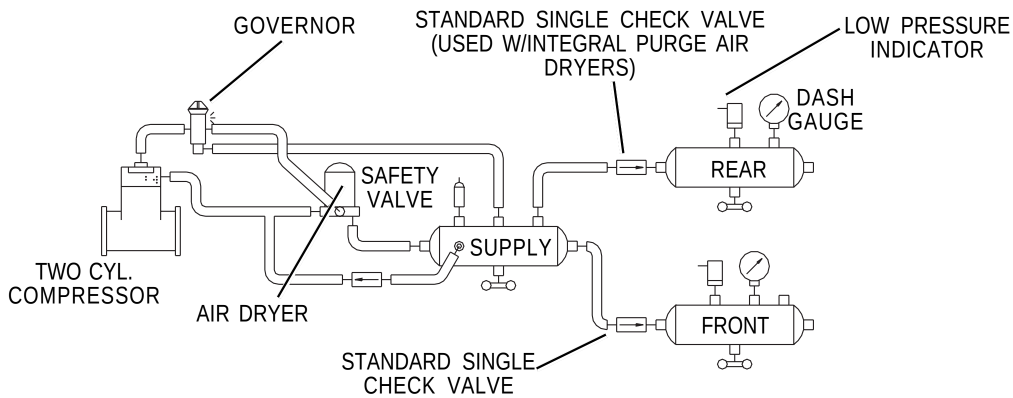
For Bendix® Tu-Flo® 550 and 750 compressors, unloader service is recommended every 250,000 miles.

Appendix B

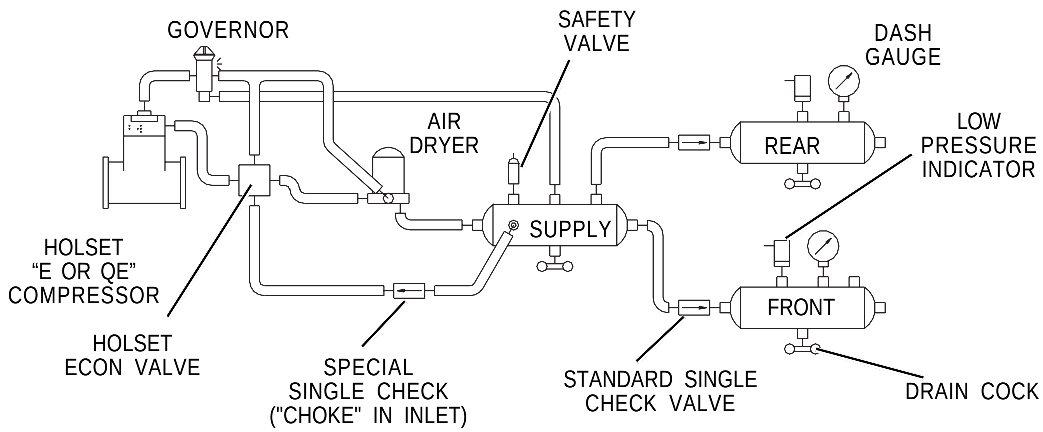
Additional Troubleshooting Information

The troubleshooting procedure presented on the following pages has been excerpted from a laminated card entitled: Troubleshooting Charging and Air Supply Systems. The complete card can be obtained from authorized Bendix parts outlets under literature number BW1779. It is presented here because of the air dryers connection to the supply air system and for convenience. The procedure is not all inclusive but rather represents the most commonly encountered complaints.

