WEST VIRGINIA
DIVISION OF HIGHWAYS

DIVISION 400
BITUMINOUS PAVEMENT

CONSTRUCTION MANUAL

2002

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Section 401

HOT-MIX ASPHALT BASE, WEARING, AND PATCHING AND LEVELING COURSES

The performance of bituminous, or flexible, pavements depends primarily on the adequacy of the pavement's structural and mix designs and the quality achieved in producing, placing, and compacting the mix. Although adequate designs may ultimately be specified, misunderstood or misapplied specifications and the use of poor construction techniques and improper equipment operations will greatly affect pavement quality. Section 401 of the **Standard Specifications** establishes the respective obligations of the Contractor and the DOH. The following section presents specific DOH procedures and additional clarifying information on bituminous pavement construction.

401.1 GENERAL

401.1.1 Description of Work

Hot-mix asphalt (HMA) contains sieve-graded coarse and fine aggregate materials, mineral filler, asphalt binder, modifiers (as required), and, at the option of the Contractor, reclaimed asphalt pavement (RAP) material. These component materials are proportioned and mixed mechanically in a plant based on a Job-Mix Formula for the project. The HMA is then loaded on trucks, hauled to the laydown site, and placed and compacted on a suitably prepared foundation in one or more courses (i.e., layers). The Project Engineer/Supervisor and the Project Inspectors, both at the plant and at the laydown site, are primarily responsible for ensuring that the mix conforms to the requirements of the Job-Mix Formula and the contract specifications and that the work reasonably conforms to the Contractor's Quality Control Plan and the lines, grades, and cross sections of the Contract Plans.

401.1.2 Types of HMA

The term hot-mix asphalt (HMA) is used generically to refer to the following types of bituminous pavement mixes:

1. Dense. Dense-graded HMA primarily consists of uniformly graded aggregate material and an asphalt cement or performance-graded binder. Asphalt concrete and bituminous concrete are common terms used to designate dense-graded HMA. It is important to note that asphalt concrete is an HMA, but not all HMA is considered asphalt concrete.

2. Open. Open-graded HMA primarily consists of coarse aggregate, a minimal amount of fine aggregate, and an asphalt cement or performance-graded binder. The primary purpose of open-graded HMA is to provide a very open surface texture, which promotes surface water drainage and skid resistance.

3. Gap. Gap-graded and open-graded mixes are essentially the same with one important difference. Gap-graded HMA generally has a greater amount of fine aggregate material, and the amount of medium sized aggregate material, if present, will be very small.

4. Superpave™. Superpave is a class of HMA that is based on a design specification that is quite different than that used for conventional HMA. The gradation of Superpave includes a greater amount of coarse aggregate material, and the aggregate material is more angular. In addition, Superpave uses performance-graded binders (e.g., PG 64-22) and special modifiers, which are different than conventional

asphalt cements (e.g., AC-20). See Section 401.4 for additional information on Superpave.

401.1.3 <u>**HMA Component Materials**</u>

401.1.3.1 Aggregate Materials

The aggregate materials used in HMA production include coarse and fine aggregates and mineral filler. These materials must meet the material and gradation requirements of Section 401 of the **Standard Specifications**. Section 704 of this **Manual** provides guidance on the inspection of aggregate materials. The following briefly describes the aggregate materials used in production:

1. <u>Coarse Aggregate</u>. Coarse aggregate includes crushed stone, crushed gravel, and crushed slag. Crushed particles have sharp edges and corners that interlock and promote pavement stability. Gradation is achieved by combining two or more commercial aggregate sizes at the plant's cold feed. If it becomes necessary to change aggregate sources, a new JMF must be developed and submitted for approval. Note that slag is porous and will readily absorb liquid binder.

2. <u>Fine Aggregate</u>. Fine aggregate includes some combination of manufactured (e.g., screenings from crushed aggregate) and natural sand. Manufactured sand, by itself, provides stability but is more difficult to compact. A mixture of approximately equal amounts of manufactured and natural sand is often used. Fine aggregate generally passes the No. 8 sieve.

3. <u>Mineral Filler</u>. Mineral filler generally passes the No. 200 sieve. It may include one or more of the following: fines present in the larger graded aggregate, dust returned from the plant's emission-control system, fly ash, Portland cement, and other commercial products. Mineral filler is added for stabilization, but the quantity and type added significantly affects the mix. If too much is added, the mix will be tough and difficult to roll and the finished pavement will become hard and brittle. Once in production, the type of mineral filler should not be changed and the amount added should be closely monitored. Note that commercial fillers must be kept dry in storage. If too much moisture is present, the mix will look shiny and foamy and the HMA will flatten in the truck bed.

4. <u>Reclaimed Asphalt Pavement (RAP) Material</u>. The **Standard Specifications** allows the Contractor to optionally use RAP material. Note that if the Contractor elects to use a RAP design, the requirements of MP 401.02.24 will govern.

401.1.3.2 Asphalt Materials

Many different types of asphalt material are used in bituminous pavement construction. The type needed depends on the purpose of the mix (e.g., HMA base and wearing course, surface treatment, prime coat, tack coat). For example, asphalt materials used in surface treatments, tack coats, and winter-grade patching applications include rapid- and medium-curing liquid asphalts, asphalt emulsions, and cut-back asphalts, which have different properties than asphalt binders, which are used in HMA (see Section 705 of the **Standard Specifications**). Cutback asphalts lose their volatile spirits by evaporation, and the components of asphalt emulsions tend to separate over time.

Unless otherwise specified, performance-graded (PG) binders will be used in DOH construction projects. Type PG 64-22 is usually specified. Note that "performance grade" is different than the "penetration and viscosity grade" of asphalt cement. The PG designation (e.g., PG 64-22) represents the high and low temperatures at which the asphalt binder is expected to satisfactorily perform. Modifiers are typically used, especially in Superpave designs, to achieve the specified temperature requirements.

Different types and grades of asphalt binders, including those from different sources, must not be intermixed during production. Operations should be carefully monitored during the project to ensure this does not inadvertently occur. If it is necessary to change the source of asphalt binder, follow the procedures for revising the Job-Mix Formula and Form T-400 in Section 401.1.5.

401.1.4 Quality Control

In general, the Contractor is responsible for quality control, and the Division is responsible for acceptance. Section 106 of this **Manual** presents the DOH and Contractor responsibilities regarding control of materials. Consider the following guidelines during HMA pavement construction:

1. Quality Control Plan. Prior to production, the Contractor will submit a Quality Control Plan for DOH review. The Project Engineer/Supervisor will check that the Plan conforms to the sampling and testing requirements of MP 401.03.50. Frequently monitor operations to ensure that the Contractor operates within this Plan.

2. Certified Technicians. The Contractor will provide at least one DOH-certified HMA Technician at the plant to oversee mix proportioning and materials control and at least one DOH-certified Compaction Technician at the laydown site to perform the required sampling and testing. Before production, check that the Contractor provides the necessary quality control personnel and equipment.

3. Key References. Division 700 of this **Manual**, the **Standard Specifications**, and the **Materials Procedures** cover various criteria for HMA pavement construction related to the Contractor's responsibilities for quality control and the Division's responsibilities for quality assurance. Section 703 of this **Manual** provides minimum sampling and testing criteria, and Section 706 provides guidance on HMA material and construction inspection. Section 401 of the **Standard Specifications** specifies quality criteria and material control references, including AASHTO and ASTM materials testing procedures. Refer to MP 401.03.50 for HMA quality control and acceptance criteria. Other 400-level **Materials Procedures** should be consulted on an as needed basis. Contact the District Materials Supervisor or the Materials Control, Soils and Testing Division.

401.1.5 Job-Mix Formula (JMF)/Form T-400

Section 401 of the **Standard Specifications** establishes minimum and maximum design criteria for the amount of aggregate and asphalt material in various types of HMA. Before production, however, specific values (or range of values) must be specified in a Job-Mix Formula (JMF). The Contractor is responsible for developing the JMF in accordance with MP 401.02.22. The JMF will differ from project-to-project. For example, type Base-II is typically used for patch and leveling courses, and type Wearing-I is typically used for scratch courses. During the project, check and monitor operations to ensure the Contractor fulfills these requirements. The JMF will be documented on Form T-400 and include the following information:

1. source and type of materials;
2. percentages for each aggregate size;
3. percentage of asphalt binder;
4. mix temperature at the plant; and
5. ratio of fines to asphalt.

The Contractor will forward, through the District Materials Supervisor, the JMF and Form T-400 for review by the Materials Control, Soils and Testing Division. Revisions, if any, will be requested of the Contractor through the District Materials Supervisor. During initial production, verify the JMF in accordance with MP

401.02.27. If the mix cannot be consistently produced within tolerance or if there is a subsequent change in the source of aggregate, the Contractor must revise and resubmit a new JMF and Form T-400. The source of unmodified asphalt binder may be changed without submitting a new JMF. The binder grade for each mix design must always remain unchanged. If a modified binder source is changed or if the modification process is changed, a new JMF must be submitted.

401.1.6 Quality Control Plan

Prior to the start of work, the Contractor is responsible for developing and submitting a Quality Control Plan. The District Materials Control, Soils and Testing Division will review the Plan and discuss with the Contractor any suggested changes or adjust-ments. Document the salient points of the discussion. During the project, verify that the Contractor operates within this Plan and maintains all equipment in working order (e.g., plant, haul trucks, laydown and compaction equipment).

401.1.7 Maintenance of Traffic (MOT) Plan

All DOH construction projects will provide for the safe and efficient maintenance of traffic through the work zone. Large and complex paving jobs will have a project specific Maintenance of Traffic (MOT) Plan in the plans. Smaller and less complex jobs will have an MOT case specified in the plans. In either case, the type and location of warning signs, barricades, pavement markings, flagmen, pilot trucks, and flashers for either daylight or nighttime operations must be in conformance with the DOH publication **Traffic Control for Street and Highway Construction and Maintenance Operations**.

During laydown and compaction, check to ensure compliance and document the Contractor's traffic control activities on the appropriate Form 442-IDR attachment. Section 104.2 of this **Manual** provides guidance for monitoring traffic control during construction. Signing and pavement-marking applications are specifically addressed in Section 401 of the **Standard Specifications** for the following operations:

1. one-way, multilane roadways;

2. two-way, two-lane roadways including no-passing zones;

3. two-way, three-lane roadways including no-passing zones, center left-turn lanes, and truck climbing lanes; and

4. two-way, four-lane and five-lane roadways.

If traffic is to be carried on an unpaved shoulder during the paving operation, adequate measures should be taken to prevent blowing dust from becoming a traffic hazard. On pavement widening projects, the open trench is an especially dangerous traffic hazard that requires advance warning and proper signing and marking at all times. To prevent damage to the pavement, it is good practice to keep traffic off fresh tack coat, uncompacted mix, and the newly compacted surface until it has cooled sufficiently to support the load of traffic.

Traffic control should be thoroughly discussed at the pre-construction conference (see Section 401.1.9). The area in the vicinity of the laydown and compaction site deserves special considera-tion. The operation is generally fast paced and hazardous to both the traveling public and construction personnel. Maximum safety should be afforded to workmen and public without unnecessarily disrupting the paving operation.

401.1.8 Safety Considerations

Job safety at both the plant and the laydown site cannot be overemphasized. Both Division and Contractor personnel must continually practice safe working habits. Occupational Safety and Health Administration (OSHA) regulations must be understood and followed by all personnel. Each person should clearly understand what is expected and how to perform the assigned task. Moving conveyors, high temperatures and pressures, dust, noise, haul trucks, paving and compaction equipment, and moving traffic all pose potential hazards. New personnel should be properly instructed, and seasoned personnel should not become lackadaisical or careless. Constant care and vigilance are needed to prevent accidents and injury. It is wise to periodically remind personnel that they are operating in a potentially dangerous environment. If an unsafe work practice is observed, corrective action should be taken immediately, even if the operation has to be temporarily shut down. See Section 107.2.3 of this **Manual** for additional guidance on construction project safety.

401.1.9 Pre-Construction Conference

Section 103.3 of this **Manual** discusses activities that should be considered before construction. Section 103.3.2 specifically addresses the requirements of the Pre-Construction Conference (e.g., purpose and need, arrangement and scheduling, attendees, facilitation). The Conference will establish an overall cooperative tone and ensure that all parties involved understand the project and are ready for production work. In general, Conference attendees should discuss contractual items such as scope of work, scheduling requirements and project meetings, quality control, mix design, laydown and compaction, maintenance of traffic, job safety, and any special requirements of the project.

A pre-season paving Pre-Construction Conference is usually held at each District to discuss these items for most resurfacing projects. Subsequent field reviews then address project-specific issues.

401.1.10 Communications During Project

During the project, quality and safety depend on continued positive and meaningful communication with the Contractor. Frequent informal meetings provide a forum for meaningful dialog to mitigate potential cost and scheduling problems. In addition, frequent communication between plant and laydown/ compaction personnel during production provides critical feedback to ensure that a quality pavement is being produced. Key points of discussion should be noted in the Inspector's Daily Report.

401.2 HMA PRODUCTION AND HAULING

Hot-mix asphalt (HMA) plants mechanically blend aggregate and asphalt binder materials together to produce a hot, homogeneous paving mix. The Project Engineer/Supervisor and Project Inspector(s) are responsible for verifying plant conditions and operations (e.g., certification, scales and weights, materials, mix proportions, mix temperatures) to ensure compliance with the requirements of the project. Before production, it is good practice to become familiar with the features of the type of plant being used and to thoroughly examine the plant for compliance with the contract specifications. Any deficiencies in mechanical condition or in meeting contract specifications or safety requirements should be corrected immediately.

401.2.1 Plant Certifications

The Division must approve the plant prior to use on DOH projects. Before production, verify that the plant has been properly certified. Check compliance as follows:

1. Emission-Control System. The plant must be equipped with an emission-control system to reuse or discard lost fine material. It is preferable to reuse lost fines as mineral filler in the mix to ensure that gradation is

maintained; however, where this is not practical or otherwise desired, check to ensure that the Contractor wastes the material in accordance with the governing contract specifications. Check that the plant operator has furnished documentary evidence of compliance with the State's applicable air pollution laws and governing regulations (e.g., West Virginia Air Pollution Control Commission).

2. Scales and Weights. Plant scales that are used to weigh aggregate and asphalt binder materials and final HMA batches, including truck scales, must conform to the requirements of the **Standard Specifications**. The West Virginia Division of Labor calibrates and certifies scales and test weights every two years. Check for these certifications. Note that the seal on the scale indicates only that the scale was accurate at the time it was certified. Periodically check for scale accuracy and the need to recalibrate. See Section 708.1 of this **Manual** for additional guidance.

3. Temperature Sensing Devices. The temperature sensing device (e.g., pyrometer) at the discharge end of the aggregate dryer and all thermometers used at the plant should be checked and calibrated before the plant is certified. The pyrometer and thermometers should be recalibrated, as needed, during production.

401.2.2 Plant Laboratory

The Contractor is responsible for ensuring that the plant laboratory is provided in accordance with the contract specifications. The laboratory should be located so that production operations are readily visible. The laboratory must be furnished and equipped as specified in Section 401 of the **Standard Specifications**. The types and frequencies of quality control sampling and testing will be conducted in accordance with the Contractor's Quality Control Plan (See Section 401.1.4). The laboratory should contain copies of all reference materials applicable to the project (e.g., Plans, **Standard Specifications**, Special Provisions, **Materials Procedures**, ASTM and AASHTO publications, Quality Control Plan, JMF, Form T-400, Laydown and Compaction Plan, MOT Plan, schedule, test and inspection forms).

401.2.3 HMA Production Operations: Continuous vs. Batch

The physical HMA plant (i.e., dryer-drum plant, batch-mix plant, continuous-mix plant) may be either a commercial operation or a portable plant specifically erected for the project. Dryer-drum plants and batch-mix plants are generally used and have many common features (e.g., cold-feed system, surge and storage silos, emission-control system). Two basic types of HMA production operations are currently used: continuous and batch. The type of operation will depend on the type of plant selected for the project.

In continuous HMA production operations, aggregate and asphalt binder materials are proportioned by volume based on weight. The older style continuous-mix plant and the modern dryer-drum plant are both continuous operations. To facilitate truck loading and minimize mix segregation, the dryer-drum plant is equipped with a surge silo that essentially converts the continuous operation to a batch process. The dryer-drum plant is not, however, considered a batch-mix plant. The batch-mix plant is a true batch production operation because the aggregate and asphalt binder materials are proportioned by weight for each batch.

Another noteworthy distinction in plant operations is where the final proportioning of coarse and fine aggregate material occurs. In dryer-drum plants, final proportions are established at the cold-feed system; and in batch-mix plants and the older style continuous-mix plants, final proportions are set at the hot bins.

It is important to clearly understand plant operations and material flow to properly check and maintain plant equipment and establish and verify HMA production for the project.

401.2.4 <u>Plant Operation and Material Flow: Overview</u>

The following sections briefly describe the operation and material flow of dryer-drum plants, batch-mix plants, and continuous-mix plants.

401.2.4.1 Dryer-Drum Plants

Dryer-drum plants proportion aggregate and asphalt binder materials by volume based on weight. The final proportions of coarse and fine aggregates are set at the cold-feed system. The major components of the dryer-drum plant include the cold-feed system, asphalt binder supply system, dryer-drum mixer, surge silo, and emission-control system. The following notes correspond to Figure 401A and briefly describe the operation and material flow of the dryer-drum plant:

1. The cold-feed system includes aggregate stockpiles, cold-feed bins, variable-speed feeder conveyors, gathering conveyor, scalping screen, charging conveyor, and weigh-bridge control system. Coarse and fine aggregate materials are moved from stockpiles to their respective cold-feed bins. The gate openings under each bin and the speed of each bin's feeder belt are adjusted to establish the initial proportions of coarse and fine aggregate delivered to the gathering and charging conveyors and, ultimately, to the dryer-drum mixer. Aggregate proportions must meet the requirements of the Job-Mix Formula, and total aggregate flow must not exceed the capacity of the dryer-drum mixer.

2. The charging conveyor feeds the proportioned aggregate material to the dryer-drum mixer. The weigh idler and load cell of the weigh-bridge control system monitors the rate of "dry" aggregate that is being fed to the dryer-drum mixer.

3. The radiation zone of the dryer-drum mixer is where the proportioned aggregate material is heated and dried.

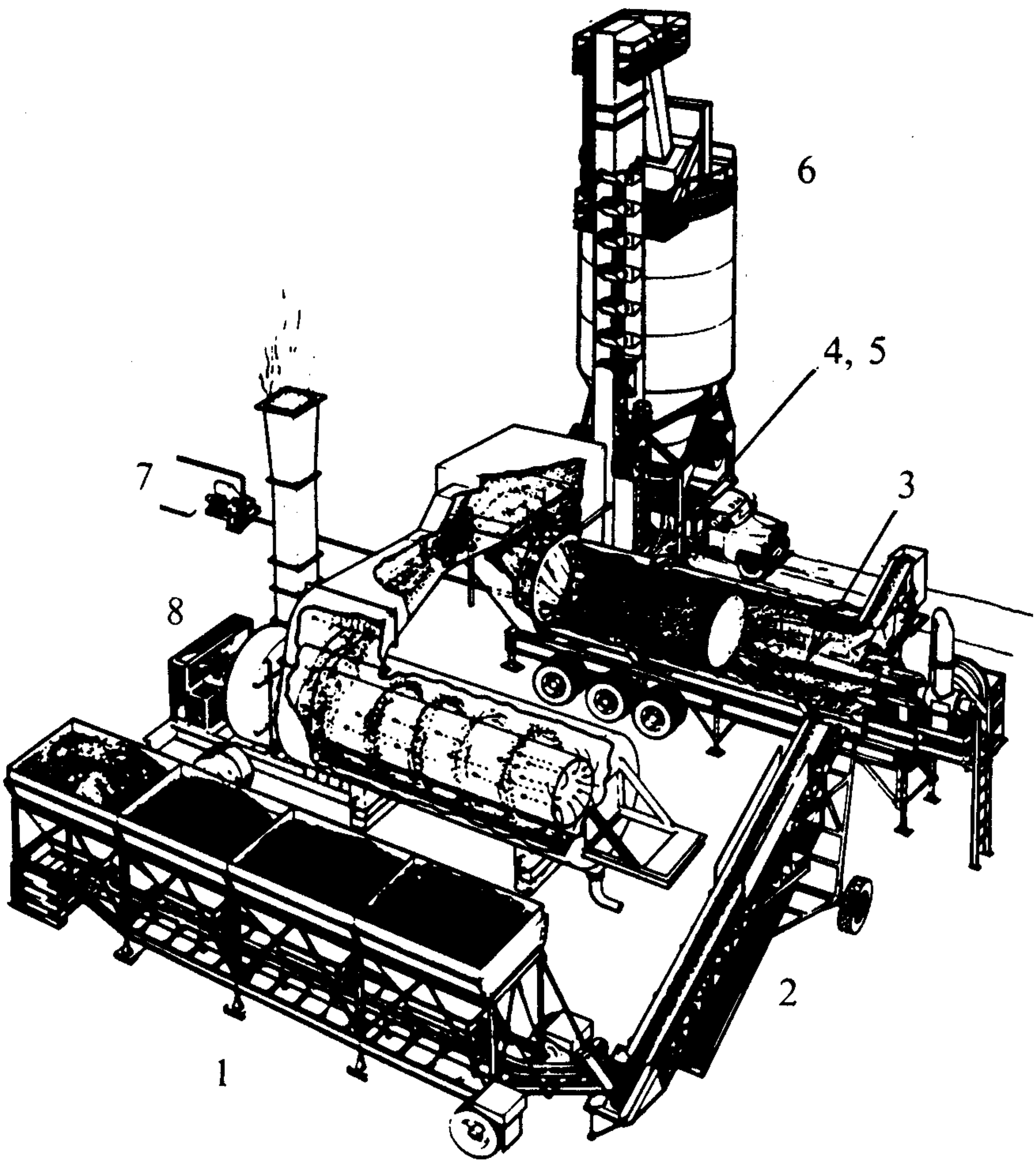
4. The convection-coating zone of the dryer-drum mixer is where asphalt binder, mineral filler, and RAP materials are introduced. The binder material is proportionally pumped through a meter based on the rate of "dry" aggregate that is being fed to the dryer-drum mixer.

5. The dual-zone design of the dryer-drum mixer minimizes emissions (e.g., blue smoke). A physical "divider" separating the two zones, and the aggregate veil that forms in the drum shield the asphalt binder and the RAP material from direct contact with the burner flame.

6. A surge silo is used to convert the continuous operation of the dryer-drum plant to a batch process, which facilitates truck loading and minimizes mix segregation.

7. A pump is used to transfer the asphalt binder from its storage tank to the rear of the dryer-drum mixer. A metering system is used to measure the amount of binder being pumped. The plant control system automatically adjusts binder flow based on the rate of "dry" aggregate that is being fed to the dryer-drum mixer, which is determined by the weigh-bridge control system. The proportion of binder must meet the requirements of the Job-Mix Formula.

8. To control plant emissions, the emission-control system (e.g., baghouse, horizontal venturi-type wet collector) removes very fine dust particles from the operation. Unless a wet collector is used, the fines may



DRYER-DRUM PLANT

Figure 401A

be returned to the mix as mineral filler at the rear of the dryer-drum.