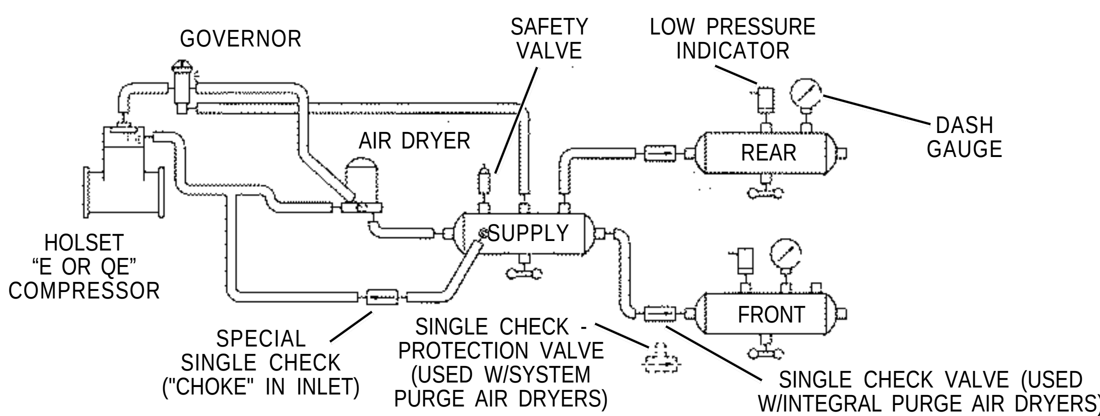
CONVENTIONAL SUPPLY SYSTEM & INTEGRAL PURGE AIR DRYER



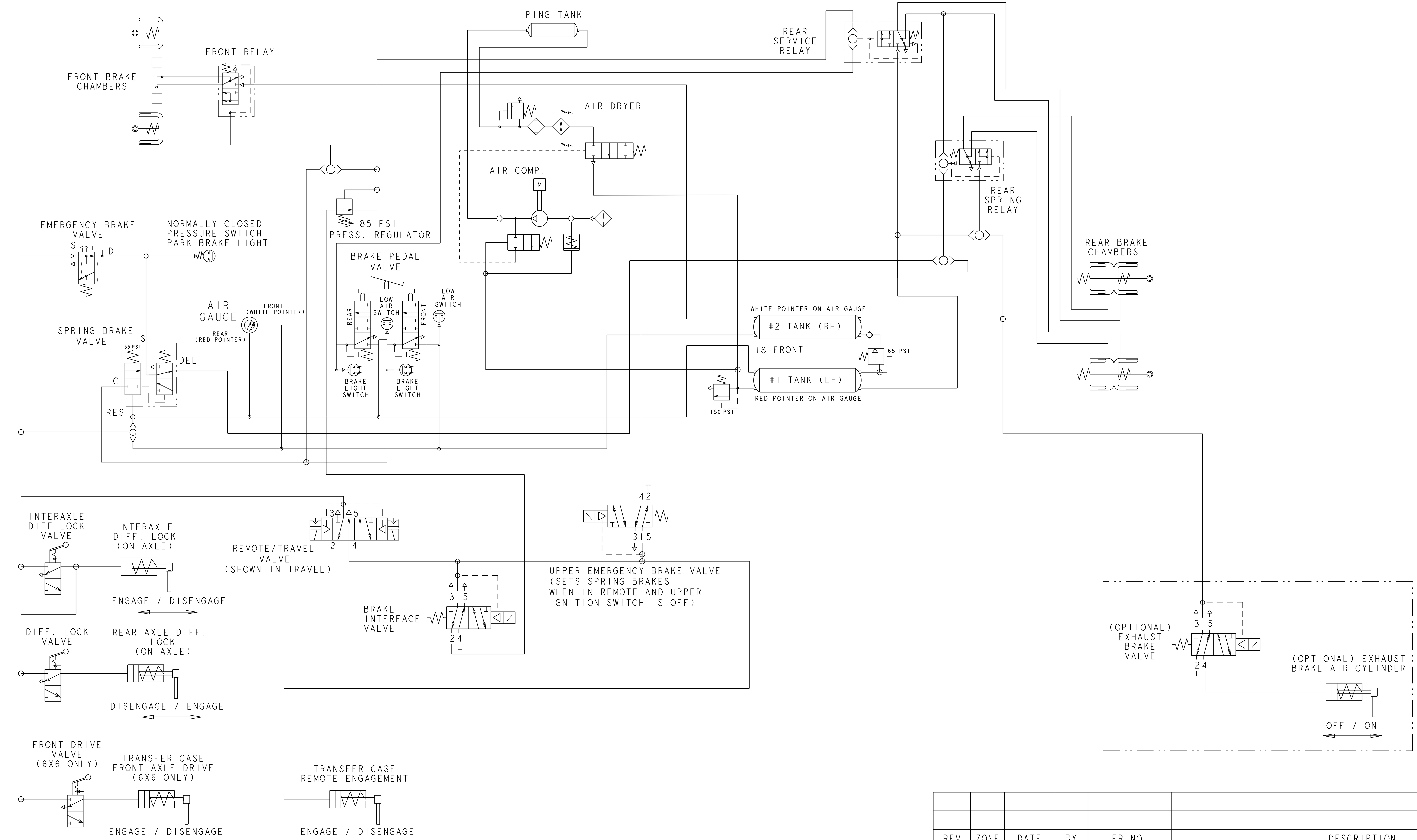
HOLSET TYPE "E & QE" COMPRESSOR WITH ECON VALVE



HOLSET TYPE "E & QE" COMPRESSOR W/O ECON VALVE



DRAWING NUMBER 80889029



UNLESS OTHERWISE NOTED:
1) THIS IS A PRO ENGINEER / WINDCHILL CONTROLLED DOCUMENT.
2) ALL DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	ER NO.	DESCRIPTION	CHKD

REVISIONS

SPECIFICATIONS
1) DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2) ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1
3) ALL DIMENSIONAL TOLERANCES ARE ± .060
4) MACHINE TOLERANCE TO BE ± .015
5) ALL ANGLES ± 1°
6) MACH. SURF. 125 √ MAX

DRAWN BY:	JPG
DATE:	26-Oct-15
CHK'D BY:	SNM
DATE:	26-Oct-15
ER NO.:	S03429817
CAGE CODE:	
SIMILAR TO:	80889016
FINISH COAT REQ:	N

GRADALL

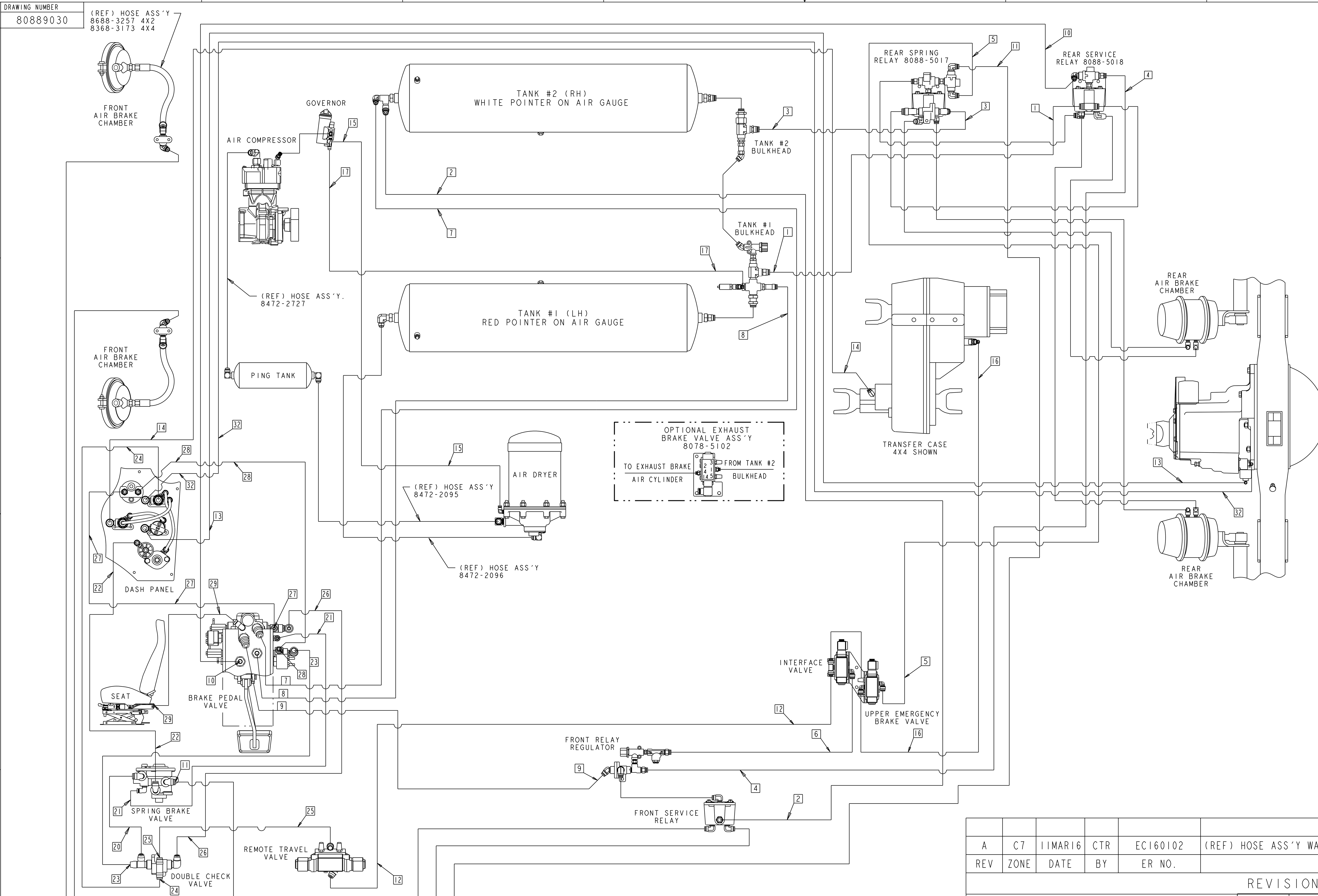
TITLE: SCHEMATIC, AIR, XL3100 SV

MATL:

NEXT ASSY 80700003

SIZE D | DWG NO. 80889029 | REV -

SCALE: | EST WT: | SHEET: 1 OF 1



UNLESS OTHERWISE NOTED:
1) THIS IS A PRO ENGINEER / WINDCHILL CONTROLLED DOCUMENT.
2) ALL DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	ER NO.	DESCRIPTION	CHKD
A	C7	11MAR16	CTR	EC160102	(REF) HOSE ASS'Y WAS 8472-2727 WAS 8472-2094	SNM

REVISIONS

SPECIFICATIONS

1) DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2) ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1
3) ALL DIMENSIONAL TOLERANCES ARE ± .060
4) MACHINE TOLERANCE TO BE ± .015
5) ALL ANGLES ± 1°
6) MACH. SURF. 125 MAX

NEXT ASSY: 80700003

DRAWN BY:	JPG
DATE:	27-Oct-15
CHK'D BY:	SNM
DATE:	27-Oct-15
ER NO.:	S03429817
CAGE CODE:	
SIMILAR TO:	80889017
FINISH COAT REQ:	N

GRADALL

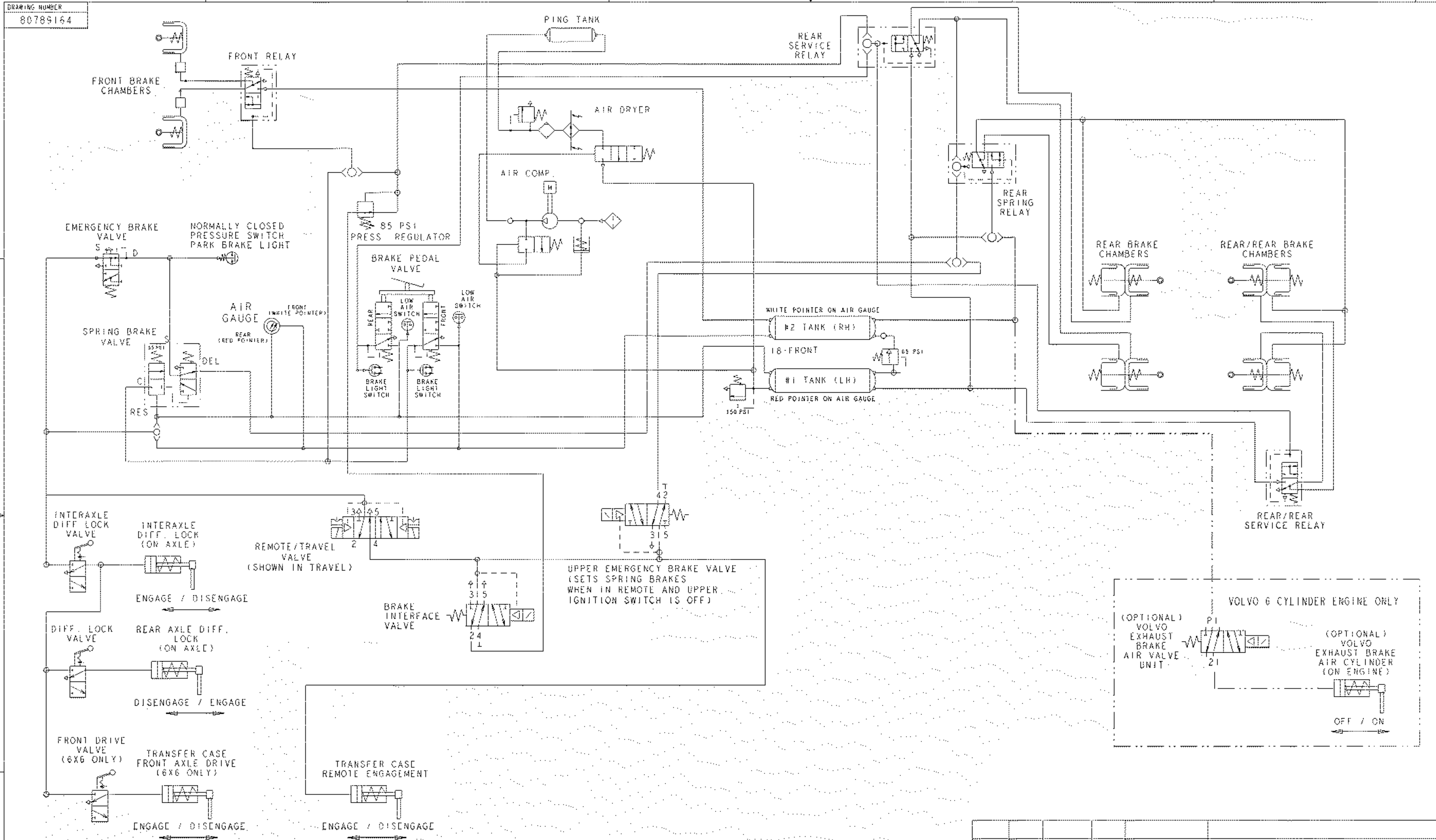
TITLE: DIAGRAM, AIR, XL3100 SV

MATL:

SIZE	DWG NO.	REV
D	80889030	A

SCALE: 1:1 | EST WT: | SHEET: 1 OF 1

DRAWING NUMBER 80789164



UNLESS OTHERWISE NOTED:
1) THIS IS A PRO ENGINEER / WINDCHILL CONTROLLED DOCUMENT.
2) ALL DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	ER NO.	DESCRIPTION	CHKD

REVISIONS

SPECIFICATIONS
1) DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2) ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1
3) ALL DIMENSIONAL TOLERANCES ARE ± .060
4) MACHINE TOLERANCE TO BE ± .015
5) ALL ANGLES ± 1°
6) MACH. SURF. 125 MAX

DRAWN BY:	SEG
DATE:	01-Dec-16
CHK'D BY:	SNH
DATE:	01-Dec-16
ER NO.:	S04188591-10
CAGE CODE:	
SIMILAR TO:	80789113
NEXT ASSY	80700003
FINISH COAT REQ:	

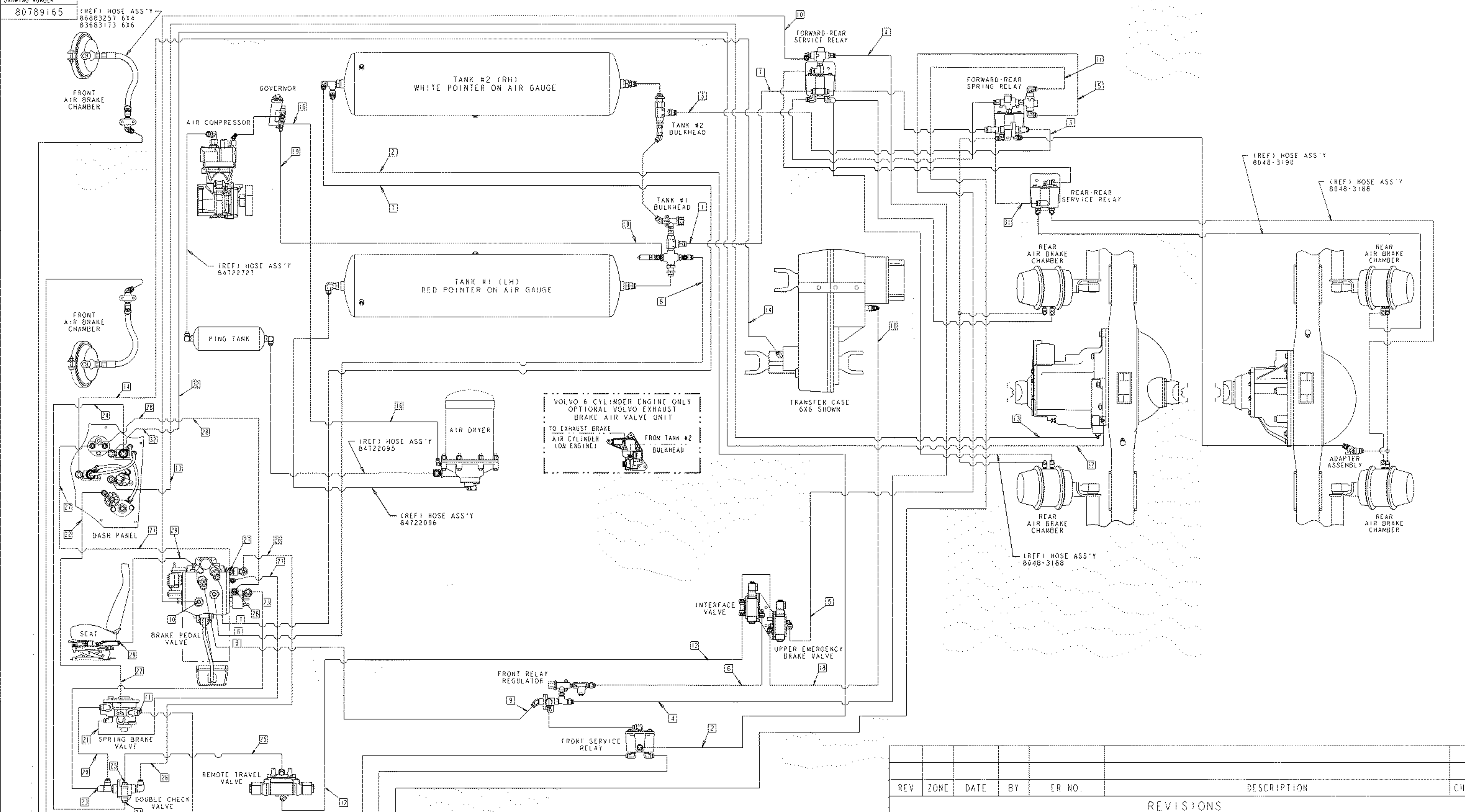
GRADALL

TITLE: SCHEMATIC, AIR, XL4100V AND XL5100V

MATL:

SIZE D | DWG NO. 80789164 | REV -

SCALE: | EST WT: 1.118 | SHEET: 1 OF 1



UNLESS OTHERWISE NOTED:
1) THIS IS A PRO ENGINEER / WINDCHILL CONTROLLED DOCUMENT.
2) ALL DIMENSIONS ARE IN INCHES.

REV	ZONE	DATE	BY	ER NO.	DESCRIPTION	CHKD

REVISIONS

SPECIFICATIONS
1) DIMENSIONING AND TOLERANCING PER ASME Y14.5M-1994
2) ALL WELDING TO STRUCTURAL WELD CODE-STEEL ANSI/AWS D1.1
3) ALL DIMENSIONAL TOLERANCES ARE ± .060
4) MACHINE TOLERANCE TO BE ± .015
5) ALL ANGLES ± 1°
6) MACH. SURF. 125 MAX

DRAWN BY:	SEG
DATE:	01-Dec-16
CHK'D BY:	SNM
DATE:	01-Dec-16
ER NO.:	S04188591-10
CAGE CODE:	
SIMILAR TO:	80789114
NEXT ASSY	80700003
FINISH COAT REQ:	

GRADALL

TITLE: DIAGRAM, AIR, XL4100V AND XL5100V

MATL:

SIZE D | DWG NO. 80789165 | REV -

SCALE | EST WT: | SHEET 1 OF 1

This servicing information is provided as a best practices guide. It is not intended to replace or supersede the service instructions supplied by your engine or vehicle manufacturer. Note: Your air cleaner service cover may be in a different position than shown.

1 Check the Restriction

Replace the filter only when the restriction level has reached the maximum recommended by the engine or equipment manufacturer or on a regular scheduled service.

2 Remove the Primary Filter