401.2.4.2 Batch-Mix Plants

Batch-mix plants proportion aggregate and asphalt binder materials by weight not volume. Initial proportioning of aggregate materials are established at the cold-feed system, but final proportions of coarse and fine aggregates are set at the hot bins. The major components of the batch-mix plant include the cold-feed system, asphalt binder supply system, aggregate dryer, mixing tower, emission-control system, and, if provided, a storage silo. The mixing tower includes the hot elevator, screen deck, hot bins, weigh hopper, asphalt weigh bucket, and pugmill. The following notes correspond to Figure 401B and briefly describe the operation and material flow of the batch-mix plant:

1. The cold-feed system includes aggregate stockpiles, cold-feed bins, variable-speed feeder conveyors, gathering conveyor, scalping screen, and charging conveyor. Coarse and fine aggregate materials are moved from stockpiles to their respective cold-feed bins. The gate openings under each bin and the speed of each bin's feeder belt are adjusted to establish the initial proportions of coarse and fine aggregate delivered to the gathering and charging conveyors and, ultimately, to the aggregate dryer. The proportional flow must not starve the plant's downstream hot bins (i.e., cause imbalance), and the total flow must not exceed the capacity of the aggregate dryer.

2. The gate opening on the fine bin and the speed of the bin's feeder belt control the initial proportion of fine aggregate (e.g., sand) being transferred to the gathering and charging conveyors.

3. The gate opening on the coarse bin and the speed of the bin's feeder belt control the initial proportion of coarse aggregate being transferred to the gathering and charging conveyors.

4. Before the combined material is transferred to the aggregate dryer, it usually passes through a scalping screen (e.g., grizzly-type device) to protect the dryer from oversize and foreign material.

5. The aggregate dryer receives a continuous flow of combined aggregate material for heating and drying. The aggregates are heated and dried through direct exposure to the flame and hot exhaust gases of the burner.

6. The lifting flights in the aggregate dryer repeatedly lift and drop the combined aggregate material in a uniform veil through the flame and hot exhaust gases for maximum heating and drying.

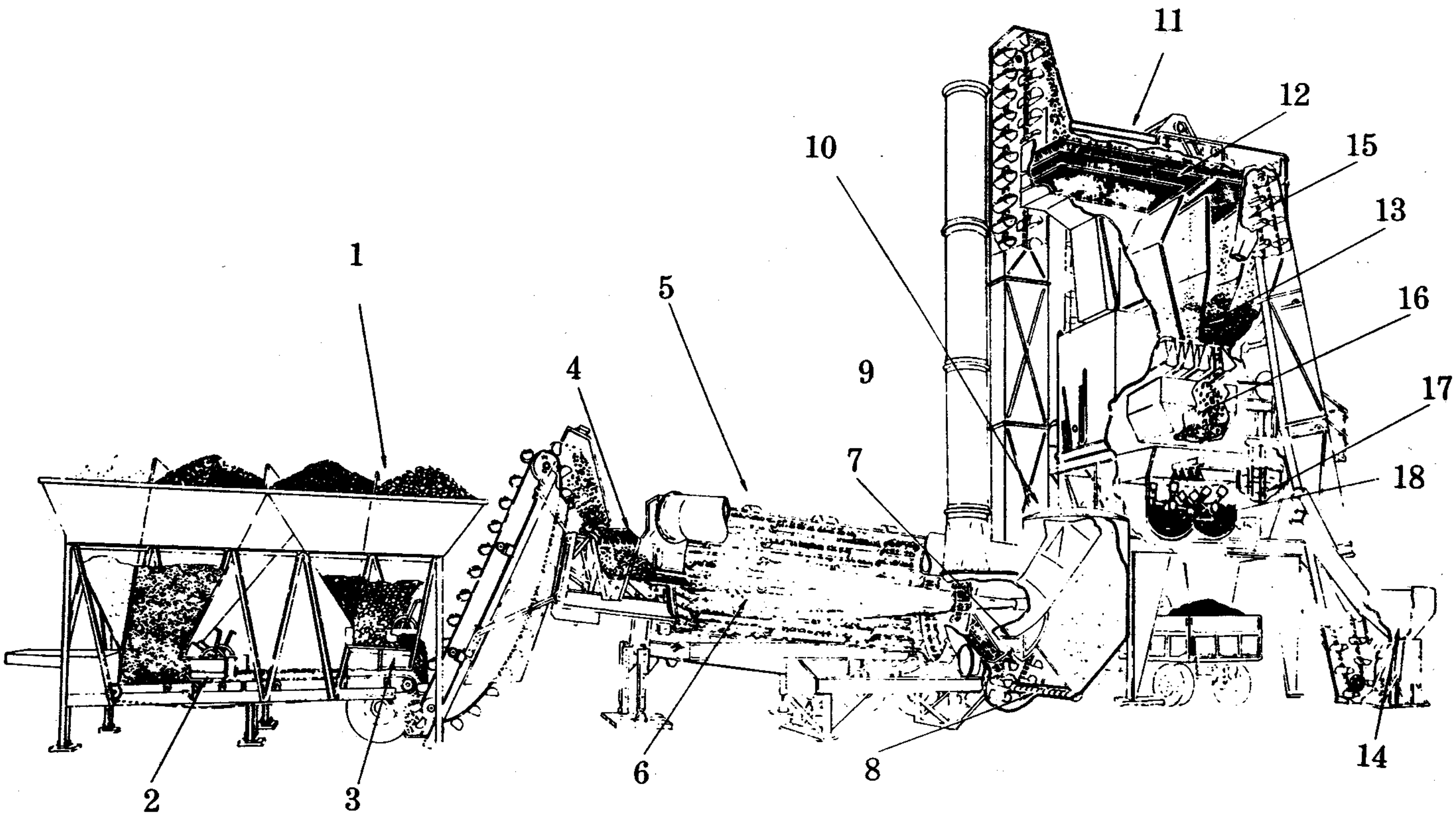
7. A motor and fan supply the air flow needed by the emission-control system and the burner's combustion system in the aggregate dryer.

8. The very fine material collected by the emission-control system (e.g., baghouse) is usually fed by screw conveyor to the boot of the hot elevator.

9. The exhaust stack carries exhaust gases above the plant area.

10. The emission-control system (e.g., dry collector, baghouse) collects the very fine material in the aggregate, indigenous or generated through tumbling in the dryer. These fines may be returned to the mix as mineral filler (See Item #8).

11. The heated and dried combined aggregate material is transported from the dryer to the screen unit, or gradation control unit, at the top of the mixing tower by the hot elevator (e.g., bucket elevator).



BATCH-MIX PLANT

Figure 401B

12. Upon discharge from the hot elevator, the combined aggregate material is graded (i.e., separated by size) as it passes through a set of vibrating screens to the hot bins. Oversize aggregates are rejected.

13. The hot bins store the graded aggregate material until needed by the pugmill. Final aggregate proportions are established as each aggregate size is discharged through a gate at the bottom of its respective hot bin.

14. The mineral filler used in the HMA is usually stored at ground level.

15. The mineral filler is measured and uniformly fed to the weigh hopper by mechanical means.

16. The weigh hopper is used to determine the total weight of aggregate, including mineral filler, required for each batch. The aggregate materials and mineral filler are proportioned, by weight, as they are released from the hot bins or mineral filler storage. Final aggregate proportions must meet the requirements of the Job-Mix Formula.

17. The jacketed (i.e., insulated) weigh bucket is used to weigh the correct amount of asphalt binder for each batch as the binder is pumped from its storage tank. The proportion of asphalt binder must meet the requirements of the Job-Mix Formula.

18. The aggregate material from the weigh hopper is dumped into a twin-shaft pugmill for a dry-mix period. The asphalt binder from the weigh bucket is then poured into the pugmill, and the combined aggregate and asphalt binder material is mixed for a wet-mix period. After mixing is complete, the gate at the bottom of the pugmill is opened and the HMA batch is discharged either into a haul truck or onto a conveying device that carries the mix to a storage silo, if provided.

401.2.4.3 Continuous-Mix Plants

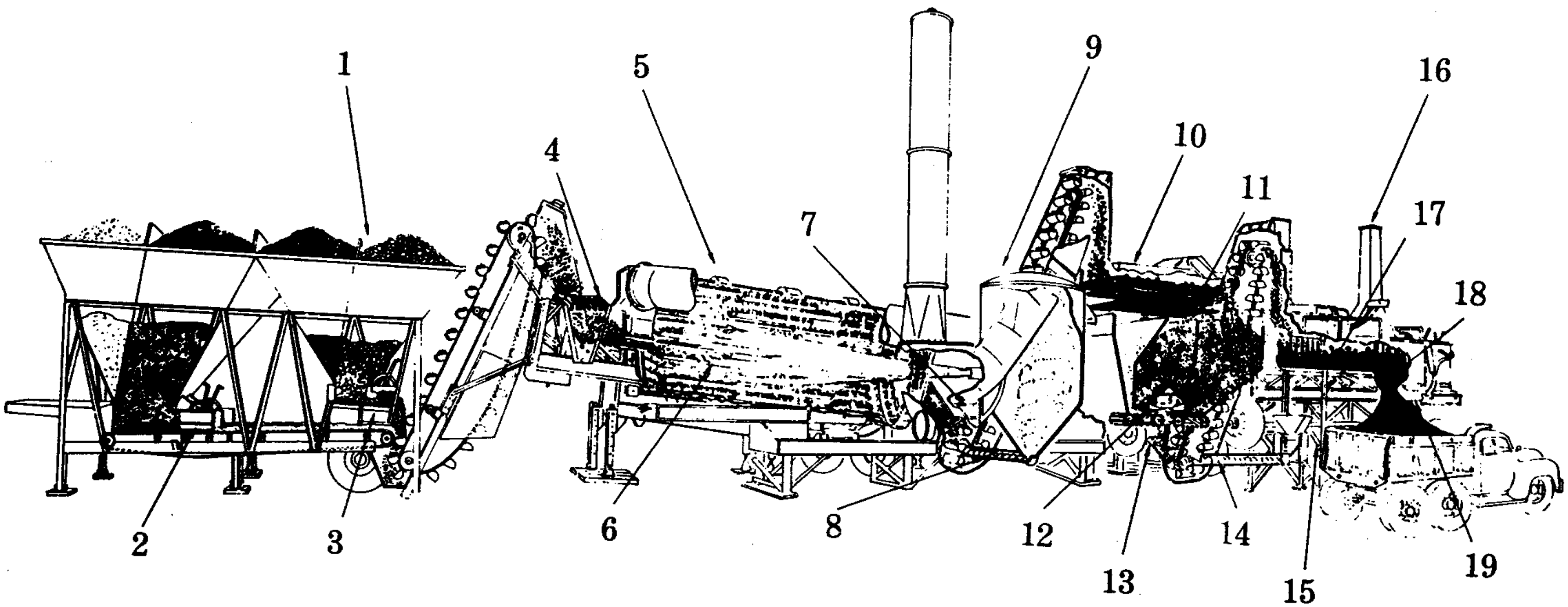
Continuous-mix plants proportion aggregate and asphalt binder materials by volume based on weight. Initial proportioning of aggregate materials are established at the cold-feed system, but final proportions of coarse and fine aggregates are set at the hot bins. The major components of the older continuous-mix plants include the cold-feed system, asphalt binder supply system, aggregate dryer, hot elevator, screen unit, hot bins, pugmill mixer and holding hopper, and emission-control system. The following notes correspond to Figure 401C and briefly describe the older continuous-mix plant:

1. The cold-feed system includes aggregate stockpiles, cold-feed bins, constant-speed feeder conveyors, scalping screen, and cold-feed elevator (e.g., gathering and charging conveyor). Coarse and fine aggregate materials are moved from stockpiles to their respective cold-feed bins. The gate openings under each bin are adjusted to establish the initial proportions of coarse and fine aggregate delivered to the cold-feed elevator and, ultimately, to the aggregate dryer. The proportional flow must not starve the plant's downstream hot bins (i.e., cause imbalance), and the total flow must not exceed the capacity of the aggregate dryer.

2. The opening of the fine bin's discharge-control gate establishes the initial proportion of fine aggregate (e.g., sand) being transferred to the cold-feed elevator.

3. The opening of the coarse bin's discharge-control gate establishes the initial proportion of coarse aggregate being transferred to the cold-feed elevator.

4. Before the combined material is transferred to the aggregate dryer, it usually passes through a scalping screen (e.g., grizzly-type device) to protect the dryer from oversize and foreign material.



CONTINUOUS-MIX PLANT

Figure 401C

5. The aggregate dryer receives a continuous flow of combined aggregate material for heating and drying. The aggregate material is heated and dried through direct exposure to the flame and hot exhaust gases of the burner.

6. The lifting flights in the aggregate dryer repeatedly lift and drop the combined aggregate material in a uniform veil through the flame and hot exhaust gases for maximum heating and drying.

7. A motor and fan supply the air flow needed by the emission-control system and the burner's combustion system in the aggregate dryer.

8. The very fine material collected by the emission-control system (e.g., baghouse) is usually fed by screw conveyor to the boot of the hot elevator.

9. The emission-control system (e.g., dry collector, baghouse) collects the very fine material in the aggregate, indigenous or generated through tumbling in the dryer. These fines may be returned to the mix as mineral filler (See Item #8). The exhaust stack carries exhaust gases above the plant area.

10. The heated and dried combined aggregate material is transported from the dryer to the screen unit, or gradation control unit, by the hot elevator (e.g., bucket elevator).

11. Upon discharge from the hot elevator, the combined aggregate is graded (i.e., separated by size) as it passes through a set of vibrating screens to a series of small hot bins where it is temporarily held. Oversize aggregates are rejected.

12. The hot bins' discharge-control gates are adjusted to accurately proportion coarse and fine aggregate materials for the mix. The aggregate is continuously removed from the hot bins in proportion to the desired gradation of the mix.

13. Aggregate samples may be quickly and easily obtained by diverting the flow of material into test containers.

14. The mineral filler is stored, measured and uniformly fed to the pugmill by mechanical means.

15. A positive displacement metering pump is interlocked with the aggregate feed to ensure that the correct volume of asphalt binder is mixed with the proportioned aggregate material. A transfer pump is used to provide a constant head of binder to the metering pump as the binder is transferred from its storage tank.

16. The pugmill mixer automatically meters the correct volume of asphalt binder for thorough mixing with the proportioned aggregate material that is discharged to the pugmill. The aggregate feed rate and the flow of binder are positively interlocked to control final material proportions. The proportions of aggregate and asphalt binder materials must meet the requirements of the Job-Mix Formula.

17. The twin-shaft pugmill thoroughly and continuously mixes the aggregate and asphalt binder materials as the mix is moved by the mixing paddles to the discharge end of the pugmill.

18. The pugmill is jacketed (i.e., insulated) to maintain the correct temperature of the mix.

19. A small-capacity holding hopper is provided at the discharge end of the pugmill to temporarily store the mix until it can be loaded on a haul truck, thus permitting continuous operation of the plant. The use of the discharge hopper also helps to reduce segregation.

401.2.5 Cold-Feed Systems

The following sections discuss the various components of the HMA plant's cold-feed system.

401.2.5.1 Aggregate Stockpiles

The aggregate materials discussed in Section 401.1.3.1 must be properly handled and stock-piled to minimize segregation, contamination, and moisture. See Section 401.4.2 for guidelines on stockpiling and monitoring for segregation during plant production. As needed, graded aggregates are moved from their respective stockpile by equipment such as a front-end loader to charge the cold-feed bins.

401.2.5.2 Cold-Feed Bins

A separate cold-feed bin will be provided for each aggregate size/type used in production (e.g., coarse, fine, RAP). RAP bins typically have steeper sides to prevent the material from sticking and bridging the gate opening. Bins usually are top-loaded via front-end loader or similar means. Bin compartments in multi-bin units should be separated by a bulkhead or divider at the top to prevent the material from overflowing into an adjacent compartment. This is especially important if the bins are kept full. A discharge-control gate is provided at the bottom of each bin directly over the feeder conveyor system.

401.2.5.3 Total and Proportional Aggregate Flow

The total and proportional flow of aggregate from the cold feed must be established and maintained to:

1. meet the proportions of the Job-Mix Formula,
2. balance production with the needs at the laydown site, and
3. ensure that downstream plant components are not starved for material or exceeded in capacity.

The total flow of aggregate from the cold feed controls the overall rate of plant production. This flow cannot exceed the capacity of downstream plant components (e.g., dryer-drum mixer, aggregate dryer, hot bins). For example, when the aggregate is wet and cannot be easily dried (e.g., after a heavy rain), the total flow may need to be reduced.

The Job-Mix Formula will specify the required proportions of coarse and fine aggregate materials. In dryer-drum plants, final proportional flow is set at the cold feed. In batch-mix and continuous-mix plants, aggregate proportions are balanced at the cold feed to meet the needs of the downstream hot bins, where final proportions are set according to the Job-Mix Formula.

A system of conveyor belts is used to transfer cold aggregate materials from their storage bins to the dryer (batch-mix and continuous-mix plants) or the dryer-drum mixer (dryer-drum plants). The type and configuration of the cold-feed conveyor system varies depending on the type of plant in use. Modern dryer-drum mixing and batch-mix plants usually have a variable-speed feeder belt for each cold-feed bin, a constant-speed gathering conveyor, and a constant-speed charging conveyor. Older continuous-mix and batch-mix plants generally are not equipped with variable-speed feeder belts.

401.2.5.4 Feeder Conveyors

In cold-feed systems equipped with variable-speed feeder belts, the proportion of aggregate from each bin is set by first adjusting the size of the opening in the discharge-control gate and then by fine tuning the speed of the individual feeder belts. Belt speeds are then synchronized to a master control to facilitate changing the total flow and the rate of production without having to change aggregate proportioning. Some HMA plants are equipped with a "no flow" device to detect when aggregate is not available from the bins. (e.g., audible warning, auto shutoff).

During production, it is good practice to calibrate and run each feeder belt at approximately 50% of maximum speed. This will facilitate any needed future adjustment to proportional flow without having to change bin gate openings. Initial cold-feed calibration should include trials at three different gate openings as well as three different belt speeds (e.g., at 20%, 50%, and 80% of maximum). In cold-feed systems equipped with constant-speed feeder belts, the proportional flow of aggregate from each bin is set by adjusting the opening in the discharge-control gate. Production should be calibrated at three different gate settings; one at production rate, one greater than production, and one lower than production.

401.2.5.5 Gathering Conveyor

Some plants are equipped with a constant-speed gathering conveyor, which receives the various sizes of aggregate discharged from the feeder belt system. The coarse aggregate material is generally deposited first, followed by the finer aggregate. This sequence is used to minimize wet fines from sticking to the conveyor belt.

401.2.5.6 Scalping Screen

Cold-feed systems are usually equipped with a scalping screen to prevent oversize or deleterious material from entering the plant's drying and mixing unit (e.g., oversized aggregates, large chunks of RAP, tree roots, clay lumps). In the dryer-drum plant, the scalping screen is usually located at the end of the gathering conveyor but may be located elsewhere (e.g., under the cold-feed bins, over the RAP cold-feed bins). In batch-mix and continuous-mix plants, a grizzly-type device may be located just before the aggregate enters the dryer.

401.2.5.7 Charging Conveyor

The aggregate material coming from the gathering conveyor is usually discharged onto a constant-speed charging conveyor for transport to the aggregate dryer in batch-mix and continuous mix plants or the dryer-drum mixer in dryer-drum plants. The speed of the charging conveyor is independent of the speed of the feeder and gather conveyors. In batch-mix and continuous-mix plants, the aggregate is usually transferred from the cold elevator to a chute at the upper end of the aggregate dryer. In dryer-drum plants, the aggregate is discharged either into a chute above the burner or onto a slinger conveyor under the burner. If equipped with a scraper blade or brush, the belt of the charging conveyor will be self cleaning.

401.2.5.8 Weigh-Bridge Control System

In dryer-drum plants, a weigh-bridge control system will be provided either on the charging conveyor or the feeder conveyor system. The weigh-bridge control system of the dryer-drum plant monitors the "dry" aggregate feed rate, in tons (megagrams) per hour, so that the asphalt binder can be accurately proportioned and fed to the rear of the dryer-drum mixer.

The primary components of the system include a weigh bridge and a belt-speed sensor. The weigh bridge includes a weigh idler and an electronic load cell, which are usually located at midpoint on the charging conveyor. The weigh idler differs from the other idlers fixed on the conveyor frame because it is free to move and is wired to a load cell. As the proportioned aggregate passes over the weigh idler, the load cell transmits the recorded weight to the plant's control system. A sensor, usually located on the gravity takeup pulley, determines the belt's speed. The moisture content of the aggregate must be provided as input to the system. Based on these three values (i.e., weight, speed, moisture content), the plant's control system calculates an equivalent "dry" aggregate feed rate and proportionally pumps asphalt binder from a storage tank to the rear of the dryer-drum mixer. The proportions of aggregate and asphalt binder materials must meet the requirements of the Job-Mix Formula.

It is good practice to periodically check the weigh bridge on the charging conveyor to see that the weigh idler is free to move and that the conveyor belt is tight around the gravity takeup pulley. This will ensure that an accurate weight and speed are being recorded.

The weigh bridge should be calibrated by collecting and weighing a quantity of aggregate passing over the weigh bridge in a set amount of time and comparing that weight to the weight determined by the plant's computer control system. The two weights should be within 1% of each other.

401.2.5.9 Flow Calibration Sampling

In general, the calibration of the cold-feed system may be accomplished during production by drawing a sample and determining the dry weight and proportion of the sample that was fed during the sampling interval. A truck may be used to gather diverted samples from the system if the truck's tare weight is known. Another method involves stopping the conveyor system and removing a length of combined material, say 2 ft. (0.5 m), from the belt. Then, run the system with the flow of coarse aggregate shut off. Remove the same length of fine aggregate from the belt. Dry and weigh both samples to determine the actual percent of materials.

401.2.5.10 Recycled Asphalt Pavement (RAP)

RAP is generally stockpiled and fed through a cold-feed system separate than that used for new aggregate material. During production, manual adjustments are usually necessary to account for the additional moisture in RAP material.

401.2.6 Asphalt Binder Storage and Supply Systems

The asphalt binder storage and supply system generally consists of one or more heated storage tanks and a pumping system. The tanks store and heat the specified asphalt binder material (see Section 401.1.3.2 of this **Manual**) to a constant temperature until it is needed by the mixing unit. The pumping system is used to draw the asphalt binder from its tank to the mixing unit. Depending on the type of plant, the proportion of asphalt binder material will either be manually weighed or automatically metered based on the requirements of the Job-Mix Formula. The grade of binder specified for the project is usually sampled and conditionally accepted at the source; however, a bypass valve is usually provided in the system for verification sampling and to calibrate the pump and metering system.

401.2.6.1 Asphalt Binder Storage Tanks

Consider the following guidelines when inspecting asphalt binder storage tanks at HMA plants:

1. Capacity. The storage tanks at the plant must be of sufficient number and capacity to maintain continuous production while allowing for some delay to refill. To prevent the accidental mixing of different binders, each tank should be clearly labeled, and the tank which is being drawn from during production should be readily apparent.

2. Heating Coils. Heating coils (e.g., hot oil, steam, electricity) will be provided in the tanks to evenly heat and maintain the binder at a constant specified temperature. Most tanks use a closed-coil system of heating oil.

Both the tank and the heating system will be insulated to minimize heat loss.