Push down on the service handle to tilt the filter to a 5° angle. This will loosen the seal. Then, pull up on the service handle to remove the filter from the housing.

3 Visually Inspect the Safety Filter

Remove any excess dirt and wipe out the housing with a damp cloth before servicing the safety filter. Visually inspect the safety filter but do not remove it unless it is damaged or due for change-out. Verify that the safety filter is properly seated in the housing. The safety filter should be replaced every three primary filter changes.

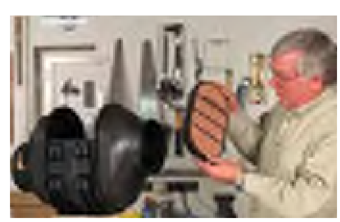
NEVER use a pressure sprayer to clean out the air cleaner housing while it is installed on the machine.

4 Remove Safety Filter if Indicated or if Excessively Contaminated

To remove the safety filter, use the plastic handle on the face of the safety filter. Pull the filter toward the center of the housing and remove it. Ensure that the outlet tube sealing area is clean and undamaged. If the safety filter is removed and the new filter is not to be installed immediately, be sure to cover the seal tube with a cloth so that dirt is not admitted. After removing the safety filter, wipe the air cleaner housing interior and seal surfaces with a clean, damp cloth.

5 Inspect the New Filters

Visually check for cuts, tears or indentations on the sealing surfaces and the media pack before installation. If any damage is visible, do not install.



The safety filter should be replaced every three primary filter changes.

Continued on next page

6 Replace the Safety Filter

If replacing the safety filter, use the plastic handle. Slide the filter at an angle into the outlet side and push it in place until the filter seats firmly and evenly within the housing.

7 Insert the Primary Filter

Slide the filter down at approximately a 5° angle until it makes contact with the end of the housing. Rotate the filter toward the outlet section to complete the seal.

8 Replace the Service Cover

Place the service cover in position and fasten the metal latches. If the cover doesn't seat, remove and re-check the filter position and access cover orientation.