3. Binder Temperature. The required storage temperature, typically between 300°F (149°C) and 350°F (177°C), will depend on the type of asphalt binder being used. The specified temperature must be maintained. This will ensure that the binder is sufficiently fluid to pump and adequately coat the aggregate material in the mixing unit. A thermometer is usually located near the discharge valve for the purpose of verifying binder temperature. An ideal temperature exists for each grade of binder, which is the lowest temperature that the material becomes sufficiently fluid to coat the aggregate material. If set too high, the binder will prematurely harden, soak into the aggregate, or drain from the mix during transport, thus shortening the life of the pavement.

4. Fill, Discharge, and Return Lines. Return lines must be provided between the tank and the mixing unit to recirculate any unused binder material. The fill, discharge, and recirculation lines are usually jacketed (i.e., insulated) and located near the bottom of the tank. This location prevents oxidation of the binder and provides for a much safer operation.

5. Release Agents. Unless otherwise approved, the use of release agents to coat the inside of storage tanks is not permitted.

6. Admixtures. Admixtures (e.g., binder modifiers, liquid antistrip materials), if used to alter HMA characteristics or to improve adhesion to the aggregate material, are usually added as the binder is pumped into the tank.

7. Storage Periods. Asphalt binders used in HMA production may be stored for relatively long periods without any significant change in consistency. However, cut-back asphalts lose their volatile spirits through evaporation, and the components of asphalt emulsions that are used in prime and tack coats tend to separate over time. If quality is in question, the material should be sampled and tested before use in accordance with the contract specifications. See Section 703 of this **Manual** for guidance on required sampling and testing.

401.2.6.2 Asphalt Binder Pump/Metering Systems

In dryer-drum plants, the quantity of binder is proportioned by volume based on weight. The volume of binder that is pumped from the tank is based on the “dry” aggregate feed rate determined by the weigh-bridge control system on the charging conveyer of the cold-feed system; otherwise the binder is recirculated. Depending on the particular type of dryer-drum plant, one of the following three pump and metering systems will be in use:

1. Constant-Volume Pump/Constant-Speed Motor. In this type of system, the same volume of binder is drawn from the tank at all times based on the opening of the proportioning valve in the line between the pump and the meter.

2. Constant-Volume Pump/Variable-Speed Motor. In this system, the volume of binder delivered to the meter is varied by changing the speed of the motor.

3. Variable-Volume Pump/Constant-Speed Motor. This system typically controls the volume of binder drawn from the tank by automatically changing the volume being pumped.

In batch-mix plants, the amount of binder is proportioned by weight, not volume. Thus, volumetric metering and temperature correction (see Section 401.2.6.3 of this **Manual**) are not necessary to proportion the asphalt binder used in the HMA. Based on the opening of the control valve, the pumping system (i.e., single-line or dual-line) draws the binder from the tank for delivery to the weigh bucket near the pugmill; otherwise it is recirculated back to the storage tank.

401.2.6.3 Asphalt Binder Measurement/ Calibration

Because the proportion of asphalt binder in the final HMA greatly affects pavement stability and durability, it is very important to calibrate and frequently check the quantity of asphalt binder being mixed with the aggregate material. Various measurements and calibrations related to the asphalt binder storage and supply system will be necessary to establish and maintain production. Consider the following guidelines:

1. Volume-Temperature Correction. Asphalt binders expand when heated. For example, the volume a binder occupies when heated to 350°F (177°C) will be greater than the volume it occupies at 300°F (149°C). Because binders may be heated to different temperatures during production, it is necessary to normalize the volume of binder to a standardized temperature (i.e., 60°F [15.5°C]). This is especially important for plants based on volumetric proportioning such as the dryer-drum plant. Such corrections may be accomplished based on the temperature and specific gravity of the binder either automatically via the plant's computer system or manually using calculations or lookup tables in the appropriate attachments of the Inspector's Daily Reports.

2. Storage Tanks. Each storage tank should be equipped with a gauge that displays the quantity of binder in the tank. Otherwise, the quantity of binder must be manually determined using the "tank-stick" method. The tank's total volume may be calculated from its length and diameter. The volume of binder in the tank (i.e., used or remaining) will be based on the level indicated on the "tank-stick" and the temperature and specific gravity of the binder. Remember, the volume of the binder must be converted to an equivalent volume at 60°F (15.5°C). See Item #1 above. Note that the volume of the "heel" (i.e., the old non-circulated binder at the bottom of the tank) may need to be considered in the calculation. If the type of binder in the tank is changed, the "heel" should be removed.

3. Automated Proportioning. In dryer-drum plants, the amount of asphalt binder is proportioned by volume as it is pumped through a meter into the rear of the dryer-drum mixer. Before production begins, the pump and metering system must be calibrated to ensure proper proportioning of binder material. Generally, this is accomplished by diverting a binder sample into a container over a specified period and then normalizing the measured volume as discussed in Item #1 above. This will be necessary unless the pump and metering system is a temperature-compensating device. The binder is usually diverted into an empty container, which has a known tare weight (e.g., distributor truck, empty drum). The actual quantity of binder in the container is determined and compared to that which is indicated by the meter. The pump and metering system should be adjusted if found not to be within specified tolerance (e.g., 0.4%). See Section 708.2 of this **Manual** for additional information on calibrating pump and metering systems.

4. Manual Proportioning. In batch-mix plants, the quantity of asphalt binder is proportioned by weight. A pump is used to draw the binder from its storage tank to the weigh bucket near the pugmill. The scale of the weigh bucket must be periodically checked and calibrated. Test weights will be provided at the plant. This is very important because an excess in quantity of as little as 0.5% above what is specified in the Job-Mix Formula can cause shoving, and a deficiency of as little as 0.5% can lead to raveling. Thus, a difference in 20 lbs (10 kg) of binder

added to a 4000-lb (2000-kg) batch can lead to serious trouble. Check the scale for zero balance, sensitivity, and accuracy according to the requirements of the contract specifications. See Section 708.1 for additional information.

401.2.7 Dryer-Drum Mixer

The operation and material flow of the dryer-drum mixing plant is briefly discussed in Section 401.2.4.1. See Section 401.2.5 and Section 401.2.6, respectively, for information on cold-feed systems and asphalt binder storage and supply systems. The following sections specifically address the dryer-drum mixing unit of the dryer-drum plant.

401.2.7.1 New Aggregate Feed

Although other types of systems are used, the conventional dryer-drum mixer is generally a parallel-flow system, meaning that both aggregate material and the burner's exhaust gas flow in the same direction. New aggregate, proportioned at the cold feed, is fed into the drum at the upper end, where the burner is located, by either a charging chute above the burner (i.e., gravity feed) or a slinger conveyor underneath the burner. As needed, the speed of the slinger conveyor can be increased to throw the material farther down the drum away from the flame. The aggregate material travels through the dryer-drum mixer by a combination of drum rotation and gravity and the lifting flights inside the drum.

401.2.7.2 RAP Feed

If RAP is added to the mix, it is usually transferred from its own cold-feed system to an opening located near the middle of the length of the dryer-drum mixer. This split-feed process protects the RAP material from high temperatures, thus reducing unwanted emissions. The difference in mix discharge temperature and the temperature of the exhaust gas measured at the stack will typically be greater than 20°F (6.7°C) and will usually increase roughly in proportion to the amount of RAP added to the mix.

401.2.7.3 Mineral Filler Feed

To stabilize the HMA, mineral filler (e.g., hydrate lime, Portland cement, fly ash, limestone dust) is usually added to the mix pneumatically through a delivery pipe in the rear of the dryer-drum mixer. The material is mixed with asphalt binder without being exposed to the high-temperature exhaust gas in the upper end of the drum. Various systems such as a storage silo/vane feeder system are used to control and meter the flow of mineral filler. The feed rate depends on the flow of new aggregate and RAP material being delivered to the drum. If the plant is equipped with a dry emission-control system (e.g., baghouse), it is good practice to return at least some of the dry material back to the mix. The dust is usually transferred out of the baghouse by screw conveyor through an air lock. Baghouse fines typically are not metered but returned on a continuous basis.

401.2.7.4 Asphalt Binder Feed

During production, asphalt binder is continuously pumped from its storage tank by a pump and metering system that controls the amount of binder being fed through the delivery line in the rear of the dryer-drum where the binder is injected onto the aggregate. Moisture released from the aggregate materials causes the binder to expand and foam. The aggregates tumble through the foaming binder and are coated in the process. The aggregate veil created by the lifting flights in the upper half of the drum protects the binder and coated aggregates from direct exposure to the burner flame, thus preventing premature hardening of the binder. The remaining lifting flights in the drum allow the asphalt-coated aggregates to continue to be heated until the desired discharge temperature is obtained. The moisture content of the mix upon discharge from the mixer is normally between 0.5% and 1.5% by weight.

401.2.7.5 Burner System

The burner provides the energy necessary to heat and dry the aggregate. The burner system must be able to properly blend sufficient air to obtain complete combustion of the fuel. Otherwise, the unburned fuel may clog the burner, contaminate the mix, and generate unwanted emissions. Several types of fuels may be used (e.g., No. 2 fuel oil). Heavy fuel oil generally requires preheating before use. Periodic checks of the preheated temperature of the fuel oil is good inspection practice to ensure efficient burner operation. Two burner types are generally used: blower-induced draft burner and force-draft, total-air burner. The latter is quieter and more fuel efficient. In some plants, the draft air may be supplied by the emission-control system (see Section 401.2.10). Burner adjustments may be needed during production to compensate for changes in total flow from the cold feed, moisture content in the aggregate, and discharge temperature of the mix. The sound of the burner should be periodically monitored. A uniform, constant roar is desirable. A coughing, sputtering, or spitting sound usually indicates the burner is not completely burning the fuel. Brown stains or lack of binder on coarse aggregates at discharge also indicates fuel is not being completely burned. Visible hydrocarbon emissions (i.e., blue or black smoke from the stack) indicates the temperature of the exhaust gas reaching the rear of the drum is too high.

401.2.7.6 Dual-Zone Configuration

The dryer-drum mixer's interior is divided into two zones: the radiant heating zone and the convection-coating zone. The radiant heating zone (i.e., front half) is where the stream of hot exhaust gas from the burner heats and dries the cold, wet aggregate (i.e., radiant heat). Conductive heating occurs where aggregate particles come in contact with each other. The lifting flights inside the drum cause the aggregate to form a dense, uniform veil across the drum in front of the burner flame, thus maximizing heat transfer and moisture removal. The convection-coating zone (i.e., lower half) is where the aggregate is coated with asphalt binder and further heated. The heat transfer process in the convection-coating zone primarily occurs through convection and conduction. The density of the aggregate veil across the drum is the key to efficient operation and economical fuel usage. The adequacy of the veil can be determined by comparing the temperature of the discharged mix to the temperature of the stack exhaust, assuming that no cooling air is added at the emission-control system. The difference should be within approximately 20°F (6.7°C). A significantly greater differential indicates poor veil density. Presence of light brown, uncoated fines on one side of the mix in the discharge chute also is an indication of poor veil density. Veil density can be increased by lowing the slope of the drum or by adding kicker flights, dams, donuts, or retention rings near the drums mid-section.

401.2.7.7 HMA Discharge

Upon discharge from the dryer-drum mixer, the HMA is deposited onto a conveying device (e.g., drag slat conveyor, belt conveyor, bucket elevator) for transport to a surge silo (see Section 401.2.11). Because a dryer-drum plant manufactures HMA on a continuous basis, a surge silo is required to temporarily store the HMA until it can be loaded into a haul truck, essentially converting the continuous-mix operation to a batch process. The top of the surge silo is normally equipped with a "batcher" or other device that prevents mix segregation as the HMA is discharged in the silo.

401.2.7.8 Production Considerations

Dryer-drum mixing plants are rated by the number of ton (megagrams) of HMA that can be produced per hour. Production rate is determined at a given mix discharge temperature and at an average moisture content in the aggregate, usually 5%. Production capacity is affected by many factors including the moisture content and the temperature of the aggregate coming from the cold feed, mix discharge temperature, drum diameter, fuel type, exhaust gas velocity, etc. An increase in the moisture content and/or an increase in the mix discharge temperature decreases the capacity of the plant. By far, the most significant factor affecting production rate is the moisture content of the combined aggregate. Fines tend to be more problematic because they tend to retain more moisture than coarse aggregates. As the average percentage of moisture increases, the production capacity of a specific dryer-drum mixer decreases because of the limited maximum capacity of the exhaust fan. Production rates for RAP mixes, up to a RAP content of about 50%, will normally be similar to the production rates for mixes containing 100% new aggregate. Above that, the production rate of the conventional dryer-drum mixer decreases as the RAP content increases.

401.2.8 Batch-Mix Plant

The operation and material flow of the batch-mix plant is briefly discussed in Section 401.2.4.2. Information applicable to the cold-feed systems used in batch-mix plants is discussed in Section 401.2.5, and Section 401.2.6 discusses asphalt binder storage and supply systems. The following sections discuss the batch-mix plant operation from the aggregate dryer to final discharge of the HMA batch. Some systems discussed in this section, if applicable to the older style continuous-mix plants, will be identified as such.

401.2.8.1 Aggregate Dryer/Burner System

The aggregate dryer/burner system found in batch-mix plants and the older style continuous-mix plants is used to heat and dry the aggregate supplied from the cold-feed system to the required temperature and moisture content. The system is composed of a rotating drum, lifting flights, burner system, discharge chute, and temperature sensing element. Consider the following guidelines:

1. Aggregate Flow/Operation. The cold, wet aggregate from the cold feed is fed into the upper end of the drum and moved through the dryer toward the burner at the lower end by a combination of drum rotation and gravity and the lifting flights inside the drum. The lifting flights are longitudinal cups or channels that lift and drop the aggregate in veils through the burner's flame and hot exhaust gas, thus maximizing heating and drying. Moisture is removed and carried out with the exhaust stream. The hot, dry aggregate exits the dryer through a discharge chute where it is transferred to the hot elevator.

2. Burner System. The burner system supplies the energy necessary to heat and dry the cold, wet aggregate. Depending on the plant, the burner may be either manually or automatically controlled. If automated, the burner control unit generally is wired to the temperature sensing element in the discharge chute. The burner is generally fueled by either oil or gas and includes a draft-air system (e.g., fan and motor) that supplies the air needed for total fuel combustion. See Section 401.2.7.5 for additional information on burner systems.

3. Temperature Control. A temperature sensing element (e.g., electric thermometer or pyrometer) is usually located in the discharge chute to measure and record the aggregate discharge temperature and, if so equipped, control the operation of the burner. If the sensing element is not operating correctly, a hand thermometer can be used to check the aggregate discharge temperature. Manual burner adjustments may be necessary until the unit can be properly adjusted.

4. Discharge Temperature/Moisture Content. The magnitude of the aggregate discharge

temperature varies based on production, environmental, and other factors. The objective is to obtain a uniform temperature at this point during production. The required moisture content of the aggregate when discharged from the dryer should generally be less than 0.5%.

5. RAP Considerations. RAP should never be placed in the aggregate dryer and exposed directly to the burner flame. For RAP mixes, the recycled material normally is added to the weigh hopper as additional aggregate and heated by conduction. Operations that add RAP to the hot elevator should place the RAP on top of the superheated new aggregate already in the elevator buckets. The temperature to which the new aggregate must be heated varies and is a function of the percent RAP added, its moisture content, and the required discharge temperature of the mix. To prevent dryer damage, the new aggregate should not be heated in excess of 500°F (260°C). Consider reducing the percent RAP if it is determined the new aggregate must be heated to a greater temperature to produce the mix.

401.2.8.2 Screening Unit

The screening unit found in batch-mix plants is used to separate the aggregate material that was initially proportioned and combined at the cold-feed system into the aggregate sizes required by the Job-Mix Formula. A similar feature is provided in the older style continuous-mix plants. Consider the following guidelines:

1. Aggregate Flow/Operation. The hot, dry aggregate from the aggregate dryer/burner system is transported by a hot elevator (e.g., bucket elevator) to the screening unit at the top of the batch-mix plant's mixing tower. As the material passes through the screening unit, each grade of aggregate material is discharged into its respective hot bin below the unit. The finest aggregate material passes directly into hot bin #1. The screens should be checked regularly for holes, blinding, overruns, and inefficient operation.

2. Screen Selection. The screening unit usually includes four flat, vibrating screen decks with a scalping screen covering the top deck to reject oversized aggregates. Screen selection is based on the aggregate size requirements of the Job-Mix Formula and the initial proportioning of the aggregate sizes at the cold feed. To determine a working combination of screen sizes for production, consider using a screen with the smallest practical openings over hot bin #1. Then, select screens that will separate the remaining material into the required sizes by equally dispersing the graded material among the remaining hot bins. If aggregate particles are predominantly round, the use of a slotted No. 6 screen over hot bin #1 is often preferred. However, if the aggregates tend to wedge in the slots, consider using a screen with square openings. Clogging and blinding can also be minimized by using screens with slightly larger openings.

3. Efficiency. The efficiency of the screening unit in separating individual sizes of aggregate should be about 85% to 90%. In other words, no more than 10% to 15% of the total material in a particular hot bin should be finer than the smallest aggregate size specified for that bin.

4. Capacity/Overrun Problems. The rate and gradation of fines passing through the screening unit and entering hot bin #1 are controlled primarily at the cold-feed system and the emission-control system, if the latter is set to return captured fines. When the screening unit is properly operated, the rate and gradation of the coarser aggregates entering the other hot bins will be practically constant. However, if too much material is being fed to the screening unit, a thick layer of aggregate will form on the screens causing #1 fines to fall into other bins. The capacity of the screening unit varies from plant to plant and should be closely

monitored for problems. More than 16% of #1 fines appearing in another bin is a definite sign of trouble. Such overruns greatly affect mix uniformity and should be corrected immediately.

401.2.8.3 Hot Bins

The hot bins found in batch-mix plants are used to hold the aggregate sizes graded by the screening unit and to proportion the material based on the requirements of the Job-Mix Formula. Similar hot bins are found in the older style continuous-mix plants, albeit in a somewhat different operation and configuration. Consider the following guidelines:

1. Aggregate Flow/Operation. In batch-mix plants, several hot bins will be provided under the screening unit to catch and store the hot, dry aggregate as it passes through the vibrating screens of the screening unit. The number of hot bins required will depend on the number of aggregate sizes required by the Job-Mix Formula. The capacity of the hot bins will be sufficient to store the quantity of graded material necessary for batch production. When a batch of HMA is to be produced, the discharge-control gates at the bottom of the hot bins are opened to allow the aggregate to fall into the weigh hopper.

2. Bin Partitions/Overflow Pipes. Each hot bin will be separated by a partition that must be tight, free from holes, and of sufficient height to prevent intermingling of material between bins. Each bin will be equipped with an overflow pipe designed to discharge excess material before it overflows into an adjacent bin. Overflow pipes must be checked regularly to ensure that they are not clogged. If material overflows into an adjacent bin or significant intermingling occurs, a large quantity of non-conforming HMA may be produced before the trouble is noticed and corrected.

3. Discharge-Control Gates. In batch mix-plants, a discharge-control gate will be provided at the bottom of each hot bin. The gates are opened only when a batch is to be produced and may be operated either manually or automatically, depending on the type of plant being used. Discharge-control gates must be maintained and regularly checked to ensure that material does not leak into the weigh hopper. Because the amount of fines and filler has such a significant affect on the characteristics of the HMA, check the gate on hot bin #1 regularly to make sure fines do not continue flowing into the weigh hopper after shut-off. In the older style continuous-mix plants, the discharge-control gates must be adjusted and locked in place to provide a continuous and uniform flow of material from each hot bin to the pugmill mixer.

4. Balancing Aggregate Flow. Total and proportional aggregate flow in a batch-mix plant are initially established at the cold feed. Final proportions are set at the hot bins by first adjusting the gate opening of the hot bin that contains the desired aggregate size and then measuring the quantity deposited in the weigh hopper in proportion to the total aggregate for the batch. A key to successful batch-mix plant operation is to balance the flow from the cold feed with the capacity of the screening unit/hot bins and the demand for aggregate during production. If the flow at the cold feed is not set properly, the capacity of the screening unit/hot bins may be exceeded and the supply of aggregate in the hot bins may become unbalanced (e.g., one hot bin may overflow while another runs short). Overflows and shortages must be corrected immediately.

5. Aggregate Sampling. Small gates or windows are usually provided on the sides of hot bins for sampling purposes. Otherwise, samples may be taken by diverting the flow of aggregate from the bin into a sampling container.

401.2.8.4 Weigh Hopper/Weigh Bucket

In batch-mix operations, the aggregate and asphalt binder materials are proportioned by weight for each batch of HMA produced. This is accomplished through the used of an aggregate weigh hopper located just below the discharge-control gates of the hot bins and an asphalt weigh bucket located above the pugmill. The materials are weighed and proportioned just before they are emptied into the pugmill mixer. Consider the following guidelines:

1. New Aggregate Feed. The aggregate weigh hopper is located directly underneath the graded aggregate hot bins. The weigh hopper is generally suspended on a springless-dial scale from which the weight of aggregate from each hot bin can be cumulatively observed and recorded. The last reading on the dial will be the total amount of aggregate for the batch of HMA. The sequence of weighing from each hot bin must be strictly observed. The recommended sequence of discharge is to weigh coarse aggregate first followed by the finer material.

2. RAP Feed. If a RAP mix is being produced, RAP material is generally transferred from a separate cold-feed system to the weigh hopper and added to the mix as additional aggregate. The RAP material should be placed in the center of the weigh hopper so that the hopper is not unbalanced and an accurate weight of the material can be obtained. Heat transfer to the RAP material begins as soon as the RAP comes into contact with the superheated new aggregate. Heat transfer continues as all heated materials are mixed in the pugmill.

3. Mineral Filler Feed. To stabilize the HMA, mineral filler (e.g., hydrate lime, Portland cement, fly ash, limestone dust) is usually added to the mix. Various systems such as a storage silo/vane feeder system are used to transfer the mineral filler to the weigh hopper. If a dry emission-control system (e.g., baghouse) is used at the plant, it is good practice to return at least some of the captured material back to the mix. The dust is usually removed from the baghouse by screw conveyor through an air lock. When placed in the weigh hopper, the mineral filler should be sandwiched between two other aggregate sizes from the hot bins so that the cold material will be warmed by the superheated aggregate. This also promotes thorough mixing when discharged into the pugmill.

4. Asphalt Binder Feed. The asphalt binder is usually weighed in an overflow-type bucket that is suspended on a springless-dial scale. Section 401.2.6 provides additional information on asphalt binder storage and supply systems. At the same time that the aggregate is being proportioned and weighed, the asphalt binder is pumped from its storage tank to a separate weight bucket located on the mixing tower just above the pugmill. The proper amount of asphalt binder is weighed in the heated bucket and held until it is discharged into the pugmill.

5. Scales. The scales used to weigh aggregate and asphalt binder materials must be certified. See Section 401.2.1 for information on certification of scales. Before production begins, it is good practice to check that the scales are clean, operational, and calibrated. Each scale will be equipped with a zero adjustment to allow the operator to quickly compensate for any accumulation of dust and/or asphalt binder during production. Modern batch-mix plants have fully automated controls for material proportioning and mixing, including an automatic printer system that records the weight of each material delivered.

6. Example Batch Procedure. The coarser aggregate, including RAP if used, should be discharged from the hot bins into the weigh hopper first, followed by the mineral filler and then #1 fines. At the same time, the asphalt binder will be weighed in the weigh

bucket. This weighing sequence must be strictly observed. When batch tickets are used to guide the plant operator, the ticket will list aggregate materials as cumulative weights (i.e., each greater than the one above it), which will coincide with the dial readings on the weigh hopper scale. The following is an example of an HMA batch ticket:

Hot Bin #3	980 lbs (444 kg)
Hot Bin #2	2110 lbs (957 kg)
Mineral Filler	2260 lbs (1025 kg)
Hot Bin #1	3768 lbs (1710 kg)
Asphalt Binder	232 lbs (105 kg)
Total Batch	4000 lbs (1815 kg)

In the second line above, 2110 lbs (957 kg) is the cumulative weight of material from hot bins #3 and #2, or the sum of 980 lbs (444 kg) and 1130 lbs (513 kg). Similarly, 3768 lbs (1710 kg) is the cumulative weight of the aggregate materials discharged into the weigh hopper from all three hot bins, including the mineral filler.

401.2.8.5 Pugmill Mixer

In batch-mix plants, after the aggregate and asphalt binder have been properly proportioned with the weigh hopper and weigh bucket, the materials are introduced into the pugmill for mixing. The pugmill mixer found in batch-mix plants and the older style continuous-mix plants are essentially the same, except for the variations in the arrangement of the paddle tips. Consider the following guidelines:

1. Mixer Components. The pugmill includes twin shafts equipped with paddles for mixing the materials into a homogenous mass. The primary components include paddle tips, paddle shanks, spray bar, liners, shafts, discharge gate, and heated jacket.

2. Efficiency. Efficient mixing operation depends several factors including the number and shape of the paddle tips, the speed (i.e., RPM) of the mixing shafts, the length of mixing time, the temperature of the combined materials, the quantity of materials in the mixer, and, especially, the clearance between the paddle tips and the liner plates. The paddle tips and liner plates should be periodically checked for excessive wear. When the manufacturers specified clearance is exceeded, the paddle tips and liner plates should be replaced.

3. Material Flow/Operation. The operation of the pugmill in batch-mix plants includes a dry-mix and a wet-mix period. When a batch of HMA is ready to be produced, the proportioned aggregate material in the weigh hopper is dumped into the center of the pugmill and mixed for a brief dry-mix time. The asphalt binder from the weigh bucket is then dumped into the center of the pugmill and mixed with the aggregate for a wet-mix time. The wet-mix time should not be more than that required to completely coat aggregate particles with a thin film of binder. The paddle tips are arranged to mix the combined materials in a figure-eight pattern and produce a hot, homogenous mass. After the wet-mix period, the gates on the bottom of the pugmill are opened and the batch is discharged into the haul vehicle or into a conveying device that carries it to a storage silo. Modern batch-plants are usually equipped with both a control that automatically regulates dry- and wet-mix times and a batch counter that records the total number of batches produced.

401.2.8.6 Production Considerations

The aggregate dryer and the pugmill are two locations in the batch-mix plant that have the greatest affect on the rate of production. It is also important that temperatures be monitored at key locations to ensure proper operation. Consider the following guidelines:

1. Aggregate Dryer. The length of time it takes the aggregate material to pass through the

dryer is a function of the slope of the dryer, its speed of rotation, diameter, length, and number and design of lifting flights. The length of time required for heating and drying is primarily dependant on the moisture content in the aggregate coming from the cold feed and the required temperature at discharge. Most dryer inefficiencies stem from feeding too much wet material to the dryer and from improper burner operation. The quantity of aggregate fed to the dryer always should be slightly less than that which can be thoroughly heated and dried.

2. Pugmill. The pugmill should be operated at nominal capacity. Both overloading and underloading can significantly decrease production efficiency. The dry-mix time should be minimal, usually no more than 1 to 2 seconds. The wet-mix time should be no longer than that required to properly coat the aggregate, usually around 27 seconds. The length of time needed to open the pugmill gates and discharge can be 7 seconds in some cases. Therefore, the total mix/ discharge cycle, regardless of pugmill size, can be as short as 35 seconds. If trucks or a storage silo are readily available, the plant should not be idled; however, if the material cannot be readily discharged, pugmill operation should be halted.

3. Monitoring Temperatures. Once production and a uniform discharge temperature at the aggregate dryer are established, a temperature check of the aggregate in each hot bin should be performed. This check will provide evidence of incomplete drying. If incomplete drying is occurring, the coarse aggregate in the hot bins will be significantly cooler than the fine material in hot bin #1, due to the cooling effect of evaporation. Furthermore, it is not good practice to have the temperature of the #1 fine aggregate 40°F (4.4°C) or more above the mixing temperature. If the temperature of the aggregate is maintained too high, the aggregate will absorb the asphalt and there will be an increased hardening of the binder. Check temperature regularly during production and calibrate pyrometers and thermometers on an as needed basis.

401.2.9 Continuous-Mix Plant

The operation and material flow of the older style continuous-mix plants are briefly discussed in Section 401.2.4.3. The design and operation of the continuous-mix plant is similar to the batch-mix plant up to the point where the hot, dry aggregate is discharged from the hot bins. At this point and beyond, the continuous-mix plant significantly differs from the batch-mix plant. Primary differences include:

1. aggregate and asphalt binder materials are proportioned by volume rather than weight;

2. aggregate and asphalt binder feeds are interlocked to mix and discharge the HMA continuously rather than in a batch process;

3. production rate is independent of mixing time and is a function of the number of revolutions of a single shaft in the pugmill, not the number and quantity of batches; and

4. variations in material proportions are very small once established, but changing from one type of HMA to another is difficult and time consuming.

401.2.9.1 Cold-Feed System

Section 401.2.5 discusses the cold-feed systems typically used in HMA plants. The cold-feed systems used in continuous-mix plants are similar to those used in batch-mix plants with one exception: a constant-speed feeder belt system is generally used under the cold-feed bins. The total flow and initial proportions of the cold, wet aggregate material are initially established at the cold feed by adjusting the openings of the cold bins' discharge-control gates. The combined material is deposited on a gathering conveyor, which is then transferred to a charging conveyor for delivery to the aggregate dryer. If a RAP mix is being produced, the RAP material is usually transferred from a separate cold-feed bin to the pugmill by a charging conveyor.

401.2.9.2 Aggregate Dryer/Burner System

From the cold-feed system, the cold, wet aggregate is transferred by the charging conveyor to the upper end of the aggregate dryer. Inside the aggregate dryer, the moisture in the combined aggregate is removed as the material is heated from ambient temperature to the desired mixing temperature. The hot, dry aggregate then exits the dryer and is carried up by an inclined hot elevator (e.g., bucket elevator) to the screening unit. If a RAP mix is being produced, RAP material should never be introduced into the aggregate dryer where it would be exposed to the direct flame of the burner. See Section 401.2.8.1 for additional information on aggregate dryer/burner systems.

401.2.9.3 Screening Unit

From the aggregate dryer, the hot elevator transfers the hot, dry aggregate to the screening unit. The screening unit separates the combined material into the various aggregate sizes required by the Job-Mix Formula and deposits each size into their respective hot bins. See Section 401.2.8.2 for additional information on screening units.

401.2.9.4 Hot Bins

Section 401.2.8.3 presents a discussion on the hot bins that are typically used in batch-mix plants. Although similar, the hot bins generally found in continuous-mix plants are smaller and are used only to temporarily queue the hot, dry and graded aggregate in a continuous operation. Up to the discharge point of the hot bins, the functions of the continuous-mix plant and the batch-mix plant are essentially the same.

401.2.9.5 Pugmill Mixer/Holding Hopper

Hot, dry aggregate material is continuously removed from the hot bins for transport to the pugmill mixer based on the proportions required by the Job-Mix Formula. See Section 401.2.8.5 for additional information on pugmill mixers. Consider the following guidelines:

1. <u>New Aggregate Feed</u>. In continuous-mix plants, the discharge-control gates on the hot bins must be adjusted and locked in place to provide a continuous and uniform flow of proportioned material from each hot bin to the pugmill mixer. The final proportion of aggregate material, including mineral filler, is set based on the requirements of the Job-Mix Formula.

2. <u>Asphalt Binder Feed</u>. The asphalt binder is delivered to the pugmill through a calibrated metering pump. The aggregate feed and the asphalt binder pump are interlocked, geared, and wired to a common power source so that proportions of aggregate and asphalt binder remain constant, regardless of variations in power supply. Asphalt binder is continuously pumped from its storage tank to the pugmill and sprayed on the aggregate based on the feed rate of the proportioned aggregate material coming from the hot bins. The asphalt binder, measured by volume instead of weight, is mixed continuously with the aggregate as the two materials are moved toward the discharge end of the pugmill by the mixing paddles.

3. <u>Holding Hopper</u>. Because the mixing is a continuous process, a small-capacity, temporary holding hopper is provided at the discharge end of the pugmill to queue the material until it can be discharged into a haul truck.

4. RAP Feed. If a RAP mix is being produced, the RAP material is usually transferred from a separate cold feed to the pugmill by a charging conveyor. The RAP material is added proportionally, by volume, to the new superheated aggregate. Heat transfer to the RAP occurs as it is mixed with the superheated materials and moved toward the discharge end of the pugmill.

401.2.9.6 Production Considerations

It is good practice to obtain a copy of the manufacturer's operating instructions for continuous-mix plants. These instructions will show the operating speed of the hot aggregate feed in relation to the asphalt binder delivery rate for various sprocket sizes. Consider the following guidelines:

1. Aggregate Flow Calibration. Before production begins, carefully calibrate the flow of aggregate from each hot bin. Weigh the quantity discharged at various gate openings and compute the quantity delivered per revolution of the feeder drive shaft. A plotted curve is a convenient way to graphically illustrate the relationship between the quantity delivered and the size of the gate openings.

2. Asphalt Binder Flow Calibration. The sprocket size setting on the asphalt binder pump must correspond to the binder delivery rate required. Check that the sprocket is set correctly. As needed, check the delivery rate by weighing the quantity of binder delivered into a container over a carefully timed interval. Volume-temperature corrections will apply (see Section 401.2.6.3). To control fluctuations in percent binder, a thermometer will usually be installed in the circulating line just ahead of the pump. Because binder temperature must be tightly controlled, check the operation of this thermometer regularly.

3. Mixing Time Adjustments. In the pugmill of continuous-mix plants, materials are fed into one end and the paddles move the HMA to the discharge end while mixing occurs. Mixing time can be increased or decreased either by changing the pitch of the paddles or by changing the height of the discharge gate. To increase mixing time, it is good practice to first reverse the pitch of the paddles so that the mix is approximately level from the discharge gate to the middle of the pugmill, leaving a gradual slope to the feed end. The mixing time can then be fine tuned by raising the height of the discharge gate and increasing the level of the mix. Do not allow the mix level to exceed the top of the arc described by the paddles, measured as the paddles are at rest. If the required mixing time cannot be established without exceeding this limit, the plant must be reset to a lower rate of production.

4. Mixing Time Calculations. The following equation may be used to calculate the mixing time for continuous-mix plants:

   $$T = C/R$$

   where:

   T = mixing time, sec;
   C = pugmill dead capacity, lb (kg); and
   R = pugmill discharge rate, lb/sec (kg/sec).

   The pugmill dead capacity (C) may be determined by stopping the pugmill and removing and weighing the entire contents. Some material will adhere to the inside components of the pugmill. A practical method to estimate the weight of this remaining material is to scrape a sample from a given area that is readily accessible, weigh the sample, and estimate the contents assuming the remaining material adheres to other areas at the same rate.

   Alternatively, mixing time can be determined from other data including data obtained from the plate affixed to the pugmill or from the manufacturer's literature. In such cases, use the following equation to calculate mixing time:

T = CVD/R

where:

T = mixing time, sec;

C = conversion constant, 1.80 (3.60 for metric);

V = pugmill volume, ft^3 (m^3);

D = density of pugmill contents, 100 lb/ft^3 (1600 kg/m^3); and

R = rate of plant production, ton/hr (Mg/hr).

Unless otherwise directed, the minimum mixing time (T) should be approximately 45 seconds. If an examination under a strong light of the coarser particles discharged shows that at least 95% of the particles are completely coated with binder, the minimum mixing time is sufficient. Otherwise, the mixing time must be increased to literally provide a complete coating of the particles. If small uncoated areas or specks are visible on the aggregate particle, that particle must be classified as uncoated.

401.2.10 Emission-Control Systems

All HMA plants have a small quantity of fine material that is ejected with the exhaust stream of the dryer-drum mixer or aggregate dryer. To meet Federal and State air-quality requirements, emission-control systems are required on HMA plants to capture fine particulate matter, which otherwise may be released into the atmosphere. In addition, rather than wasting collected fines, most plants return the material back to the mix, thus preserve the integrity of the original aggregate gradation.

401.2.10.1 Purpose and Classification

Emission-control systems serve two purposes: they reduce the amount of emissions to the atmosphere, and they return the collected material back to the mix. Emission-control systems may be classified as either primary or secondary. The purpose of the primary collector is to remove the largest of the finer particles from the plant's exhaust stream, thus reducing the load on the secondary system. The secondary collection system is used to capture the finest of particles.

401.2.10.2 Types of Systems

There are three basic types of emission-control systems found in HMA plants: dry collectors, wet collectors, and baghouses. The dry collector is a primary collector, which will be located before one of the other two types of systems. The baghouse and wet collector are secondary systems, through which the exhaust gas flows once cleaned by the primary system. Most plants use a dry-collection system as its primary system and a baghouse as its secondary system. The fines collected are either wasted or, desirably, fed uniformly back to the mix. If a wet collector is used in lieu of a baghouse, the fines collected should not be returned to the mix.

401.2.10.3 Production Considerations

HMA plants in West Virginia are required to have a baghouse as the secondary system. See Section 401.2.1 for additional information on plant certification and emission-control systems. Consider the following guidelines during inspection of emission-control systems:

1. Dust Trail. Check the plant's stack exhaust for a dust trail at the end of the steam plume. If one exists, check the operation of the emission-control system.

2. Pressure Drop. The pressure drop across the bags in baghouse operations should be in the

range of 2 in (50 mm) to 6 in (150 mm) of water column.

3. Exhaust Temperature. The temperature of the exhaust gas entering the baghouse should not exceed 400°F (205°C); otherwise, the plant's automatic shutoff should stop production. Higher temperatures are a good indication of an inefficient veil of aggregate inside the dryer-drum mixer or aggregate dryer.

4. Wet Collector. If a wet collect is used, periodically check the spray nozzles in the venturi to ensure that all are open and spraying water. Additionally, check the cleanliness of the water being returned to the spray nozzles from the pond at the point where the water is drawn by the pump. This is the point where clogging occurs. If a wet collector is used, the fines collected should not be returned to the mix.

5. Gradation. During production, the design and actual mix gradation should be compared, whether or not collected fines are returned to the mix. Either case significantly affects gradation.

401.2.11 Surge and Storage Silos

At the discharge end of many HMA plants, the final mix is transported to a specially designed bin called a silo. Silos come in a variety of shapes including circular, oval, elliptical, rectangular, and square. The circular shape is commonly used because it tends to introduce less mix segregation. Depending on the type of plant, the silo may be either a surge or storage silo.

401.2.11.1 Surge Silos

The primary purpose of the surge silo is to turn a continuous-mix operation (e.g., dryer-drum plant) into a batch process and to temporarily hold batch surges from batch-mix plants when haul trucks are not available. Surge silos are designed to hold HMA for relatively short periods (e.g., 2 to 3 hours) and, thus, are smaller in capacity and generally insulated but not heated. This makes the surge silo unsuitable for use as a storage silo. The proper use of surge silos increases productivity by minimizing stop-and-go operations, which also minimizes plant emissions and variability in mix composition and temperature.

401.2.11.2 Storage Silos

The primary purpose of the storage silo is to hold the HMA for periods longer than a surge silo (e.g., overnight). Storage silos have relatively larger capacities and are both insulated and heated, either partially or completely. The discharge gates are heated and sealed to reduce the amount of air infiltration, and inert gases and additives (e.g., silicone) are usually added to retard hardening of the mix. A storage silo can also be used as a surge silo.

401.2.11.3 Conveyor Systems

A variety of systems are used to transport the mix from the plant's discharge to the silo. These systems include belt conveyors, bucket elevators, skip hoists, screw conveyors, and slat conveyors. Slat conveyor systems are commonly used. Their primary purpose is to convey and charge the silo without introducing mix segregation or causing an appreciable drop in mix temperature. On some systems, the speed of the conveyor can be adjusted to better match the plant's rate of production.

401.2.11.4 Charging Operations

Mix segregation will occur if the mix is continually dropped in a conical pile or thrown to one side of the silo. To minimize segregation, the top of surge and storage silos are equipped with baffles, splitters, rotating chutes, or batchers to disrupt the continuous flow of mix into the silo. The most effective and commonly used system is the batcher, which is a holding hopper that momentarily holds the mix coming from the conveyor. The conveyor system must be set to deposit the mix in the center of the batcher. When dumped from the batcher, the mix falls in a mass and uniformly splats in all directions, thus minimizing segregation. For the batcher system to function properly, the silo cannot be completely full and the batcher's gate timer must be properly controlled. If the batcher gate is improperly timed or left open, the mix will continuously flow, defeating the purpose of the batcher. To help monitor mix level, some silos are equipped with a high-level warning indicator.

401.2.11.5 Discharge Operations

The bottom of silos generally have a conical shape, which are generally heated in storage silos. The steep angle of the cone walls and a large gate opening at the bottom ensures that larger aggregates do not roll into the center of the cone when discharged and, thus, cause mix segregation. Even with this design, segregation may occur if the level of mix drops below the top of the cone. To help monitor this situation, silos may be equipped with a low-level warning indicator. Additionally, silos may have a discharge batcher to load trucks in the same manner the silo is charged, which further reduces the potential for mix segregation.

401.2.11.6 Production Considerations

Segregation caused by improper silo operation is common and most evident behind the paver, appearing as a dark strip along one side of the lane being paved. Gap-graded mixes and mixes that have a significant proportion of coarse aggregate material are especially susceptible to this phenomena. If this type of segregation is suspected, consider having several haul trucks pull under the silo in a direction opposite their normal loading pattern. If the segregation behind the paver changes from one side to the other, the problem is most likely created at the silo.

Over prolonged storage periods, an HMA mix tends to harden due to oxidation. Although storage silos are designed to minimize premature hardening (e.g., heated cones and batchers, insulated walls, inert gases), it is good practice to check mix temperature and quality if a problem is suspected. The mix should be free of segregation and mix temperature and quality must not degrade below the limits required by the contract specifications. With demonstrated positive results and previous approval from the District Materials Supervisor, HMA mixes may be stored in either surge or storage silos for up to a maximum of 12 hours, and up to 24 hours for some dense-graded mixes. Beyond these limits, consider the need to check mix temperature for acceptance and to visually inspect the mix for hardening or stripping of the binder. Any needed mix samples should be taken from haul trucks immediately after loading.

401.2.12 <u>Truck Loading and Hauling</u>

The following sections present guidelines on truck loading and hauling that should be considered during HMA production.

401.2.12.1 Haul Trucks

Haul trucks that are used on the project should be inspected prior to beginning plant production. In general, they must be adequately maintained and capable of effectively hauling and loading the completed mix to the paver at the laydown site. The primary objective is to not have the truck fleet become the critical path during the paving operation. There are too many other factors that are critical to production. To adequately document the quantity of mix delivered in the Inspector's Daily Report, ensure that each haul truck is assigned a number, or some other means of identification, before the operation begins. In addition, a small hole shall be provided in the side of all haul trucks to obtain mix temperatures.

401.2.12.2 Release Agents

Before loading, the truck bed should be free of all debris and lightly, but uniformly, coated with an approved release agent. The use of diesel fuels or solvent-based products, which can dissolve the binder film from the aggregate, are prohibited. After treatment, make sure the truck bed is raised to remove any excess release agent before the truck is loaded. All release agents collected from this operation shall be properly disposed of in its entirety. Note that if a polymer modified performance-graded binder is used in the mix, it is best to use a release agent that is recommended by the binder supplier.

401.2.12.3 Covers and Insulation

All truck beds shall be insulated and provided with a waterproof cover. The cover shall be suspended slightly above the HMA mixture, extend over the sides of the truck, and be securely fastened to eliminate air infiltration and to prevent water from coming into contact with the mixture. Heat loss of the mixture due to the cooling effects of wind and rain on the top of the load and heat loss through the sides of the truck shall thereby be minimized.

401.2.12.4 Truck Scales

All plants must be equipped with truck scales or a hanging weigh hopper under the silo to accurately weigh the quantity of material being delivered. Scales and test weights must be certified by the West Virginia Division of Labor or similar agency if outside West Virginia. Note that truck scales are not required at automatic batch-mix plants that monitor and print mix quantities delivered. Obtain and attach any digital printouts to Inspector's Daily Report. The printout should include project number, item number, truck identification, number of axles, gross, tare, and net weights as well as the time and date of loading and the signature of the scale operator. Notify the Project Engineer/Supervisor of any scale malfunctions and recalibrate as needed.

401.2.12.5 Loading

Haul trucks should never be loaded by slowly driving the truck forward as the mix is being delivered from the silo. This will cause coarser aggregate particles to collect at the tailgate of the truck and significantly increase the amount of segregation that occurs at the laydown site. To minimize segregation, each haul truck should be loaded in multiple drops from the silo. The first drop should be placed toward the front of the truck. After the truck moves forward, the second drop should be placed near the tailgate. The last drop should be placed between the first two drops, and so forth. This will minimize segregation of the coarser aggregate materials. The operator should never be allowed to dribble small amounts of mix into the bed for the purpose of topping off the load to legal capacity.

401.2.13 Inspection Guidelines

Section 401.1 discusses HMA material requirements, Quality Control Plan, certified technicians, reference materials, and Job-Mix Formulas. The following sections present general guidelines that should be considered during HMA production and hauling inspection.

401.2.13.1 Plant and Production Inspection

Consider the following guidelines during plant and production inspection:

1. Quality Control. Before production, check the Contractor's Quality Control Plan for compliance with the contract specifications, and make sure the Contractor has provided the requisite number and type of certified technicians (see Section 401.1.4). Make sure

you understand both Contractor and Division responsibilities with respect to quality control and acceptance procedures. During production, check that the technicians are sampling and testing in conformance with the Quality Control Plan. Make sure the Contractor submits Form 441 and other required test data and reports in a proper and timely manner. See Section 701.4.5 for additional information on Form 441.

2. Certification. Check that the plant has been properly certified (see Section 401.2.1). Visually inspect the plant for compliance and any obvious violations. Deficiencies must be corrected before production begins.

3. Laboratory. Check the plant laboratory for compliance with the contract specifications, and ensure all testing equipment is on hand and in good condition (see Section 401.2.2).

4. Scales and Weights. Check plant scales and test weights for proper certification (see Section 401.2.1). As needed, check scales for accuracy; zero balance, and sensitivity. During production, make sure that scales are checked at the required frequency and that validation reports are submitted in the proper manner.

5. Operations. Periodically inspect plant operations. Check aggregate stockpiles and the cold-feed system for unacceptable intermingling of aggregate materials. Occasionally watch for evidence of improper plant emissions and incomplete combustion of burner fuel (e.g., blue or black smoke coming from plant exhaust, oily coating of heated aggregate particles, incomplete binder coating on aggregates). Visually inspect screens, hot bins, overflow pipes, and other plant components for proper operation. Check for low levels of aggregate material in hot bins. Excessive carryover of fines into other bins due to worn or blinding of screens is unacceptable. Check bin gate openings periodically because vibrations may cause gates to loosen. Check for insufficient binder supply due to clogged strainers, partially closed valves, or line leaks.