9 Inspect the Entire Air Cleaner System

Make sure that inlet and outlet connections are in good condition. Torque to and do not exceed 40 in•lb. Replace rubber connectors if necessary and reset the service indicator.

GRADALL INDUSTRIES, INC.

80709019 FINAL TEST REPORT - MODELS 3100 SV, 4100 SV, 5100 SV

SALES ORDER #	SERIAL NUMBER	DATE

#	PRESSURE TESTS (All at high idle. Hydraulic oil 100°F min except where noted *. Standard boom configuration and 60" ditching bucket.)	GAGE LOCATION	3100 SV	4100 SV	5100 SV	INITIAL	FINAL
1	**ENGINE SPEED** (RPM) - SET BODEM/BODAS SOFTWARE						
a	HIGH IDLE	Laptop	**1850 - 1950**				
b	LOW IDLE	Laptop	**1050-1100**				
2	**FLUSHING PRESSURE** (NO FUNCTIONS MOVING)	G1 (Heater/AC Manifold)	**360 - 570**				
3	**PILOT PRESSURE**	Pilot Valve A1	**500 - 650**				
4	**PUMP DIFFERENTIAL** (BOOM OUT BOTTOMED) *	G1 - Main Valve LS	**300-320**				
5	**LS CUTOFF** (BOOM CYLINDER RETRACTED) *	X @ Valve	**4950 - 5050**				
6	**OIL COOLER FAN** (With engine idling, adjust oil cooler fan Imn to 1000 mA. Heat oil to 150°F minimum. Unplug temperature sensor to turn fan at max speed. Set engine at full throttle. Readjust oil cooler fan Imn value to achieve desired pressure.)	Pilot Valve G	**3450 - 3550**				
7	**SWING**						
a	SWING MOTOR HIGH STAGE RELIEF PRESSURE - LEFT	MA (@ Swing Motor)	**3600 - 3800**	**4400 - 4600**	**4700 - 4900**		
b	SWING MOTOR HIGH STAGE RELIEF PRESSURE - RIGHT	MB (@ Swing Motor)	**3600 - 3800**	**4400 - 4600**	**4700 - 4900**		
c	SWING REGULATOR PRESSURE - LOW STAGE *	MA (@ Swing Motor)	**900 - 1100**				
d	SWING REGULATOR PRESSURE - HIGH STAGE *	MA (@ Swing Motor)	**2900 - 3100**	**4100 - 4300**	**4450 - 4550**		
e	DYNAMIC BRAKING - RIGHT *	MA (@ Swing Motor)	**2000 - 2200**	**2500 - 2700**	**2900 - 3100**		
f	DYNAMIC BRAKING - LEFT *	MB (@ Swing Motor)	**2000 - 2200**	**2500 - 2700**	**2900 - 3100**		
8	**TRAVEL**						
a	HIGH STAGE - FULL SPEED POWER REVERSE - FORWARD	Motor G Port	**4750 - 4900**	**5075 - 5300**			
b	HIGH STAGE - FULL SPEED POWER REVERSE - REVERSE	Motor G Port	**4750 - 4900**	**5075 - 5300**			
c	LOW STAGE - FULL SPEED & LET OFF (BRAKING) - FORWARD**	Motor G Port	**2900 - 3100**	**3700 - 3850**			
d	LOW STAGE - FULL SPEED & LET OFF (BRAKING) - REVERSE**	Motor G Port	**2900 - 3100**	**3700 - 3850**			
9	**STEERING** (Turn wheels to stop & hold in remote operation)	G @ Steering Valve	**1950 - 2050**				
10	**MAIN PUMP POWER SETTING** - ENGINE DRAWDOWN RPM (Tool stalled, hoist up and boom out at full speed) * SET AFTER CYCLE TIMES COMPLETED	BB-3 or Laptop	**Mechanical Setting** (Pump HP Solenoid Coil Removed) **1400 - 1600**				
			Electrical Setting (Pump HP Solenoid Coil Installed) **1725 - 1825**				
11	**TILT**						
a	TILT MOTOR CCW (INSIDE RELIEF VALVE)	MLS(@ VALVE)	2450-2750 (STD) / 4750-4950 (360)				
b	TILT MOTOR CW (OUTSIDE RELIEF VALVE)	MLS(@ VALVE)	2450-2750 (STD) / 4750-4950 (360)				
12	BOOM EXTEND PORT RELIEF	G1 (Heater/AC Manifold)	**3200 - 3400**				
13	HOIST DOWN PORT RELIEF	G1 (Heater/AC Manifold)	**3300 - 3500**				
14	AUXILIARY (OPTIONAL EQUIPMENT) "A" PORT	G1 (Heater/AC Manifold)	**3000 - 3200**				
15	AUXILIARY (OPTIONAL EQUIPMENT) "B" PORT	G1 (Heater/AC Manifold)	**3000 - 3200**				
16	BOOM RETRACT PORT RELIEF	X @ Valve	**5075 - 5200**			NOT FACTORY CHECKED	
17	HOIST LOCK VALVE (BOOM STARTS TO DRIFT WITH LOAD)	X @ Valve	**5000 - 5100**			NOT FACTORY CHECKED	
18	HOIST UP PORT RELIEF (BOOM STARTS TO FALL WITH LOAD)	X @ Valve	**5100 - 5175**			NOT FACTORY CHECKED	
19	TOOL OPEN PORT RELIEF	X @ Valve	**5075 - 5200**			NOT FACTORY CHECKED	
20	TOOL CLOSE PORT RELIEF	X @ Valve	**5075 - 5200**			NOT FACTORY CHECKED	