6. Extremely Hot Mixes. Extremely high temperatures usually occur at the start of operations and should be carefully monitored. Extremely hot mixes can be spotted by blue smoke coming from the mix. If the temperature is too high, production must be immediately adjusted, and the overheated mix must be discarded. High temperatures cause premature hardening of the asphalt binder, which results in a less durable pavement.

7. Extremely Cold Mixes. Extremely cold temperatures should also be monitored at the start of operations. Cold mixes can be detected by a rather grayish color in the mix. This is caused by the larger aggregate particles not being completely coated with asphalt binder. If the condition is serious, the cold aggregate must be removed from the hot bins and operations adjusted accordingly.

8. Proportioning and Mixing. Before production begins, check that the Contractor has supplied the plant operator with the appropriate Job-Mix Formula for the project (see Section 401.1.5). During production, make sure the plant operator establishes aggregate and asphalt material proportioning, moisture content, and mix temperature in accordance with the requirements of the Job-Mix Formula. As needed, have material proportions, moisture content, and aggregate and binder temperatures checked for compliance. Visually inspect the discharged mix for evidence of non-uniformity and incomplete mixing. Occasionally check the mixing unit to determine if aggregate and asphalt binder materials are being properly mixed. Complete coating of aggregate materials is required. Periodically check and record the discharge temperature of the mix.

9. Surge and Storage Silos. Check surge and storage silos to ensure that the requirements of the contract specifications are not being exceeded.

401.2.13.2 Loading and Hauling Inspection

Consider the following guidelines during loading and hauling inspection:

1. Scale Certification. Check that the truck scale has been certified by the West Virginia Division of Labor. The seal of current approval should be affixed to the scale (see Section 401.2.1).

2. Truck Weighing. Frequently check the truck weighing process to ensure that it is in compliance with the requirements of the contract specifications. Pay particular attention to weighing platform. It should be clean and free to move with no binding.

3. Batch-Mix Plants. In batch-mix plant operations, the theoretical weight of batches should be periodically compared to the weight of the material in the truck as determined by the scale. Multiply the theoretical batch weight by the number of batches deposited into the truck and compare it to the weight of material determined by the truck scale. If there is a discrepancy greater than 2%, investigate to determine the cause of the discrepancy.

4. Release Agents, Tarps, and Insulation. Inspect truck beds for the proper use of release agents, tarps, and insulation. Ensure that truck beds are insulated and clean, with no foreign substances or dried chunks of mix present. Ensure that tarps are present and in good condition.

5. Truck Loading. Visually inspect haul trucks and truck beds for compliance during loading. Develop a mental picture of the appearance of the proper mix when loaded in the truck. A load of mix that peaks more than usual is an indication of a lean mix (i.e., too much fines and/or insufficient asphalt binder). A load that flattens in the truck bed indicates a fat mix (i.e., too much asphalt binder, too much coarse aggregate, and/or insufficient fines). Occasionally check with the Project Inspector at the laydown site concerning the workability and uniformity of the mix being delivered.

401.3 HMA LAYDOWN AND COMPACTION

Although construction may take several months, public opinion of the Division is ultimately based on the final quality of the pavement and the effectiveness of traffic maintenance during construction. Unsafe or inefficient traffic operations during construction and bumps, choppy waves, long swells, and the early appearance of cracks, potholes, and raveling joints are highly criticized. As taxpayers, the public expects a quality product. The Project Inspector at the laydown site must be proactive in enforcing the contract specifications to ensure the provision of safe and efficient traffic operations and a smooth riding surface that will not require premature maintenance.

The principal duty of the Project Inspector at the laydown site is ensure that the pavement is constructed to the line, grade, and cross section required by the Contract Plans and to the density, riding surface, and texture required by the contract specifications. To achieve this objective. the Project Inspector must continually monitor surface preparation, mix delivery, paving operations, compaction operations, and the finished surface for compliance.

401.3.1 Pre-Paving Considerations

Before paving operations begin, become thoroughly familiar with the Contract Plans and Specifications including the requirements of the Quality Control Plan (see Section 401.1.4), Job-Mix Formula (see Section 401.1.5), and

Maintenance of Traffic Plan (see Section 401.1.7). Check that the proper certified technicians, traffic control, and paving and compaction equipment are in place and in conformance before construction begins. Inspect the paving surface for correct grade and cross section and that the surface has been adequately prepared. To ensure paving continuity, check that pavement edges are marked at the correct width and grade by taut stringline or electronic paver guide.

401.3.2 Weather Considerations

Weather plays an important role in determining whether or not the Contractor should begin or continue with HMA paving, tacking, or priming operations. Consider the following guidelines:

1. Wet Weather. The laydown surface must be dry (i.e., no standing water) and the weather conditions must permit the proper handling, finishing, and compaction of the mix. If rain is imminent or the surface is wet – don't pave. As soon as practical, direct the plant to halt production until further advised. Only the mix in route to the site should be spread, and then the operation should be properly halted. The HMA placed during wet conditions is to be evaluated prior to finalization of the project for performance as intended with possible price reductions if not satisfactory. Paving should not be started again until standing water is no longer on the surface. When downpours occur, the paver should be stopped, the receiving hopper covered, and the crew advised to wait until there is no standing water on the surface.

2. Cold Weather. Unless otherwise directed, do not permit the Contractor to place surface courses when the ambient temperature falls below 40°F (4°C). Cold weather provisions of the Contract will apply when the ambient temperature falls below 50°F (10°C) or the paving surface temperature falls below 60°F (15°C). During cold weather paving, measure the paving surface temperature at least once an hour, monitor mix temperature for each truckload delivered, and measure mat temperature at final density to ensure conformance to the contract specifications. If the provisions of cold weather paving are exceeded, ensure that the Contractor coordinates with the plant to deliver a mix with an acceptable temperature. Mix temperatures will be recorded on the mix delivery ticket and the Inspector's Daily Report.

401.3.3 Laydown and Compaction Equipment

Project Inspectors must never operate or adjust Contractor equipment. However, it is good practice to understand the operation of equipment to ensure it is being properly adjusted and operated. The Project Inspector should make a visual inspection of the Contractor's equipment, checking the condition and adjustment of the component parts. Ensure that obvious deficiencies are corrected before the operation begins. Doing so will avoid delays and ensure that a quality surface can be obtained. The following sections present guidelines that should be considered.

401.3.3.1 Paving Machines

One of the most important pieces of equipment is the paver. The paver must be capable of spreading and finishing the mat to the required cross section and profile. The self-propelled paver must be equipped with a heated strike-off assembly or activated screed and either mechanical or automatic grade and slope controls. Automatic controls are necessary only if specified in the Contract. If automatic controls fail, allow the Contractor to complete the day's work via manual control; afterward, the controls must be fixed. Check grade and slope controls periodically for proper working order. Consider the following additional points of inspection:

1. paver motor has governor that operates smoothly without missing;
2. track linkage on track-laying machines is properly adjusted and tracks and pins are not excessively worn;
3. pneumatic tires, if present, are inflated to correct pressure and chain drives are properly adjusted and not excessively worn;
4. tamper bars are adjusted to correct RPM, proper clearance from screed, proper length of stroke and are not excessively worn;
5. screed vibrator, if provided, is operating properly;
6. strike-off plate is set at proper height above screed;
7. screed plates are not excessively worn and are adjusted for proper crown and tilt;
8. screed heater is operating properly;
9. screed extensions, if used, are in a true plane and flush with screed bottom;
10. there are no gaps between screed plates; and
11. thickness controls are operating properly.

The Project Inspector must know the surface defects that can be caused by improper adjustment or operation of the paver (see Section 401.4). Poor results must not be accepted. If adjusted and operated properly, little hand work will be required. Hand methods and special equipment may be used for small or irregular areas, if previously approved. However, it is poor practice to scatter loose material to improve mat texture due to paver problems. Proper paver speed will result in a quality mat with uniform texture and density across the full width, provided the mix other conditions are satisfactory. Paver speed must be in balance with mix delivery and sufficiently slow to avoid tearing the mat. If tearing occurs, repairs must be made and the paver speed adjusted.

401.3.3.2 Compaction Equipment

Depending on the sequence of operation in the Contractor's Laydown and Compaction Plan, the compaction equipment used on the project will include steel-wheel rollers, pneumatic-tire rollers, vibratory rollers, or some combination of the three. However established, the rolling operation must not result in excessive crushing of the aggregate.

Pneumatic-tire rollers are equipped with smooth tires of equal size and ply. Tire pressures and loading of the roller can be varied to achieve the desired ground contact pressure. There are three basic types of steel-wheel rollers: three-wheel rollers, two-axle tandem rollers, and three-axle tandem rollers. Three-wheel rollers are primarily used to initially break down each course laid. The two- and three-axle tandem rollers are primarily used for compaction and finishing. Vibratory rollers can be used as either a breakdown or finishing roller. In inaccessible areas, hand held rollers and vibrating plates are generally used. Consider the following points of inspection:

1. wheels are capable of rolling in a true plane and are free from flat spots or ridges;
2. steering and driving mechanism is free of excessive play or backlash;
3. motor and transmission free from leaks;
4. roller's water tank, wetting mats, and spray bars are properly operating;
5. pneumatic tires are properly inflated and in good condition without wobble or creep;
6. vibration and propulsion controls of vibratory roller are set and operating properly; and

7. total weight, weight per inch (millimeter) of width, average ground contact pressure, and/or vibrations per minute and amplitude set and properly documented.

The compaction density obtained by pneumatic-tire and steel-wheel rollers is related to the weight, speed, and the number of roller passes. The density obtained by a vibratory roller is primarily related to the frequency (i.e., number of vibrations or downward impacts per minute, VPM) and the amplitude (i.e., the greatest amount of movement in one direction from a position at rest). As the vibratory roller travels, the vibrating drum produces rapid impacts on the surface of the mat. These impacts produce pressure waves of equal frequency that pass through the mix. The pressure waves cause the particles to move closer together, thus densifying the mix.

401.3.3.3 Miscellaneous Tools

It is good practice before the paving day begins to visually check to see that the Contractor has available an adequate supply of rakes, lutes, shovels, brooms, and other required miscellaneous tools.

401.3.4 Surface Preparation

When called for in the plans, before HMA is placed over an existing surface (e.g., subgrade soil, aggregate base, asphalt stabilized material, PCC), the surface must be shaped to the correct grade and cross section and be properly prepared. The following sections discuss typical surface preparation operations.

401.3.4.1 Sealing

Cracks in an asphalt surface to be resurfaced should be sealed as specified, either individually or with an appropriate surface sealing treatment. In addition, poorly sealed joints in existing PCC pavements should be routed and sealed, and any rocking slabs should be stabilized before the paving operation begins.

401.3.4.2 Patching and Leveling

Depending on the condition of the underlying surface, rough and uneven asphalt surfaces are typically leveled by either placing a patching and leveling course or by milling high spots on the existing surface. The purpose of the patching and leveling course is to repair potholes, correct surface irregularities (e.g., short dips), shape the cross section, and raise the existing outside edge to provide a uniform template. If designated, the application of tack coat as discussed in Section 401.3.4.5 is applied before the patching and leveling course is laid. Either three-wheel or pneumatic-tire rollers may be used for compaction.

Aggregate materials for patching and leveling courses differ from that of HMA base and wearing courses and typically have a specified maximum size. Pay particular attention to the type of patch and leveling course specified for the project. If patching and leveling is not specified in the Contract, ensure that the Contractor corrects surface irregularities with the wearing or base mix material. Where extensive base failures are encountered and no Contract provisions are made for repairs, notify the Project Engineer/Supervisor. It may be necessary to modify the Contract to correct the problem.

401.3.4.3 Scratch Course

Prior to paving, all depressions and potholes must be repaired to provide a firm and unyielding paving base. The purpose of the scratch course is to fill in deep ruts and other depressions in the caused by traffic on the existing surface. If specified, the limits of scratch course will be designated on the Contract Plans, and a tack coat must first be applied. Either three-wheel or pneumatic-tire rollers may be used for compaction.

401.3.4.4 Cleaning and Sweeping

Once the underlying surface is repaired, the paving surface must be cleaned of all dust, dirt, and caked or loose debris. This is usually accomplished using multiple passes of a mechanical broom and/or flushing with air or water. The limits of cleaning and sweeping are generally beyond the width of paving and will be specified in the Contract.

401.3.4.5 Tack Coat

Before an existing asphalt or PCC pavement surface is overlayed, a tack coat is generally specified to seal the contact surfaces. Where designated, the tack coat must be applied in conformance with Section 408 of the **Standard Specifications**. See Section 408 of this **Manual** for additional information on tack coats.

401.3.5 <u>HMA Mix Properties</u>

The construction of an HMA pavement begins with the delivery to the laydown site of a workable mix that is proportioned and heated in conformance with the Job-Mix Formula (see Section 401.1.5) and the contract specifications.

401.3.5.1 Material Proportioning Considerations

The pavement will not perform as intended if the material proportions in the mix exceed the limits specified for the type of HMA being produced. For example, if the quantity of asphalt binder is too low, the pavement will become brittle and crack under traffic loading. Brittleness also may occur if the binder material itself is too hard as a result of overheating the mix. Excessive binder material will cause the pavement to move under traffic and push up in waves or cause the binder itself to come to the surface, which causes a hazardous, slippery traffic condition during wet weather. During the project, it is good practice to visually check the mix for any signs of unacceptability. If a problem is suspected, corrective action should be taken immediately.

401.3.5.2 Temperature Considerations

When operations are first begun, production operations should be adjusted in accordance with the procedures established in the contract specifications. The temperature of the mix upon delivery must be within tolerance of the limits specified in the Job-Mix Formula and the master range of the contract specifications. Otherwise, the mix should be rejected. If cold weather operations are imminent, the mix temperature should be increased, but not beyond the threshold of the master temperature range. The mix temperature will be monitored at both the plant and at the laydown site. To obtain mix temperature upon delivery, a dial-type thermometer can be inserted through the access hole in the gate of the truck. When operating under cold weather paving provisions, the mix temperature of each truckload should be recorded, checked for compliance, and documented on the mix delivery ticket and the Inspector's Daily Report.

401.3.5.3 Mix Inspection Guidelines

When haul trucks first arrive at the laydown site, it is good practice to visually inspect the mix for acceptability. It is better to reject a bad mix than it is to reject a bad pavement. Usually, the Project Inspector at the plant will reject the mix before it has a chance to be hauled; however, the Project Inspector at the laydown site must be able to spot a bad mix before it is laid and compacted. There are several deficiencies that may warrant rejection of the mix. Consider the following guidelines:

1. <u>Mix Temperature</u>. Reject the mix if its temperature is not within tolerance of the Job-Mix Formula or the governing contract specifications. A mix that is too cold generally will appear stiff or have an improper coating of the larger aggregate particles. A mix that is too hot will have blue

smoke rising from the truck or spreader hopper. Temperature deficiencies are common and should be closely monitored and properly documented in the Inspector's Daily Report.

2. Asphalt Content. A mix that has too much or not enough asphalt binder must be rejected. If there is too much binder, the mix generally will not peak but flatten in the truck bed and appears slick under the screed. If there is too little binder, the mix will appear lean and granular and lack a shiny black luster. The aggregate also may not be completely coated.

3. Aggregate Proportions. Reject the mix if aggregate proportioning fails to meet specified requirements. A mix that has too much coarse aggregate generally will have a coarse appearance and will exhibit poor workability. A mix that has too much fine material will usually have a lean, brown, or dull appearance and will be very stiff and difficult to work.

4. Moisture Content. Too much moisture in the mix is grounds for rejection. A mix with too much moisture will have steam rising from the material when dumped into the hopper and may be bubbling and popping.

5. Contamination. When delivered, check the mix for contamination, which may include gasoline, kerosene, oil, rags, dirt, or trash that has inadvertently gotten into the mix. Minor contamination may be removed; serious contamination warrants rejection of the load.

6. Segregation. Segregation of the aggregates occurs because of improper handling (see Section 401.4.2). Serious segregation is grounds for rejection.

7. Non-Uniform Mixing. Non-uniform mixing produces a mix that has spots of lean, brown, or dull appearing material that is intermixed with material that has a rich and shiny appearance. This type of mix should be rejected.

A fast means of communication between the Project Inspectors at the plant and the laydown site is essential to placing a workable and uniform mix on the road and keeping load rejection to the minimum. The spread should be checked frequently to ensure that the proper mix is incorporated into the pavement.

401.3.6 Mix Placement

401.3.6.1 Paver Operations

Once production and hauling have been established, the Contractor will begin placing the mix. It is good practice for the Project Inspector at the paving site to observe the operation of the paver for any obvious substandard or improper operation. Consider the following guidelines:

1. Edge of Pavement. The exact edge of pavement, except on PCC overlay projects, will be established by a string or chalk line for a distance of not less than 500 ft (150 m) ahead of the paving operation.

2. Screed Temperature. The screed should be heated to the proper temperature before the paving operation begin.

3. Thickness, Grade, and Slope Controls. Thickness, grade and slope controls should be set and checked for proper operation. This is especially important when paving first begins, because the controls must be set to properly construct a transverse joint.

4. Truck Tarps. To prevent unnecessary heat loss, the tarp over the truck bed should remain in place until just before the truck is emptied.

5. Transfer Operation. Haul trucks should not bump or transfer weight to the paver. Otherwise, the paver may be thrown off line, or the screed may be pushed into the mat.

Each truck should stop short of the paver and allow the paver to pick up the truck instead of the truck backing up and possibly bumping the paver.

6. Dumping Procedure. The truck bed should be raised just enough to break the load before opening the tailgate, thus allowing the mix to flow as a mass into the hopper. This will minimize mix segregation.

7. Hopper Level. The mix level in the hopper should not drop below the bottom of the flow gates. The hopper should not be emptied to the point where slat conveyors are visible, and the hopper should not be so full that mix runs out the front.

8. Clinging Mix. Mix that clings to the sides and corners of the hopper should be continually loosened and pushed into a relatively full hopper when the mix consists of finer aggregate and the mix and ambient temperatures are high. When the mix contains coarser aggregates and the mix and ambient temperatures are low, the clinging mix should be allowed to accumulate and periodically removed in a proper manner. When the mix accumulates on the sides of the hopper, it cools rapidly and, if permitted to reach the grade, will result in a non-uniform surface texture. Wings on the paver can be folded, as needed, to prevent cold mix from accumulating in the corners.

9. Paver Movement. Paver starting and stopping operations should be minimized and be smooth without jerky movement. Once the hopper is charged, the paver should maintain constant speed in proportion to mix delivery. This keeps a constant head of material in front of the screed. During truck exchanges, the paver should maintain forward movement to minimize the occurrence of a "bump" at the point of exchange. If the mix pulls under the paver, suspend the operation until the cause can be determined and corrected.

10. Flow Control. Flow gates should be set at a height that permits the slat conveyor and auger to operate at close to 100% capacity. The key to a smooth surface is a constant head of mix in front of the screed, which depends on constant paver speed and continuous operation. The majority of mix in front of the screed should be located near the center of the auger shaft. If automatic flow-control devices are used, the flow-control device should be set at a location near the end plate. This will cause the auger to run continuously and maintain a constant head in front of the screed; otherwise, mix may be carried at the screed's outside edge.

Soon after the first load of HMA has been spread, check the surface of the mat to ensure that a uniform texture is achieved and that the grade and cross section are in compliance with the Contract Plans. Ensure that the Contractor makes any needed repairs to the mat and adjustments to the paver (e.g., screed, tamping bars, vibrators, feeder screws, hopper feed).

401.3.6.2 Automatic Screed Controls

If automatic screed controls are used on the paver for grade and slope adjustment, it is good practice for the Project Inspector at the paving site to become familiar with their proper use and observe the operation of the controls for any obvious substandard or improper operation. Consider the following guidelines:

1. Screed Adjustment. The paver operator should not adjust thickness controls for the purpose of changing the screed's angle of attack, unless the mat thickness actually needs to be adjusted.

2. Grade Sensor. The grade sensor should be in constant working order. If the wand is raised through input from the stringline or mobile reference, there should be a corresponding movement of the actuator. If not, sensitivity adjustments may be needed. During paving,

sensor indicators should properly indicate the signal being received.

3. Tow-Point Actuator. The movement of the tow-point actuator should be smooth, without a constant up and down movement.

4. Stringline. If a stringline is used as the grade reference, the line should be taut without sags between vertical supports, as visually verified by sighting down the line. The vertical supports must not interfere with the path of the wand. Once set, the integrity of the stringline should be protected.

5. Mobile Reference. If a mobile reference is used for grade control, its length should be sufficient to compensate for variations in surface elevation, and each shoe should be checked to ensure that it is clean and free to move. The sensor should be checked for proper operation.

6. Joint Matching Shoe. If a joint matching shoe is used for grade control, check the shoe for proper operation. It should be clean and free to move.

7. Combined Grade/Slope Control. If the paver has grade control on one side and slope control on the other, regularly check the cross slope for compliance. This is particularly important on very wide pavements.

401.3.7 Compaction Operations

The number, type, and operation of rollers documented in the Contractor's Laydown and Compaction Plan must be sufficient to obtain the required density when the mix is in a workable condition. After a course has been spread and before the compaction operation is started, check the surface behind the paver for non-conformance and ensure that the Contractor makes the proper corrections. The following sections present guidelines on typical compaction operations that will obtain a uniform pavement density and a smooth riding surface.

401.3.7.1 Thickness and Temperature Considerations

The time available for compaction is primarily related to the thickness of the course being placed with mix and ambient temperatures also being important factors. An increase in lift thickness can substantially increase the time available for the roller to densify the mix. Also, mix temperature greatly influences the compaction operations. Temperature affects mix stiffness and workability. If too high, the mix will move or shove under the roller. If too low, the mix will be difficult to compact. The proper mix temperature will allow sufficient time to achieve the required density before the mat cools too much for further rolling to be effective. An increase in laydown temperature can significantly increase the amount of time available for compaction. However, the feasibility of using this approach depends on the properties and tenderness of the mix at the selected temperature and compaction effort.

Mix and paving surface temperatures also are critical considerations, particularly in the spring and fall seasons. As needed, contact the District Materials Supervisor for information on mix temperature and optimum compaction time. The required density must be obtained prior to the mat temperature reaching 175°F (80°C), unless otherwise demonstrated by the Contractor. Mat temperature is normally measured using a non-contact infrared thermometer.

401.3.7.2 Roller Pattern

The optimum combination of rollers and roller patterns for a past project may not be the same optimum combination for a current project or even for a different type or layer of mix on the same project. Test sections are normally constructed to determine the most efficient and most effective combination of compaction equipment and roller patterns to use for each combination of job variables. It is not good practice to make more roller passes than are required to satisfy density requirements. For example, two similar rollers run side by side (i.e., in echelon) will typically produce a greater level of density in the mix, with the same number of roller passes, than will the same two rollers operated end to end as a breakdown and an intermediate roller.

After determining the number of passes required to obtain optimum density, the compaction operation can proceed using the same pattern and number of passes as was determined to be successful in the test section. Once a roller pattern has been established, it should not changed unless the mix or the lift thickness changes. The roller pattern should be monitored to ensure that the compaction equipment is applying the same amount of compactive effort at all points transversely across the lane being paved. Use the following six rolling procedures, in the order they appear, when paving in echelon or abutting a previously placed lane.

1. transverse joints,
2. longitudinal joints,
3. edges,
4. initial or breakdown rolling,
5. secondary rolling, and
6. final or finish rolling.