CHECKED BY	CLOCK #

ALL VALUES TO BE MEASURED WITH HEATER OFF AND AIR CONDITIONER OFF

*** MEASURE WITH HYDRAULIC OIL TEMPERATURE 120-150°F (may require the oil cooler to be blocked off) - SEE BOTTOM OF NEXT PAGE FOR ADDITIONAL SETTING INFORMATION**

**** SET TIMES FOR 100 FT PROPEL SPEEDS PRIOR TO DYNAMIC BRAKING PRESSURE ADJUSTMENTS**

INSTALL TAMPER-PROOF CAPS AFTER ALL ADJUSTMENTS (1-15 ABOVE) ARE COMPLETE

GRADALL INDUSTRIES, INC.
80709019 FINAL TEST REPORT - MODELS 3100 SV, 4100 SV, 5100 SV

SALES ORDER #	SERIAL NUMBER	DATE

#	CYCLE TIME TESTS (All at high idle. Hydraulic oil 100^{o}F min except where noted *. Standard boom configuration and 60" ditching bucket.)	3100 SV	4100 SV	5100 SV	INITIAL TIME	FINAL TIME	FINAL mA	GRADE MODE mA (set less than std. by:)	actual mA
1	**BOOM OUT*** (LEVEL)	4.8 - 5.2	4.9-5.2	6.0-6.5				(-100mA)	
2	**BOOM IN*** (LEVEL)	5.0 - 5.4	5.4-5.8	5.8-6.5				(-100mA)	
3	**HOIST UP*** (WITH BOOM IN, RAISE FROM GROUND TO CUSHION SWITCH)	2.5 - 3.1						(-75mA)	
4	**HOIST DOWN*** (WITH BOOM IN, LOWER FROM BOOM STOP TO GROUND)	2.0 - 3.2		2.5 - 3.5				(-75mA)	
5	**TOOL OPEN**	2.8 - 3.2						(same)	
6	**TOOL CLOSE**	2.6 - 3.8						(same)	
7	**SWING RIGHT 360^{o}** (BOOM IN OR OUT)	8.0 - 9.0						(-50mA)	
8	**SWING LEFT 360^{o}** (BOOM IN OR OUT)	8.0 - 9.0						(-50mA)	
9	**PROPEL FORWARD** (100 FT; CREEPER OFF)	14 - 16					N/A		
10	**PROPEL REVERSE** (100 FT; CREEPER OFF)	14 - 16					N/A		
11	**PROPEL FORWARD** (100 FT; CREEPER ON)	28 - 32					N/A		
12	**AIR CONDITIONER MOTOR SPEED (RPM)**** (OPTIONAL EQUIPMENT)	2000 - 2150					N/A		

CHECKED BY	CLOCK #

*** ADJUST Imin CURRENT SUCH THAT Imin IS 50 Ma BELOW ACTUAL BEGIN OF MOTION**
(EXAMPLE OBSERVE BOOM OUT PHYSICALLLY STARTS MOVING AT 325 Ma. **SET Imin = 275 Ma**)

*** ADJUST Imax CURRENT SUCH THAT Imax IS NOT MORE THAN 25 Ma ABOVE THE REQUIRE CURRENT FOR RECORDED SPEED**
(EXAMPLE OBSERVE BOOM OUT T = 4.8 SECONDS AT 1000 Ma. REDUCING Imax SHOWS THAT LOWEST Imax FOR T = 4.8 SECONDS IS 925 Ma. **SET Imax = 925-950 mA**)

**** MEASURE WITH HEATER AND AIR CONDITIONER OFF; HYDRAULIC OIL TEMPERATURE 120-150^{o}F (may require the hydraulic oil cooler to be blocked off)**