401.3.7.3 Roller Speed and Operation

Establishing roller speed is very important. A decrease in speed will increase the compactive effort applied to the mix; however, the objective is to obtain target density before the mix cools below the specified minimum temperature. Roller speed will depend on the roller type and its position in the roller pattern. In general, rollers should be operated at a slow and uniform speed with smooth deceleration and acceleration to avoid shoving the mix. For static steel-wheel and pneumatic-tire rollers in the breakdown position, the maximum speed should generally not exceed 2.5 miles/hr (4.0 km/hr). For vibrator rollers in the same position, the maximum speed should not exceed 3 mi/hr (4.8 km/hr). See Section 401.3.7.4 for additional information on vibratory rollers. If rollers cannot keep up with the paver because of laydown productivity, do not change the rolling pattern or increase the roller speed. Add another roller or reduce productivity to better balance with the compaction operation.

Breakdown and intermediate rollers should be operated with the drive wheel as close to the paver as practical. In general, roll as close to the paver as the stability of the mix will permit. Shoving or cracking of the mat or having the mix pick up on the roller wheels is a sign of mix instability and tenderness. If the mat is unstable or subject to too much lateral displacement, drop the roller back a sufficient distance behind the paver to eliminate displacement and not unduly influence the pattern for the density and finishing rollers. If displacement occurs, inform the Contractor to restore the displaced area to proper grade and cross section with loose material and roll the loose material to target density. The finish rolling should be completed while the mat is sufficiently workable for the removal of roller marks.

During rolling, the roller wheels should be kept moist with only enough water to avoid picking up the mix. This, as well as tire temperature, is especially important if pneumatic-tire rollers are used. Changes in direction should be effected gradually and rollers allowed to roll or slowly brake to a complete stop before reversing. Stopping points for alternate trips should be staggered at least 3 ft (1 m). It is best to park rollers off of the new mat, or on a portion that has cooled; however, where rollers have to park on the mat, they should do so at a 45-degree angle with the centerline so that subsequent rolling will remove any depressions.

401.3.7.4 Vibratory Roller Operation

Compaction of HMA is a complex process made even more complicated by the use of vibratory rollers. Various makes and models are available for various compaction needs. This section emphasizes their characteristics and proper operation, with which the Project Inspector should become familiar.

The addition of a vibratory mode to static rollers makes it possible to increase and vary the total force applied to the pavement. This makes the roller versatile and able to achieve satisfactory results under a wide variety of conditions, including fewer roller passes. No vibratory roller compacts by vibration alone; and, at times, its static weight must be considered to avoid overstressing the pavement, even when the vibratory mode is not being used. The features of the roller that influence compaction are:

1. frequency in vibrations per minute;

2. amplitude of the up and down movement of the roller;

3. downward force applied; and

4. the travel speed of the roller.

Each of the above factors must be set and maintained in proper relationship with each other to achieve the desired results. Although operating a vibratory roller, in many respects, is no different than operating a static roller, the following guidelines should be considered for optimal results:

1. Mix Temperature. Usually, vibratory rollers can operate at higher mix temperatures because of their ability to adjust the total force applied to the material. As a result, density can usually be achieved with fewer roller passes.

2. Rolling Pattern. The basic rolling pattern is similar to that which is used for static rollers except that after the roller completes a pass toward the paver, the roller should be reversed along the same path. The vibratory mode of the roller must be turned off when the roller stops to reverse direction. The adjacent pass then proceeds in the same manner (i.e., in and out, back and forth) on the same path with a minimum overlap of 6 inches (150 mm). Similar to other compaction rollers, vibratory rollers should be operated as close behind laydown as practical.

3. Longitudinal Joints. The longitudinal joint is not "pinched" by having most of the roll on the previously compacted lane, but with most of the roll on the uncompacted material. The joint may be pinched in the standard manner with the vibratory mode turned off.

4. Tandem Vibratory Rollers. Some tandem vibratory rollers provide vibration in either or both rolls. Depending on the stability and the temperature of the mix, the breakdown rolling operation may be performed with both rolls vibrating, with only one roll vibrating, or none vibrating. Rolling that is accomplished with as much vibration as practical will achieve the quickest and perhaps the optimum compaction. However, watch for shearing or shoving of the mat and, if necessary, reduce the compactive effort by lowering or turning off the vibratory mode in either the forward or both rolls. After satisfactory breakdown rolling, the vibration can be increased for secondary and intermediate rolling. Finishing rolling (i.e., to iron out roller marks) may be accomplished most effectively in the static mode.

5. Frequency/Amplitude Adjustment. Frequency and amplitude must be properly selected. Use a high amplitude and low frequency for a lift thickness greater than 2 in (50 mm) and a low amplitude and high frequency for a lift thickness of 2 in (50 mm) or less. When running the test pattern, try to select the highest amplitude that will result in the fewest number of passes without blemishing the mat. If two different amplitudes can achieve identical roller patterns, use the lower amplitude. In general, at least 8 to 10

impacts/ft (26 to 33 impacts/m) are needed to obtain adequate density and layer smoothness.

6. Roller Speed. There is an important relationship between vibration frequency and roller speed. The spacing between tamps will be too great at high speeds, resulting in low density and roughness. The roller speed should be selected so that the distance between blows of the roll is approximately equal to the depth of the mat being placed, without exceeding a maximum operating speed of 3 mi/hr (4.8 km/hr). In other words, the frequency, in vibrations per minute, multiplied by the thickness of the mat, in inches (millimeters), will equal the maximum speed of the roller, in inches (millimeters) per minute. For example, using 2400 VPM on a 2 in (50 mm) mat would yield a maximum roller speed of 4800 in/min (120 000 mm/min) or 4.5 mi/hr (7.2 km/hr). However, because this is greater than the specified allowable limit, the maximum operating speed of 3 mi/hr (4.8 km/hr) will govern. For thin overlays, the blows should be spaced 1 in (25 mm) apart regardless of the lift thickness. This rule provides a practical speed for thin lifts, but may not establish the maximum speed that can produce acceptable results. Remember, thin lifts can be easily over-rolled. The amplitude value is very critical and should be kept as low as practical.

401.3.7.5 Joint Construction

To ensure pavement durability and a smooth riding surface, the Project Inspector at the laydown site should pay particular attention to how the Contractor constructs joints in the pavement. Consider the following guidelines:

1. Longitudinal Joints. Longitudinal joints are used between two adjacent lanes of paved mix. The paver will overlap the adjacent lane by approximately 1.5 in (40 mm); if greater, raking is usually required. Minimal raking should be needed; however, if performed, ensure the raker does not broadcast material across the newly placed mix. Excess material should be carefully pushed to within 1 to 2 in (25 to 50 mm) of the joint as deposited on the uncompacted side. Extraneous mix must be removed by broom or lute before rolling. Rolling is usually accomplished from the hot side with the roller wheels lapping approximately 6 in (150 mm) over the cold mat. Where multiple courses are being paved, the longitudinal joint in the top course layer will coincide with the centerline or lane line, and the longitudinal joints of the underlying lifts will be laterally offset by a minimum of 6 inches (150 mm). The Contractor should start placement of the adjoining lane in sufficient time to close the joint at the end of the day. If the joint is not closed, a hazardous traffic condition is created, and proper traffic control devices must be erected.

2. Construction Joints. Construction joints occur where one day’s operation ends and the next day’s operation begins. If required, treated paper is normally used as the bond breaker. Prior to beginning the day’s operation, a transverse vertical cut is made in the mat to the full depth of the new course, and the vertical face tacked prior to paving. Because the mix placed on the downstream side must be higher than the compacted side to allow for compaction, screed adjustments are needed initially. Minimal raking should be necessary; however, if performed, rakers should not disturb the paver-placed mix except to clear away extraneous material. Ideally, the joint should be compacted in a transverse roller direction. However, on a practical basis, the joint can be properly compacted in the longitudinal direction. Construction joints in overlying layers will be offset by approximately 6 feet (1.8 m). All construction joints will provide a smooth transition free from irregularities.

3. Heeled-In Joints. Transverse joints at the beginning and end of the project and at other locations where the new HMA terminates against an existing asphalt pavement will be "heel-in" in accordance with the typical sections of the Contract Plans. The heeled-in joint will provide a smooth transition between the old and new surface. The Contractor should use a straightedge or stringline to ensure smoothness of the joint.

401.3.7.6 Quality Considerations

A primary object of the Project Inspector at the laydown and compaction site is to ensure that the Contractor fulfills the quality requirements of the contract specifications (see Section 401.1.4). The Contractor is ultimately responsible for quality control, but the Division is responsible for acceptance. Section 401 of the **Standard Specifications** specifically addresses the following quality criteria:

1. Thickness. Cores will be taken by the Division after the project is completed and measured for thickness in accordance with Section 401.7.3 of the **Standard Specifications** to verify compacted thick-ness where a uniform thickness of 3 inches (75 mm) or more is specified, excluding resurfacing. Cores may not be required for short projects (i.e., less than 1000 feet [300 m]), tapered paving mats, and widening projects. Failure to meet specified requirements may result in either a price reduction or provisions for an additional lift.

2. Density. Test procedures and acceptance criteria for compaction testing methods will be in conformance with the contract specifications and MP 401.05.20. Density will be verified using either the lot-by-lot method or the rollerpass method, depending on the lift thickness and the total new pavement thickness. Do not include the thickness of patching and leveling and scratch courses in the total new pavement thickness. The method to use for non-uniform thickness or tapered edge pavements will be determine by the Project Engineer/Supervisor on a case-by-case basis. Acceptability of a lift thickness less than two times the nominal maximum aggregate size will be governed by the rollerpass method. Visually inspect areas that restrict access to a full-size roller because acceptance testing is not required for these areas.

3. Surface Tolerance. Check the final compacted surface for acceptability. It should have a uniform texture and a line and grade that conforms to the cross section. The Contractor will provide the specified straightedge and template and check the surface. Monitor this check to ensure that the finished base and wearing course is within specified tolerance. If unacceptable, inform the Contractor to correct high and low places in accordance with the contract specifications.

4. Smoothness. For projects with a total new pavement thickness of 3 in (75 mm) and a minimum length of 1100 ft (340 m), the smoothness criteria of the contract specifications will apply. Within 30 days of project completion, perform an inertial profilometer or Mays Ride Meter test to ensure acceptability. Failure to meet specified requirements may result in either a price reduction or corrective action.

401.3.8 Inspection Guidelines

Consider the following guidelines when inspecting HMA laydown and compaction operations:

1. Check that the roadway is properly marked or staked out. Verify that paver guides are properly set. Check the condition and adjustment of paving machines and rollers for acceptability.

2. Check that traffic control and flaggers are in place and that traffic is flowing properly. At

the end of the day, make sure that signs not needed during non-working hours are removed or covered.

3. Check surface preparation for conformance. Verify tack coat is applied uniformly without running and on only those surfaces that can be paved for the day. Verify patching and leveling areas are properly designated, and that potholes are patched according to typical sections. Make sure cold mix or winter-grade patching is completely removed. Verify that the surface is clean.

4. Check that haul trucks are covered and insulated with no oil leaks or damage. Verify that haul trucks properly charge the paver hopper. Observe the mix for obvious signs of unacceptability. Check and record mix temperature on delivery tickets at least once an hour. Record any load limit violations.

5. Inspect the mat behind the paver for signs of non-uniform mix, roughness, or tearing. Verify that the vibrating screed is on. Check rate of application to ensure thickness placed conforms to typical sections. Check mat thickness (prior to compaction) and mat temperature (at final compaction pass) every 1,000 ft (305 m) or a minimum of three times per day. Calculate and record application rate every 2,500 ft (762 m). If field conditions require additional material, record the station and rate of application, as well as the rationale for same. Record the application rate for the day's production. Check that the operation is continuous and in balance with plant production. Check with the Project Inspector at the plant to corroborate daily totals.

6. Check that construction joints are cut back to vertical and tacked. Check that "heeled-in" joints are constructed according to Contract Plans. All joints should have a smooth appearance. Check that longitudinal joints are pinched and not overlapped and that all joints are properly raked and compacted.

7. Verify that the Contractor's density technician is on site. Watch the compaction operation for improper rolling sequence and operation and for compliance with that established for density requirements. Check that the Contractor is performing straight edge checks and the finishing operation is acceptable. Check for compliance with the Quality Control Plan and record results of the requisite quality control tests.

8. When paving is permitted beyond the seasonal limitations, record the air temperature, base temperature, and weather conditions prior to the start of paving each day and when noticeable changes occur.

401.4 SUPERPAVE CONSIDERATIONS

Albeit no greater than those experienced with conventional HMA mixes, there are a number of issues and construction problems that are unique to Superpave. The following section discusses these unique considerations and presents some common problems encountered with Superpave production and placement.

401.4.1 <u>Material Differences</u>

401.4.1.1 Coarse-Graded Aggregates

Superpave generally has more coarse aggregate material than conventional HMA and, thus, tends to be more difficult to heat, dry and coat. The dwell time may need adjusting to adequately heat, dry and coat the aggregate. The gap in gradation also makes Superpave mixes prone to segregation. Watch for evidence of segregation during production and placement. In addition, because Superpave requires aggregates with more angularity (fractured faces), the mix tends to be stiffer and is generally more difficult to place and compact. The resulting pavement performance is enhanced, however, due to the use of more angular aggregate material.

401.4.1.2 Performance-Graded Binders

A performance grade (PG), which is different from conventional HMA viscosity and penetration, is typically designated for Superpave asphalt binders. The performance grade designation (e.g., PG 64-22) represents the high and low temperatures at which the asphalt binder is expected to satisfactorily perform.

401.4.1.3 Modified Asphalt Binders

For Superpave designs, modifiers are typically mixed with the asphalt cement to meet the temperature requirements of the performance grade specified. Mixes that use these modified asphalt binders require special consideration because production and placement characteristics will differ from those of conventional HMA. At the plant, close control and verification of proportioning and mixing are required. The plant must be able to store and mix the modifier at the appropriate temperature and at the appropriate rate. Proportioning is usually determined based on metering. Any significant deviation in modifier content may change the volumetrics and mechanical properties of the mix. Mixing temperatures are usually higher than for conventional HMA mixes, and the mix will generally be stiffer and more difficult to place and compact but will result in a paved mat that is resistant to rutting with improved durability.

401.4.2 <u>Plant Production Considerations</u>

401.4.2.1 Aggregate Stockpiles and Cold Feeds

Aggregate stockpiling and cold feeding techniques used for Superpave are not much that different from those used for conventional HMA. Because Superpave tends to have greater amounts of coarse-graded aggregate, however, special attention should be given to how the coarse-graded aggregate material is stockpiled. Steps should be taken to minimize moisture retention because these larger aggregates tend to be more difficult to dry during mixing. Consider stockpiling these materials under roof on paved surfaces that are graded to drain. As practical, the loader operator should remove the coarse material from the sunny side of the stockpile and attempt to avoid the bottom. Where reclaimed asphalt pavement (RAP) is used, it should be similarly stockpiled and handled, and, as necessary, separated into fine and coarse stockpiles for remixing. To minimize segregation and allow for better gradation control, it may be desirable to divide and separately stockpile the required coarse-graded material into different aggregate sizes and separately feed the stockpiles into individual cold feeders.

401.4.2.2 Asphalt Binder Storage and Handling

The performance of Superpave designs greatly depends on the asphalt binder used in the mix – largely due to the specified performance grade of the modified asphalt binder to resist rutting. Consider the following guidelines:

1. <u>Tank Loading</u>. Individual grades of asphalt must be maintained separately to prevent mixing of differing performance grades. Note that asphalts the meet a specific performance grade may or may not be identical binders. One tank may contain a PG 70-22 binder of neat asphalt while another may contain a PG 70-22 modified asphalt binder (i.e., with modifying additives). The plant operator must take the necessary precautions to ensure that different grades are not inadvertently mixed when storage tanks are loaded and that the correct asphalt binder is used during production. Where multiple tanks are used to store different types of binders, check that separate plumbing and sampling valves are provided for each tank.

2. Higher Storage Temperatures. Superpave mixes specifically designed to resist rutting against heavy traffic generally use modified asphalt binders with a high temperature performance grade. These stiffer binders generally are more difficult to mix and require a relatively higher storage temperature. Note that long-term storage at these higher temperatures may degrade some modified binders. Individual temperature controls should be provided for each storage tank to separately control the storage temperature for the specific binder.

3. Stratification. The modified asphalt binders typically used in Superpave designs tend to separate and stratify over time. Tanks used for storing these modified binders should be adequately equipped to recirculate the binder.

401.4.2.3 Drying, Mixing, and Storage

To minimize potential problems and fully consider production tradeoffs, consider the following factors relative to drying, mixing and storage of Superpave:

1. Moisture Retention and Heating. The coarse-graded aggregate material typical of Superpave is prone to moisture retention and non-uniform heating. A good practice for checking drying efficiency is to monitor and compare the exhaust gas and mix temperatures. The temperature difference should be relatively low. Compaction difficulties at the laydown site may result if the aggregate is inadequately dried and heated. To better dry, heat and coat the coarse aggregate material, it may be necessary to increase retention time in the dryer; however, a tradeoff exists because of the more angular nature of the aggregate required for Superpave. Increasing retention time in the dryer (e.g., flighting, changes in slope or rotational speed) will tend to undesirably wear (i.e., round) the angular aggregates. As needed, monitor the operation for unacceptable rounding of the aggregate material.

2. Mixing Temperature. The modified asphalt binders typical of Superpave designs generally require higher mixing temperatures than conventional HMA mixes. Nighttime paving operations also tend to require an increase in mixing temperature. Some existing HMA plants may not have the capacity to heat the mix to the required temperature and may require an increase in dryer retention time. This may result in additional hardening of the binder and an increase in plant emissions. Consider these tradeoffs where Superpave is specified.

3. Metering and Pumping. Performance-graded binders with higher specified temperature grades used for Superpave generally are stiffer and more difficult to pump, especially when modifiers are used. If a significant change in binder stiffness is evident, metering and pumping should be verified and corrected as needed. A different size of pump or type of meter may be required.

4. Recycled Asphalt Pavement (RAP). The heat transfer process may be additionally aggravated if RAP is used in the Superpave design. Depending on plant capacity and capabilities, the RAP percentages may need to be limited if heat transfer continues to be a problem.

5. Mix Storage. Storage silos are commonly used to maintain a continuous flow of trucks to the laydown site. However, the high temperature requirements of Superpave may result in draindown and excessive hardening of the asphalt binder if the mix is stored at high temperatures for extended periods. In addition, because of the larger aggregate sizes, the storage silos should be monitored for signs of segregation.

401.4.3 Loading and Hauling Considerations

Where loading and unloading trucks with Superpave mixes, consider the following guidelines:

1. Truck Bed Maintenance. Superpave designs that use modified asphalt binders have a greater tendency to stick and are more difficult to remove from truck beds than conventional HMA mixes. Monitor operations to ensure that truck beds are adequately cleaned and treated with an approved release agent between loads.

2. Segregation. Coarse-graded aggregates typical of Superpave are susceptible to segregation. Periodically monitor truck loading for evidence of mix segregation. Truck loading techniques should be employed to minimize segregation.

3. Cooling. Superpave mixes have a tendency to cool more quickly than do conventional HMA mixes. If the mix temperature is increased, excessive draindown and hardening of the binder as well as increased plant emissions may result. To minimize heat loss, check that trucks are adequately insulated and that the mix is covered with a good tarp.

4. Long-Distance Hauling. Where long-distance hauling is required, draindown of the asphalt binder is a common problem that should be closely monitored. Reducing the temperature slightly may reduce draindown; however, it also may adversely affect mixing, workability and compaction.

401.4.4 Paving Operation Considerations

401.4.4.1 Laydown Operations

The paving equipment and techniques used for Superpave are not substantially different than that used for conventional HMA. However, because of the nature of coarse-graded mixes, it is recommended to closely monitor the laydown operation and the surface of the mat for visible signs of segregation. If segregation is evident, the cause should be immediately investigated and corrected. The construction of longitudinal joints also should be closely monitored. Because Superpave tends to be rather stiff due to the coarse aggregates and modified performance grade binders, special attention is required to construct a good, tight longitudinal joint. Sufficient non-segregated material must be supplied by the paver so that the roller can compact a satisfactory joint.

401.4.4.2 Compaction Operations

It is critical in Superpave jobs to closely monitor compaction operations (e.g., compaction temperature, mix reaction under rollers, density achieved). For various reasons (e.g., higher amount of crushed particles, use of modified asphalt binders, susceptibility to moisture and cooling), Superpave tends to be more difficult to compact than conventional HMA. Nonetheless, it is very important to achieve optimum density to ensure the stability of the pavement as designed. Consider the following guidelines:

1. Test Strips. It is good construction practice to place and compact test strips before full Superpave production begins. This will provide an opportunity to evaluate placement and compaction techniques and to identify and correct any problems that arise. Pay particular attention to how the mix reacts under specific rollers and ensure adjustments are made as needed. One specific objective of this procedure is to establish an optimum roller pattern and compaction temperature.

2. Lift Thickness. As a general rule of thumb, the minimum lift thickness of Superpave mixes should be approximately three times the nominal maximum aggregate size.

3. Shoving. In general, rollers should remain as close as practical behind the paver. Pay particular attention, however, to evidence of

shoving. If the mix is being shoved by steel-wheel rollers, additional rolling will only worsen the situation. Rubber-tire rollers can be used effectively without such detrimental movement; however, the tires may tend to pick up the mix, especially if the mix includes a modified binder. To minimize pickup, the tires must be kept hot by skirting or other similar means. The objective is to adjust rolling based on visual evidence of mat response. If shoving is evident, stop steel-wheel rolling and either go to rubber-tire rollers or wait until the mix has cooled and stabilized for steel-wheel rolling. Keep in mind, though, that rolling must be balanced with paving and plant production.

4. Mat Temperature. It is important to closely monitor mat temperature during compaction. There will exist a temperature range (i.e., tender zone) where rolling becomes problematic. Outside this range, the mat usually behaves satisfactorily. Superpave generally is tender from 200°F to 240°F (93°C to 115°C). Although rubber-tire rollers can be effective in this range, the tires may pick up the mix if a modified binder is being used. It is preferred to obtain target density before cooling to within the tender zone. Depending on available equipment (e.g., additional break-down rollers), this may not always be practical because Superpave tends to cool quicker than conventional mixes allowing less time for compaction. Different rolling techniques may need to be considered. For example, a vibratory steel-wheel breakdown roller could be used above the tender zone, followed by a rubber-tire roller that can be satisfactorily operated within the tender zone. A finishing roller could then be used after the mix has stabilized below the tender zone. To minimize excessive aggregate breakdown, the vibratory mode should not be used below the tender zone. Another possibility is to use a breakdown steel-wheel roller above the tender zone and then finish compaction after the mat is no longer tender. Watch for differential cooling of the mat in such operations. If tenderness persists in yielding poor in-place density, mix design adjustments may be needed to reduce the tender zone.

5. Mix Adjustments. It is important that paving and plant personnel communicate during production. With an established paving and rolling operation, reaction of the mix under the roller will be satisfactory and predictable. However, if the mix begins to react differently when rolled, a change in plant production may have occurred. Minor changes at the plant (e.g., moisture content) can have a significant effect on handling and compacting Superpave. Minor modifications at the plant may be all that is needed to reestablish the paving and rolling operation.

6. Density Testing. Compacted Superpave mats typically have a rough surface texture. If a nuclear density gauge is used on such a surface, it can report skewed or erroneous results. To minimize such error, consider using sand to better seat the gauge on the surface of the mat. Also, consider occasionally taking core samples to verify calibration of the gauge. Be aware, however, that Superpave core samples tend to be porous and susceptible to water permeation. Care should be taken (e.g., sealing) to prevent water from permeating the sample and skewing the results.

401.4.5 Inspection Guidelines

Superpave mixes typically have a rich looking appearance, which is different from that of conventional HMA. This is primarily due to the lower surface area of the aggregate and the higher asphalt content. It is not wise to change mix proportions based solely on mix appearance. There are new sampling and testing procedures (e.g., gyratory compactor tests), which are different from those used for conventional HMA. It is important that project personnel include certified technicians and inspectors that fully understand these differences. For example, aggregate properties are typically specified for the blended material, including RAP if used. It is therefore important to ensure that tests are performed on the blended aggregate material, not individual components. Furthermore, if samples are taken prior to being blended and dried, the test results may be erroneous due to rounding of the aggregate material as it tumbles through the dryer reducing angularity and producing more fines. For the resulting pavement to perform as designed, ensure that the properties of the blended aggregate material and the performance-graded binder meet the specified requirements. Consider the following guidelines during inspection:

1. Draindown. If draindown is evident, check to see if the mix temperature or the binder content is too high. It may be necessary to lower the mix temperature, use a stiffer binder, use or increase fiber or filler material, or reduce the binder content. Check with the project Engineer/Supervisor before making any significant changes to the original Job-Mix Formula.

2. In-Place Permeability. In-place permeability may be caused by low density. If this problem persists, it may be necessary to reestablish the rolling procedure (e.g., increase compactive effort, avoiding rolling within the tender zone). Also, check the thickness of the lifts before they are compacted. The minimum lift thickness for Superpave mixes should be approximately three times the nominal maximum aggregate size.

3. Shoving. If the mix is being shoved as it is rolled, the rolling operation is most likely occurring within the tender zone. It may be necessary to reestablish the rolling operation (e.g., use rubber-tire roller within the tender zone, change roller pattern, finish compaction above the tender zone).

4. Poor Workability. Superpave mixes, especially those with modified asphalt binders, tend to be stiffer and more difficult to work than conventional HMA. If the mix is excessively difficult to work at the laydown site, it may be necessary to increase the mix temperature and, as practical, minimize handwork.

401.5 RECORDS AND DAILY REPORTS

It is important that Project Inspectors at the plant and the laydown and compaction site accurately and completely document the necessary information for the project records. Attempting to reconstruct events at a later time without written notes and complete test data is usually frustrating and often results in conflicting opinions. One procedure should be consistently followed. It is important that the Division's Form 442, and applicable attachment, for the Supervisor's and Inspector's Daily Reports be utilized for this objective. If in doubt about whether the information is important or beneficial, write it down.

401.5.1 Plant Records and Reports

The Materials Inspector at the plant should document a complete summary of materials incorporated in the project and the plant operations performed, which will form an unquestionable basis for pay quantities. The results of all daily and periodic tests performed at the plant should be recorded in the plant diary. Data that should be considered include:

1. date and Project Inspector's name;

2. project number and location;

3. weather and temperature conditions;

4. source of materials, including laboratory numbers;

5. applicable information from the Job-Mix Formula;

6. times of plant scale checks;

7. aggregate gradation and asphalt content test data and mix test results;

8. quantity of each material used (i.e., aggregate, asphalt binder, additives);

9. daily quantity of mix produced;

10. location on pavement where daily production was placed;

11. date, time, location of samples taken and name of technician;

12. procedure used to measure mix properties;

13. tests conducted or observed, results, and any corrective action taken;

14. mix material rejected and disposition;

15. instructions given to the Contractor. or received from Project Engineer/Supervisor;

16. visitors and their comments and agreements;

17. remarks, unusual occurrences, or test results failing the contract specifications including corrective action, changes to mix proportions, plant operation, and test procedures; and

18. number of inspection hours for the day.

For each load of HMA mix dispatched from the plant, there should be a delivery ticket prepared to accompany the truck to the job site. This ticket should include the following:

1. item number and description;

2. weighman name, printed and initialed;

3. date and project number;

4. truck number;

5. number of contact axles;

6. tare weight of truck;

7. time or loading;

8. gross or net weight, based on type of scales used;

9. temperature of mix;

10. mix design number; and

11. laboratory number.

401.5.2 Laydown and Compaction Records and Reports

The Project Inspector at the laydown and compaction site is key personnel in documenting the acceptability of the construction operation. The purpose of the Inspector's Daily Report and its pertinent attachments is to document for possible later reference the routine and non-routine events that occur during each paving day. The information obtained must be detailed and complete. Many claims and lawsuits have been settle on the basis of information within the IDR. The IDR will allow for more meaningful discussion later if deficiencies develop in test results or in the performance of the pavement under traffic. Section 401.3 covers key information that should be recorded during inspection. During laydown and compaction operations, also consider the following:

1. project number and location;

2. weather conditions;

3. type and quantity of mix placed and the exact location of the mix layer number;

4. mix delivery tickets and laboratory numbers;

5. thickness, lane, and station number;

6. type and make of equipment used by the Contractor;

7. density results obtained;

8. type, amount, and location of any tack coat material placed, as required;

9. location of transverse and longitudinal station number of samples taken;

10. running total of the quantity of each mix laid on the project;

11. samples taken and made properly;

12. location, time, and date of the sample;

13. reason sample was taken;

14. name of the technician taking the sample;

15. unusual conditions or test results that occur during the day;

16. failing test results, explanation, and steps taken to correct the problem;

17. results of corrective actions;

18. changes made in the mode of operation of the asphalt plant or the laydown and compaction equipment;

19. different or unusual events that occur;

20. visitors to the site and their comments; and

21. reason for delays in paving (e.g., equipment breakdown, poor weather).

401.6 MEASUREMENT FOR PAYMENT

The contract unit price includes for HMA includes furnishing all materials and work including labor, tools, equipment, field lab, supplies, and incidentals. Cleaning and sweeping is part of HMA construction. No tack coat material for minor spot areas to be patched and leveled will be included in any other HMA items and the Contractor will receive no additional compensation. In addition, interim pavement markings also will not be included and the Contractor will not receive additional compensation.

401.6.1 HMA Base and Wearing Course

The HMA base and wearing course specified in the Contract will be measured by the ton (megagram), square yard (square meter), or cubic yard (cubic meter) complete in place. The method by which the measurement is determined is similar to that which is described for patching and leveling course in Section 401.6.2.

401.6.2 Patching and Leveling Course

Patching and leveling course specified in the Contract will be measured in tons (megagrams) complete in place and accepted. No additional payment will be made for patching or leveling course placed on subbase or base course for another HMA item (e.g., incidental) in the Contract. If measured on the square yard (square meter) basis, the measurement will be based on the width of the cross sections in the Contract Plans, including additionally approved widening, and the length along the centerline of the main facility and all ancillary ramps. If measured on the ton (megagram) basis, the measurement will be based on the delivery tickets for each truck load or from the digital printout slips from the plant. If measured on the cubic yard (cubic meter) basis, the quantity will be measured based on the volume established in the Contract Plans as determined from Plan dimensions, subject to any adjustments governed by the Specifications.

401.6.3 Contract Price Adjustments

Depending on the results of quality acceptance criteria as specified in the contract specifications, several Contract price adjustments may govern as follows:

1. Density. Contract price adjustments for HMA pavement density not within tolerance will be determined based on the criteria presented in the contract specifications. The target density will be 92% to 96% of the maximum density as determined through the procedures described in the contract specifications. Note that less than 88% of density will require the Division to make a special evaluation of the material and determine an appropriate action.

2. Thickness. Contract price adjustments for HMA pavement thickness not within tolerance will be determined based on the criteria and procedures presented in the contract specifications. Note that one of two situations may be required based on a review by the Division of the Contract Plans and Project Records: either a price reduction or an additional lift. If an additional lift is required, the Contractor will be responsible for the expense of the precipitating actions and requirements.

3. Smoothness. Contract price adjustments for smoothness of surface courses will be determined based on the equations and procedures presented in the contract specifications. Note that if the smoothness value measured in the field exceeds the limits specified in the contract specifications by more than 50%, the subject surface course will be corrected by the Contractor at no additional expense to the Division.

Section 402

HOT-MIX ASPHALT SKID-RESISTANT PAVEMENT

402.1 GENERAL

Section 401 covers many topics that are applicable to the construction of HMA skid-resistant pavements. Section 401.1 covers general topics including aggregate and binder materials, quality control, Job-Mix Formulas, maintenance of traffic, pre-construction conferences, and safety considerations. Sections 401.2, 401.3, and 401.4, respectively, present a significant number of topics and inspection guidelines that are associated with HMA production and hauling, laydown and compaction, and troubleshooting equipment and mat problems. The following sections present information specific to the construction of HMA skid-resistant pavements.

402.1.1 Description of Work

The HMA skid resistant pavement is an HMA wearing course that has skid resistant properties. The Contract Plans will designate the limits of this work. The wearing course will be constructed in accordance with the guidelines presented in Section 401 of this **Manual**. The following sections clarifies the exceptions and additions to Section 401. The Project Inspector is responsible for ensuring that the Contractor performs the work in conformance with the Contract Plans and Specifications.

402.1.2 Aggregate and Asphalt Binder Materials

The primary difference between the HMA discussed in Section 401 and the HMA skid-resistant wearing course is that the skid-resistant wearing course contains a coarse aggregate blend that is polish resistant. Acceptable types of these aggregate material blends are documented in Section 402 of the **Standard Specifications** and will be designated in the contract specifications. During the work, verify that the correct materials are being used.

402.2 RECORDS AND DAILY REPORTS

The Project Engineer/Supervisor should request the performance of skid resistance and smoothness tests when required by the contract specifications.

402.3 MEASUREMENT FOR PAYMENT

See Section 401.6 for applicable guidance on measuring quantities for payment for HMA skid-resistant pavements.

Section 405

SURFACE TREATMENTS

405.1 GENERAL

Section 401 covers many topics that are applicable to the application of surface treatments. Section 401.1 covers general topics including aggregate and bituminous materials, quality control, Job-Mix Formulas, maintenance of traffic, pre-construction conferences, and safety considerations. Sections 401.2, 401.3, and 401.4, respectively, present a significant number of topics and inspection guidelines that are associated with HMA production and hauling, laydown and compaction, and troubleshooting equipment and mat problems, which are generally applicable to surface treatments. The following sections present specific guidelines for the inspection of surface treatments.

405.1.1 Description of Work

Where surface treatment is designated in the Contract, it generally refers to the construction of a wearing course, composed of aggregate and bituminous material, placed and compacted in one or more courses on an acceptable base course or existing surface. The Contract Plans will designate the type of surface treatment and the location, lines, grades, number of courses, course thickness, and cross section for the work. The following type of surface treatments may be specified:

1. Type A – Light Seal. Type A – Light Seal is a seal coat that consists of applying a bituminous material at a specified rate upon an existing surface, and immediately placing a single, uniform application of cover aggregate on the bituminous material. The cover aggregate is then promptly embedded in the bituminous material by rolling. Seal coats are used to lengthen the service life of an existing facility by waterproofing it, slightly increasing its strength, and improving the surface texture.

2. Type B – Single Surface Treatment. Type B – Single Surface Treatment is similar to Type A except that it is usually applied to prepare base courses and is for the purpose of water-proofing and providing a wearing surface.

3. Type C – Double Surface Treatment. Type C – Double Surface Treatment is very similar to Type B in that the operation is repeated until the desired number of courses are obtained. The maximum size aggregate for each successive course is usually smaller than the preceding course.

The Project Inspector is responsible for ensuring that the Contractor performs the work in conformance with the Contract Plans and Specifications.

405.1.2 Aggregate and Bituminous Materials

The aggregate material used for surface treatments is a coarse aggregate material. Section 405 of the **Standard Specifications** specifies the types of aggregate and bituminous materials that should be used for each type of available surface treatment. Check the materials delivered to the project to ensure that they are from an approved source (i.e., laboratory number) and that they are the correct type for the surface treatment specified for the project (i.e., Type A, Type B, Type C).

405.1.3 Weather Considerations

The temperature limits for paving projects, as governed by the contract specifications, cannot be exceeded unless the request is previously approved in writing by the Project Engineer/ Supervisor. In general, surface treatments can only be applied if the temperature of the surface being overlaid is above 50°F (10°C). In addition, the surface must be dry with no imminent rain in the forecast. See Section 401.3.2 for additional weather considerations.

405.1.4 Maintenance of Traffic

The Contractor is responsible for the proper maintenance of traffic and protection of the newly treated surface during construction. Do not permit wheeled traffic to operate on the treated surface before it has fully cured. Otherwise, the surface will ravel or the wheels will pick up and broadcast the material. Check that the required traffic control is in place and that the flow of traffic is satisfactory. Document your findings on the appropriate attachment of the Inspector's Daily Report. See Section 401.1.7 for additional information on traffic control.

405.1.5 Equipment Considerations

Surface treatment jobs require many types of construction equipment including power brooms, power blowers, broom drags, scrapers, hand brooms, shovels, bituminous distributor truck, aggregate spreader, compaction equipment, and single-pass surface treatment machines. Single-pass surface treatment machines offer one important advantage in that there is no delay between the application of the bituminous material and the aggregate. The same calibrations and adjustments necessary for asphalt distributors and aggregate spreaders must be made for this equipment. All calibrations and adjustments should be made in accordance with the manufacturer's recommendations.. It is important to check material distribution equipment for proper calibration so that application rates and quantities used can be accurately determined. All equipment, by which a material is to be distributed or spread, must be adjusted so that the material will be properly and uniformly placed. The following sections briefly discuss the equipment used for surface treatment work. Section 401.3.3 presents the types and operation of equipment used on HMA paving jobs. The primary responsibility of the Project Inspector is to check the equipment for good working operation and ensure that the equipment is being used by the Contractor to perform the work as required.

405.1.5.1 Bituminous Material Distributor

The distribution truck must be a self-powered unit with a heated and pressurized tank to haul the bituminous material while it is being distributed. The tank must be able to uniformly heat the bituminous material to the specified temperature. A thermometer-type device will be provided for the convenience of checking and documenting the material's temperature. The truck also will be equipped with a pressure gage to check and ensure adequate and uniform pressurization of the material, and either a volume gauge or calibrated tank for the purpose of accurately measuring and documenting the application rate and quantity used. The distribution unit (e.g., transverse line of spray nozzles under or behind the truck) must be capable of spraying the bituminous material at variable widths and at controlled rates. The temperature of the bituminous material and the width and rate of application must be within tolerance of the Contract Plans and Specifications. The following discusses the primary components of the bituminous material distributor:

1. Tank. The tank consists of an insulated shell with flues, a thermometer, baffle or surge plates, a manhole, and an overflow pipe. The capacities of distributor tanks vary considerably. All distributors are equipped with a float-type gauge and a measuring

stick for determining the amount of material in the tank. The measuring stick should be marked in volumetric increments. To control and check the rate of application and, in some instances, to provide a basis of measurement for payment, the Contractor should be required to furnish calibration data and a notarized statement, both signed by a person of recognized authority. The statement should identify the distributor, and give the interior dimensions and a description of the tank. The tank should be inspected to see that it has not been changed from the dimensions and description contained in the statement. If the distributor is new or if the notarized statement and calibration data cannot be furnished, it will be necessary to calibrate the tank to relate the depth of material, as determined by the measuring stick, to the volume contained in the tank.

2. Heating System. The heating system consists of one or two burners and an equal number of heating flues. Each burner emits a flame directly into a flue which transfers heat to the bituminous material. The heating system should be checked to make certain that it is capable of maintaining the bituminous material at the desired application temperature. When being heated, the bituminous material must be circulated. Care should be taken that the safe maximum heat of the material is not exceeded.

3. Circulating System. The circulating system consists of a pump and lines passing through the distributor tank to the spray bar and to the hand spray. The pump should be checked to make certain that it is capable of circulating the bituminous material through the tank and the spray bar, and developing and maintaining a constant, uniform pressure along the entire length of the spray bar so that an equal amount of material will be sprayed from each nozzle without atomizing the bituminous material or emitting a distorted fan. The control for the valve system, by which the discharge of bituminous material from the nozzles is controlled, should be inspected and adjusted, if necessary. There should be no slack in the linkage from the control to the valve system so that all of the nozzles will be completely opened or completely closed immediately when the control is operated. The pump tachometer or pressure gauge, which registers the pump discharge, should be checked for accuracy.

4. Bitumeter. A bitumeter consists of a rubber-tired wheel, mounted on a retractable frame and connected to a dial in the cab of the truck by a cable. The bitumeter should be checked to determine whether it accurately registers all of the data it is designed to measure. The wheel should be maintained in a clean condition because, if material is allowed to build up and remain on the wheel, the bitumeter will register erroneously.

5. Spray Bar. To ensure proper working condition of the spray bar, the following inspections and adjustments must be made:

   a. Nozzles. The nozzles should be removed from the spray bar, cleaned, and examined for size, wear, and damage to the edges of the nozzle opening. Uniform distribution of the bituminous material depends on the nozzles being in good condition and being the proper size. Usually, the smallest size nozzle available for a distributor will provide the most uniform distribution. The nozzles should be set so that the slots make the angle with the spray bar recommended by the manufacturer of the distributor.

   b. Spray Bar Height. The height of the spray bar should be set so that the exact number of laps of bituminous material desired will be obtained. The height for a double lap can be determined by closing every other nozzle, operating the distributor at the proper pump speed or pressure, and raising or lowering the spray bar in small increments until it is determined by visual observation that exactly one single lap of material will be applied. For a triple lap, close the second and third, fifth and sixth, etc., nozzles and follow the above procedure. The distributor truck should be equipped with springs that are strong enough to prevent the difference in the height of the spray bar, when the distributor tank is loaded and when it is empty, from being great enough to significantly affect the uniformity of the distribution of the bituminous material. If the uniformity of the distribution is significantly affected, corrective action, such as installing stronger truck springs or connecting the frame of the distributor to the axle when the tank is fully loaded, should be taken.

c. Spread. To ensure uniform distribution, the transverse spread and the longitudinal spread should be checked by any of several acceptable methods. The variation should not exceed approximately 10%.

405.1.5.2 Hand Spraying Equipment

Hand spraying equipment is typically used for areas that are inaccessible to the distribution truck. The hand sprayer is generally connected to the main distributor tank.

405.1.5.3 Aggregate Spreader

Aggregate spreaders are of three general types: tail gate, mechanical, and self-propelled. Of these types, the self-propelled spreader is the most satisfactory. It affords close control on traveling speed, can apply the cover aggregate in a continuous and more uniform manner, and can stay relatively close to the distributor. The aggregate spreader should be calibrated and adjusted in accordance with the manufacturer's recommendations and operating manual. The transverse spread and the longitudinal spread should be checked to make certain that uniform distribution will be obtained. The operating speed should always be less than that at which the spread will lope or undulate. The hitch by which the spreader connects itself to the aggregate trucks should be checked to make certain that it will afford positive connection. The spreading equipment used to spread the coarse aggregate material must be in good working order and capable of uniformly spreading the aggregate at the specified quantity per unit area. The rate will be designated in the Contract.

Where haul trucks are used, they should be inspected for acceptability and operating condition. Each truck should be assigned an equipment number and only that number should be on the truck. No two trucks should be assigned the same number. If cover aggregate is to be measured by volume, determine the volume of each truck bed and record the dimensions with the assigned truck identification number. If cover aggregate is to be measured by weight, determine the weight of the empty truck at such frequency as considered necessary. This information must be recorded with the truck identification numbers.

405.1.5.4 Compaction Equipment

Standard compaction equipment is generally used to key the aggregate into the bituminous material. Hand tampers are used in areas inaccessible to the rollers. See Section 401.3.3 for information on the types and proper operation of compaction rollers. Consider the following additional guidelines:

1. Pneumatic-Tire Rollers. Pneumatic-tire rollers should be checked to determine that it has the desired effective rolling width, the required number of wheels, that it can be loaded to the desired weight, and that the tires are inflated to the pressure necessary to provide the desired ground contact pressure.

2. Steel-Wheel Roller. If steel-wheel rolling is specified, the rollers should be checked to see that they can be loaded to the desired weight and to determine whether they have the desired rolling width. Each wheel should be examined to make certain that it is free of grooves, that it is not pitted, and that the wheel rims are not worn excessively.

3. Power Broom. Power brooms are used for cleaning the existing surface in preparation for construction and for removing excess aggregate from the new surface after the bituminous material has hardened.

4. Drag Broom. Drag brooms are used as a supplement to the aggregate spreader to obtain uniform distribution of the aggregate and proper keying.

405.2 CONSTRUCTION OPERATIONS

The construction operations are of the utmost importance in surface treatment work. Even the most precise design will be of no value if the construction operations are not properly conducted. The proper sequence of operations and the rate of materials applied by the Contractor will depend on the type of surface treatment specified in the Contract. Section 405 of the **Standard Specifications** specifies this criteria for the following surface treatments:

1. Type A – Light Seal,
2. Type B – Single Surface Treatment, and
3. Type C – Double Surface Treatment.

In general, the level of effort and the rate of materials applied increases from Type A to Type C. Type A is a light treatment, and Type C is an improved treatment for more deteriorated surfaces. The following sections discuss typical construction operations and present general inspection guidelines.

405.2.1 Surface Preparation

The importance of surface preparation cannot be over-emphasized. The riding surface of the new surface treatment will be no better than the surface on which it is placed. The existing surface (e.g., base, HMA or PCC pavement) should be prepared as specified for the type of surface treatment designated in the Contract Plans. Breaks, holes, depressions, and other surface irregularities will be repaired with minor patching and leveling (see Section 401.3.4.2). Patching and leveling, in this case, does not necessarily imply the need for a full-width, patching-and-leveling course, unless otherwise designated in the Contract Plans. Check that the repaired surface is properly cleaned and swept as discussed in Section 401.3.4.4. After cleaning and sweeping, check that the remaining aggregate is firmly embedded and that edges are neatly trimmed to line. Waste materials should be disposed of in accordance with Contract requirements. Consider the following additional guidelines:

1. New Base Courses. On new base courses, it seldom will be necessary to repair the surface, since the base course has been constructed to the specified tolerance when finished.

2. Existing Pavements. For existing pavement surfaces, it will almost always be necessary to repair surface defects. The most common surface defects are raveling, cracks (e.g., transverse, longitudinal, alligator, slippage, shrinkage), broken edges, potholes, corrugations, depressions, bumps, foreign material adhered to the surface, absorbent areas, and flushed or bleeding areas. These repairs should be made well in advance of the construction operations.

3. Surface Cleaning. The existing surface must be cleaned just prior to the application of the bituminous material. All foreign materials such as paper and mud should be removed and the entire surface should be thoroughly broomed to remove dirt and dust.

405.2.2 Application of Bituminous Material

The distribution truck is used to spray the type and rate of bituminous material for the type of surface treatment specified over the area designated in the Contract Plans. The operation should be closely monitored. The rate of application is controlled by the length of the spray bar, the pressure developed by the pump, and the speed of the distributor. The speed is measured by a tachometer. The pump must develop enough pressure to produce a sharp, straight-edged spray from each nozzle. The pressure is controlled by setting the governor on the pump engine. If the distributor has been properly adjusted, the material will be applied uniformly in the transverse direction, unless one or more of the nozzles have become clogged. In the longitudinal direction, the circulating pump and the distributor must be operated at a proper and constant speed. The length of spread for each distributor load of material can be determined and marked on the road as an aid to obtaining the desired rate of application. Consider the following additional guidelines:

1. Surface Condition. Before the bituminous material is applied, the surface must be clean, dry, and properly prepared (see Section 405.2.1).

2. Stringline. Application must be made to the width and alignment required by the Contract Plans. Check that a stringline, or similar method, is used by the distributor operator to guide the operation of the equipment. Do not assume that the width of application is correct. It is good practice to frequently measure and check the width for conformance.

3. Contact Surfaces. Check to ensure that contact surfaces such as curbs, gutters, manholes, and adjacent PCC edges are properly sealed. The application of the bituminous material should be uniform without running.

4. Quantity Determination. Before application. check the quantity in the tank. The distributor should be parked off the roadway with the tank in a level position. Also check the temperature for compliance and enforce adjustments as needed. After application, with the truck in a level position, check the quantity remaining in the tank. The volume will have to be corrected for temperature. Volume-temperature correction tables are provided in the attachment of the Inspector's Daily Report.

5. Gauges. Periodically check the temperature and pressure gauges of the distributor truck for proper working order. If a problem is suspected, verify the cause and, as needed, inform the Contractor to repair the equipment.

6. Spray Bar. Periodically check distributor nozzles to make sure all nozzles are open and set at the correct angle and that the spray bar is set at the proper height above the pavement surface. Longitudinal strips with no bituminous material is a sure sign of a clogged distributor head.

7. Application Rate. The application rate should be checked. Too little material will not provide sufficient bonding between layers, and too much material will promote slippage of an overlay or cause bleeding through a thin course. A milled surface may need a higher rate of application.

8. Overspraying. Make sure the operator of the distribution equipment does not splatter bituminous material and mar the surfaces of sidewalks, curbs, structures, and trees in adjacent areas. If overspraying occurs, the Contractor is responsible for correcting the problem.

9. Traffic. Ensure that traffic does not damage surfaces that are treated with uncured bituminous material. Phased construction may be needed. For example, one-way traffic could operate on an untreated section

and later be diverted to the treated section after the bituminous material has sufficiently cured. This requirement is to prevent the material from being picked up and distributed by the wheels of the vehicles.

10. Curing. The bituminous material must be thoroughly cured before a subsequent course is placed or traffic is allowed to operate on the surface.

Document points of inspection on the appropriate attachment of the Inspector's Daily Report.

405.2.3 Application of Aggregate Material

Because bituminous material cools rapidly, its distribution must be carefully coordinated with the spreading of the cover aggregate, if cover aggregate is specified. The period between the distribution of the bituminous material and the application of the cover aggregate should be kept to an absolute minimum to obtain the greatest wetting action and better seating of the aggregate. The objective is to obtain a layer that is approximately one aggregate particle thick, because additional aggregate cover will not adhere to the bitumen and will be wasted. Immediately after the bituminous material is applied, the aggregate spreader will apply coarse aggregate of the type and rate specified for the type of surface treatment designated in the Contract. It may be necessary to direct the Contractor to wash the aggregate with water to eliminate or reduce the dust coating on the aggregate. This enhances adhesion and penetration of the bituminous material, especially with low-viscous material such as prime coat. If washing is needed, it should be performed the day before the aggregate is spread. Where trucks are used to spread the aggregate, do not allow the Contractor to operate the trucks on areas with bituminous material that does not have an aggregate cover. Check the application rate of aggregate material and record your findings on the appropriate attachment of the Inspector's Daily Report.

405.2.4 Brooming and Rolling Operation

After the bituminous material has been applied to the suitably prepared surface, the brooming and rolling operation will begin as discussed in the following sections. Document points of inspection on the appropriate attachment of the Inspector's Daily Report.

405.2.4.1 Brooming

After each course of aggregate has been spread, the Contractor will broom drag the surface to ensure a uniform distribution of aggregate material. Randomly observe areas to see that the material has a uniform depth. Inform the Contractor of any needed corrections.

405.2.4.2 Rolling

The rolling operation should immediately follow the aggregate spreading and brooming operation to embed the aggregate while the bituminous material is still soft and tacky. The purpose of the rolling operation is not to compact the material in terms of achieving a target density, but to key (i.e., firmly embed) the aggregate into the layer of bituminous material. Rolling may have to be conducted over the course of several days to achieve this objective. Consider the following guidelines:

1. Roller Operation. During the operation, the rollers should travel in a direction parallel to the centerline, starting at the edge of pavement and progressing toward the centerline. On superelevated curves, it is good practice to start at the lower edge.

2. Roller Passes. Roller passes should overlap, but rolling should not progress to the point where the aggregate is being significantly crushed. Do not use any more roller passes than that needed to firmly embed the aggregate into the bituminous material.

3. Steel-Wheel Rollers. The utmost caution must be exercised with steel-wheel rollers. Quite frequently, serious degradation of the aggregate occurs due either to the roller being too heavy or too much rolling. Usually one coverage with the steel-wheel roller is adequate on all courses of aggregate.

4. Pneumatic-Tire Rolling. Pneumatic-tire rollers should not be used on intermediate courses of cover aggregate, but should immediately follow steel-wheel rolling on all final courses. Pneumatic-tire rollers must be operated at a speed low enough to prevent the tires from displacing or picking up the aggregate. The ground contact pressure may be adjusted by adjusting the amount of ballast on the roller or by adjusting the tire pressure, or both. The rolling operation should begin at the outside edge of the surface and progress toward the center. Each pass of the pneumatic-tired roller should overlap the preceding pass by at least one-half of the roller width. Rolling should be discontinued when the bituminous material has set or hardened.

5. Joint Construction. Transverse joints should be carefully constructed so that they will not be rough and unsightly. This is usually performed by starting and stopping the application of materials on building paper. Each successive application should overlap the end of the preceding one by 0.5 in (15 mm) to avoid a gap in the surface. Because it is not practical to use building paper on longitudinal joints, it is better to have a slight build-up due to overlapping adjacent passes than it is to have a gap in the surface. Where half-width operations are used, loose aggregate should be removed from along the longitudinal joint before the adjacent lane is surfaced. Check that longitudinal joints are clean of foreign material and are not constructed with gaps. Where the operation is halted, ensure that transverse joints are constructed with treated paper to prevent the overlapping of bituminous material. Upon continuing the operation, the treated paper should be removed and the joint constructed as discussed in Section 401.3.7.5.

6. Raveling. Periodically inspect areas for evidence of raveling, If raveling is observed, inform the Contractor to repair and reroll the area.

7. Release Agents. If, during the rolling operation, material is adhering to the roller wheels, water or an approved release agent should be applied to the roller wheels to prevent the roller wheels from picking up any more material.

8. Loose Aggregate. Usually there will be some loose aggregate particles on a new surface after the rolling operation has been completed. This loose aggregate should be broomed off in the cool part of the morning when the bituminous material is hard and the bonded aggregate particles will not be disturbed. This is a recommended practice for each half of a roadway that is surfaced in half-widths because the half that is finished first will probably carry traffic while the other half is being surfaced, and damage to automobile finishes and windshields will be minimized. Loose aggregate may be the tool by which traffic will create more loose aggregate.

See Section 401.3.7 for additional information on roller operations. Document points of inspection on the appropriate attachment of the Inspector's Daily Report.

405.3 RECORDS AND DAILY REPORTS

Section 111 discusses the general requirements of project records and daily reports. See Section 401.5 for additional information on records and daily reports for paving projects. Consider and document the following key points of inspection on the proper attachment on the Inspector's Daily Report:

1. Check and verify that the required equipment is on site and in good working order.

2. Check and verify that traffic control devices and flaggers are in place. At the end of the day's work, ensure that signs that are not needed during non-working hours are covered or removed.

3. Verify that the proper type and quantity of aggregate and bituminous materials are available. As required, record quality sampling information (e.g., field samples, stockpiles and location references, laboratory numbers, source approval).

4. Check that the sequence of operation is correct for the type of surface treatment designated in the Contract.

5. Check that the surface preparation is in conformance. Verify that the surface has been properly cleaned and swept and that surface breaks, holes, depressions, and other damage has been repaired. Verify that prime coat has been applied and properly cured over any new base construction. The surface must not have standing water when the operation begins.

6. Verify for conformance and record the temperature and application rate of the bituminous material. Calculate and record the application rate twice, minimum, in the morning and afternoon. Check that vehicles are not operating on bituminous material that does not have aggregate cover. Periodically check for evidence of clogging in spray nozzles.

7. Check and record the application rate of aggregate material. Check that each layer of aggregate is broomed to ensure uniform distribution.

8. Check roller pattern and operation for compliance. Check that the aggregate is firmly keyed into the bituminous material and that the aggregate is not being crushed. Check that longitudinal joints are constructed without overlaps or gaps and that treated paper is used for transverse joint construction to prevent overlapping bituminous material.

9. Inspect the surface for raveled areas and ensure that the Contractor properly repairs and rerolls the areas.

10. Record the air and base temperature twice, minimum, in the morning and afternoon.

405.4 MEASUREMENT FOR PAYMENT

All quantities will be paid for at Contract unit prices for the bid items. Use the following guidelines when determining the payment quantities for surface treatments:

1. <u>Aggregate Material</u>. Measure the quantity for payment, in tons (megagrams), of aggregate material accepted complete in place. Determine the quantity based on the total sum of the quantities on the delivery tickets or digital printouts from truck scales. The digital printouts will include the project number, truck identification, the gross, tare and net weights, and the time and date of delivery. Deduct the weight of surface moisture on the aggregate from the total quantity. See Section 401.6 for additional information.

2. <u>Bituminous Material</u>. Measure the quantity for payment, in gallons (liters), of bituminous material incorporated in the work. The project records will include the volume applied in the project based on the readings from the distributor truck's volume gauge or calibrated tank. Volume-temperature corrections will apply as discussed in Section 401.2.6.3 of this **Manual**. Volume-temperature correction tables are provided in the attachment of the Inspector's Daily Report.

3. Cleaning and Sweeping. Measure the quantity for payment, in square yards (square meters), of cleaning and sweeping completed. Determine the area based on the length along the centerline and the finished pavement width. Include areas of any authorized widening in the final total (e.g., curves, turnouts, intersections).

4. Maintenance of Traffic. Maintenance of traffic will be measured and paid as provided for in Section 636 of the **Standard** Specifications.

Section 408

TACK COAT

408.1 GENERAL

Section 401 covers many topics that are applicable to tack coat operations. Section 401.1 covers general topics including aggregate and bituminous materials, quality control, Job-Mix Formulas, maintenance of traffic, pre-construction conferences, and safety considera-tions. Sections 401.2, 401.3, and 401.4, respectively, present a significant number of topics and inspection guidelines for HMA production and hauling, laydown and compaction, and troubleshooting equipment and mat problems, which are generally applicable to the application of tack coat. The following sections present information relative to the application of tack coats.

408.1.1 Description of Work

Where tack coat is designated in the Contract Plans, it generally refers to preparing and treating an existing HMA or PCC pavement surface with bituminous material and, where specified, cover aggregate to ensure a thorough bond between the old and new courses. Tack coats are used primarily in connection with the higher types of bituminous pavements. The Contract Plans will designate the location, lines, grades and, where applicable, the number of aggregate courses, course thickness, and cross section for the work. The Project Inspector is responsible for ensuring that the Contractor performs the work in conformance with the Contract Plans and Specifications.

408.1.2 Aggregate and Bituminous Materials

The bituminous material (i.e., type and grade) and aggregate material (i.e., type and gradation) for tack coat will be specified in the Contract. Quality criteria for bituminous and aggregate materials acceptable for use in tack coat applications are referenced in Section 408 of the **Standard Specifications**. Check to ensure that the materials are from an approved source (i.e., laboratory number) and are the proper materials for use in the operation.

408.1.3 Weather Considerations

Tack coat can only be applied if the temperature of the surface being overlaid is above 40°F (4°C). If the temperature falls below 50°F (10°C), it is good practice to periodically check to see that the tack coat "breaks" before applying an HMA surface course. See Section 405.1.3 for additional information.

408.1.4 Maintenance of Traffic

See Section 405.1.4 for information on maintenance of traffic during construction.

408.1.5 Equipment Considerations

See Section 405.1.5 for information on the bituminous material distribution equipment and the aggregate spreading equipment typically used in tack coat operations.

408.2 CONSTRUCTION OPERATIONS

Unless otherwise designated in the Contract Plans, the proper sequence of operations for cleaning and sweeping and applying bituminous and aggregate materials, including rates of application, will be as specified in Section 408 of the **Standard Specifications**. The following sections discuss typical construction operations and present general inspection guidelines.

408.2.1 Surface Preparation

The surface preparation activities discussed in Section 405.2.1 also apply to the application of tack coat. Note that minor (spot) areas that have been tacked, patched and leveled may be retacked and the quantity used in the second tacking included for payment. This is discussed further in Section 408.4.

408.2.2 Application of Bituminous Material

The temperature and application rate of bituminous material for tack coat is defined in Section 408 of the **Standard Specifications**. Although applicable to surface treatments, the application of a prime coat for new base construction is not applicable to tack coat operations. Note that the areas receiving spot patching and leveling, as discussed in Section 408.2.1, will be initially tacked, then patched and leveled, then retacked. This is further discussed in Section 408.4. See 405.2.2 for additional guidance. Document points of inspection on the appropriate attachment of the Inspector's Daily Report.

408.2.3 Application of Aggregate Material

An application of cover aggregate material may be applied over the bituminous material to absorb excess bituminous material or to protect the surface from damage due to traffic. It may be necessary to direct the Contractor to wash the aggregate with water to eliminate or reduce the dust coating on the aggregate. If this treatment is needed, it should be performed the day before the aggregate is spread. Where designated on the Contract Plans and immediately after the bituminous material is applied, the aggregate spreader will apply the aggregate of the type and rate specified in Section 408 of the **Standard Specifications**. After the cover aggregate is spread, check for deficient areas and have the Contractor correct the deficiency by spreading additional aggregate. Where trucks are used to spread the aggregate, do not allow the Contractor to operate the trucks on areas with bituminous material that does not have an aggregate cover. Check the application rate of aggregate material and record your findings on the appropriate attachment of the Inspector's Daily Report. See Section 405.2.3 for additional guidance.

408.2.4 Broom Dragging/Sweeping

After the cover aggregate has been spread, the surface will be broom dragged to provide a uniform distribution of aggregate material. Where needed, aggregate should be added to absorb any excess bituminous material. The surface then will be swept to remove excess aggregate material without dislodging or removing the embedded aggregate.

408.2.5 Joint Construction

Check that longitudinal joints are clean of foreign material and are not constructed with overlaps or gaps. Where the operation is halted, ensure that transverse joints are constructed with treated paper to prevent overlapping of bituminous material. Upon continuing the operation, the treated paper should be removed and the joint constructed as discussed in Section 401.3.7.5.

408.3 RECORDS AND DAILY REPORTS

Section 111 discusses the general requirements of project records and daily reports. See Section 401.5 for additional information on records and daily reports for paving projects. Consider and document the following key inspection points on the attachment for tack coat in the Inspector's Daily Report:

1. Check and verify that the required equipment is on site and in good working order.

2. Check and verify that traffic control devices and flaggers are in place. At the end of the day's work, ensure that signs that are not needed during non-working hours are covered or removed.

3. Verify that the proper type and quantity of aggregate and bituminous materials are available. Note the method of determining quantities (e.g., dip stick, dial gauge, delivery tickets). As required, record quality sampling information (e.g., ticket number, material type and source, samples, stockpiles and location references, laboratory numbers).

4. Check that surface preparation is in conformance. Verify that the surface has been properly cleaned and swept and that surface breaks, holes, depressions, and other damage has been repaired. The surface must not have standing water when the operation begins.

5. Verify for conformance and record the temperature and application rate of the bituminous material. Calculate and record the application rate twice, minimum, in the morning and afternoon. Check that vehicles are not operating on bituminous material that does not have aggregate cover. Periodically check for evidence of clogging in spray nozzles. Verify that the bituminous material is applied uniformly with a triple overlap.

6. Check and record the application rate any aggregate material applied. Check that each layer of aggregate is broomed to ensure uniform distribution.

7. Record the air and base temperature twice, minimum, in the morning and afternoon.

408.4 MEASUREMENT FOR PAYMENT

All quantities will be paid for at the Contract unit prices for the items. Use the following guidelines when determining the payment quantities for tack coat:

1. Patching and Leveling. Where patching and leveling is designated in the Contract Plans, it may be for either a spot improvement (i.e., surface preparation) or full-width treatment. The underlying surface is normally "tacked." Where the tack-coat bid item is designated in the Contract Plans, it refers to a full-width treatment. Tack coat is not placed over a full-width, patching-and-leveling course. The surface preparation work of the tack-coat bid item includes spot improvements (i.e., small areas that must first be tacked then patched and leveled). Where the Contractor performs the work for the tack-coat bid item, it is therefore possible to have small areas where tack material is placed both under and over patching-and-leveling material. When payment is made for the tack-coat bid item, the quantity of tack under the patching-and-leveling material should not be included in the quantity for tack coat placed and accepted. The cost of the underlying tack material will be included in the unit bid price for the minor patching-and-leveling work. Payment for the tack coat operation applies only to the quantity of materials placed over the previously prepared surface.

2. Aggregate Materials. Measure the quantity for payment, in tons (megagrams), of aggregate material accepted complete in place. Determine the quantity based on the total sum of the quantities on the delivery tickets or digital printouts from truck scales. The digital printouts will include the project number, truck identification, the gross, tare and net weights, and the time and date of delivery. Deduct the weight of surface moisture on the aggregate from the total quantity. See Section 401.6 for additional information.

3. Bituminous Materials. Measure the quantity for payment, in gallons (liters), of bituminous material (prior to dilution in the field) incorporated in the work. The project records will include the volume applied in the project based on readings from the distributor truck's volume gauge or calibrated tank. Volume-temperature corrections will apply as discussed in Section 401.2.6.3 of this **Manual**.

4. Cleaning and Sweeping. Measure the quantity for payment, in square yards (square meters), of cleaning and sweeping completed. Determine the area based on the length along the centerline and the finished pavement width. Include areas of any authorized widening on curves, turnouts, and intersections in the final total.

5. Maintenance of Traffic. Maintenance of traffic will be measured and paid as provided in Section 636 of the **Standard** Specifications.

Section 415

REMOVING EXISTING PAVEMENT SURFACE

415.1 GENERAL

415.1.1 Description of Work

This Contract bid item is a cold milling operation that is typically specified to remove all or part of an existing asphalt pavement surface to remove distressed pavement, restore cross section, improve profile, restore clearances, improve drainage, and to prepare the existing pavement for the placement of additional courses. The pavement will be removed at the locations, depths, widths and in accordance with the typical sections contained in the Contract Plans. The milled material will be removed from the right-of-way and the surface cleaned, flushed, and prepared suitable for maintaining traffic prior to resurfacing.

415.1.2 Maintenance of Traffic

Check that the Contractor slopes transverse vertical faces so as not to create a traffic hazard. Longitudinal vertical faces should not exceed 2 in (50 mm). See Section 401.1.7 for additional information on maintenance of traffic.

415.2 INSPECTION GUIDELINES

415.2.1 Equipment Considerations

Equipment for cold milling include self-propelled planers or grinders. These machines must be capable of removing the existing pavement to within tolerance of the required depth of cut and slope. Consider the following:

1. Grade-Control. A grade-control system on the machine is typically used to automatically control the longitudinal profile and cross slope of the milled surface. The system references input from one or more skid sensors moving along the pavement surface or from a preset fixed reference line.
2. Uniform Surface. It is important that the milling machine leave a uniform surface suitable for maintaining traffic, if necessary, without excessive damage to the underlying pavement structure.
3. Material Removal. An integral loading means may be provided to remove the material being cut from the roadway. This material is usually discharged into haul trucks in a single operation. The advantage of this system is that windrow operations are not required.
4. Obstructions. The milling machine should have a control system to uniformly vary the depth of cut while the machine is in motion to prevent cutting or damaging drainages works, manholes, and other appurtenances. Additional equipment may be necessary to remove the pavement in the area of manholes, water valves, curb and gutter, and other obstructions.
5. Dust Considerations. The milling equipment should be equipped with a means to effectively limit the amount of dust escaping from the removal operation.

415.2.2 Milling Operation

The Contract Plans will indicate the depth, width, grade and cross section for removal. The milling operation should be continually checked to determine that the proper depth of milling has been achieved, that the proper profile and cross slope are achieved, and that the surface texture is free from longitudinal ridges and has a uniform pattern. Consider the following additional guidelines:

1. Surface Uniformity. The machine must be operated to produce a uniform surface. Improper adjustment can cause long swales and other irregularities. Changes in the resulting surface are primarily dependent on changes in the forward speed of the milling machine and the speed of the mandrel. If the machine is leaving a coarse or rough surface and traffic is maintained on the rotomilled lanes, have the Contractor to slow the forward speed of the milling machine to obtain a smoother surface.

2. Surface Damage. Inspect the pavement cutting operation to ensure that the pavement is not torn, gouged, shoved, broken, or otherwise damaged so that the base is unsuitable for a HMA overlay.

3. Cuttings. The cut material may be windrowed behind the miller or directly loaded into haul trucks for transport. Disposal or wasting of oversize pieces of pavement or loose aggregate material should not be permitted within the right-of-way. Unless designated areas are identified in the Contract Plans, or approved by the Engineer, stockpiling of the cut material in the right-of-way is not permitted. The cut material is the property of the Contractor, unless noted otherwise in the plans. Cut material from milling operations can be effectively used as additional aggregate in HMA RAP mixtures.

4. Cleaning. The milled pavement surface should be thoroughly cleaned of all loose aggregate particles, dust, and other objectionable material by the use of a power broom, power blower, power vacuum, or similar means.

5. Dust. The pavement removal operation should be conducted to effectively minimize the amount of dust being emitted.

6. Safety. The operation should be planned and conducted so that it is safe for persons and property adjacent to the work including the traveling public. At the end of the day's work, a smooth transition should be provided to the existing, unmilled pavement. Longitudinal vertical faces should not exceed 2 in (50 mm).

415.3 RECORDS AND DAILY REPORTS

Section 111 discusses the general requirements of project records and daily reports. See Section 401.5 for additional information on records and daily reports for paving projects. Use the appropriate attachment to the Inspector's Daily Report and consider the following guidelines during inspection:

1. Check that the locations of water, gas valve, manholes, etc. have been properly marked to avoid damage during milling.

2. Check that traffic control devices and flaggers are in place.

3. Check that the width and length limits of milling have been established and properly marked.

4. Verify width and length measurements at all break points that are recorded.

5. Check that the cross section conforms to the Contract Plans after the milling operation. One check should be performed each 2,000 ft (610 m), minimum. The surface should be removed to the depth shown on the plans.

6. Verify that haul trucks are not interfering with the flow of traffic.

7. Verify that vertical transverse and longitudinal faces greater than 1 in (25 mm) are sloped prior to reopening to traffic.

8. Check that the pavement is cleaned and swept prior to reopening to traffic.

9. Verify that sidewalk areas are properly cleaned and swept.

10. Check that milled material is stockpiled or removed from the project site, unless otherwise denoted on the Contract Plans.

415.4 MEASUREMENT FOR PAYMENT

Measure the quantity of Removing Existing Pavement Surface based on the total number of square yards (square meters) that was planed or ground, without regard to the number of passes or to the thickness of the material removed. Payment will be based on the unit price specified in the Contract.