WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

POLICY FOR MATERIALS CERTIFICATION RECIPROCITY ~~AND APPRENTICE CERTIFICATION~~

1. PURPOSE

1.1 This Materials Procedure is for certifying applicants who do not hold current materials certifications from West Virginia. Details for the Technician program can be found in MP 106.03.50 on the Materials Division Website[1].

1.2 This Materials Procedure establishes a path for those applicants who wish to become certified PCC Inspectors and/or Aggregate Technicians ~~materials inspectors~~ in the state of West Virginia. For those who currently hold certifications in surrounding states or recognized industrial certifications the Provisional Path is available. This path is available only if the West Virginia Division of Highways deems the certification(s) transferable into the West Virginia certification program. ~~For those who do not hold any certifications, the Apprentice Path is available.~~

2. PROVISIONAL PATH

2.1 This certification path is for applicants who hold a current, applicable certification from another state, or recognized industrial certification and wish to become a certified West Virginia Inspector. To become certified through this path, the applicant must take the West Virginia certification exam. ~~(which may be subject to a testing fee.)~~ The applicant will be given only one (1) attempt to test-out and receive a passing score. The applicant may only test-out for disciplines that the West Virginia Division of Highways deems as a comparable certification. ~~The applicant shall take the next available opportunity to take the West Virginia certification exam. The Division of Highways will notify the applicant by email of the next available date.~~

2.2 If a passing score is not obtained on the test-out, the Provisional Certification will be revoked and applicant will be required to take the respectful class to be certified in West Virginia.~~, and the applicant may be issued an Apprentice Certification. The requirements for West Virginia certification will then revert to the Apprentice Certification guidelines.~~ If a passing score is obtained the applicant will become a

[1] https://transportation.wv.gov/highways/mcst/Pages/MaterialProcedures.aspx

West Virginia certified inspector and be bound by the rules of the West Virginia Certification Program.

2.3 To request a Provisional Certification, the following steps are required:

2.3.1 ~~Fill out the Certification Request Form, which is available on the Materials Division~~ **Error! Hyperlink reference not valid.**[2]~~.~~

2.3.2 The applicant must attach copies of all current, applicable certification cards / certificates.

2.3.3 Email the ~~completed form~~attachment(s) to qaschoolscoordinator@wv.gov

2.3.4 The West Virginia Division of Highways will review the application and will notify the applicant within 30 days by email if the application has been approved or rejected. The applicant shall then be required to create an online learning account. (See Section 43.)

~~3. APPRENTICE PATH~~

~~3.1 For applicants that do not hold any applicable West Virginia or other states material certifications. The applicant may apply for an Apprentice Certification card. The Apprentice Certification will allow them to learn and become familiar with the West Virginia material testing procedures prior to attending the West Virginia certification classes.~~

~~3.2 The Apprentice shall work directly under a West Virginia certified inspector or their designee. The Apprentice shall not work in any area that the West Virginia inspector is not certified. The certified inspector shall sign off on and be the responsible party for all completed test results and work. The certified inspector shall observe all testing that is performed and shall remain in close proximity to the Apprentice in order to render assistance during all testing. Disciplinary action, which may include revocation of certifications, may be taken by the West Virginia Division of Highways Certification Board as Defined in MP 106.03.50 for failure to follow these requirements.~~

~~3.3 The Apprentice shall take the first available certification class that is held by the West Virginia Division of Highways. The class schedule will be posted on the Materials Division web page a minimum of four (4) weeks prior to the class. If the Apprentice fails the exam, or does not take the first available class, their Apprentice Certification will be revoked, and they shall not participate in any testing until they obtain a West~~

[2] **Error! Hyperlink reference not valid.**

~~Virginia Certification. The Apprentice Certification shall only be available once per applicant.~~

~~3.3.1 To request an Apprentice Certification the following steps are required:~~

~~3.3.2 Fill out the Certification Request Form, which is available on the Materials Division~~ **Error! Hyperlink reference not valid.**~~[3].~~

~~3.3.2.1 Email the completed Apprentice application to~~ **Error! Hyperlink reference not valid.**

~~3.3.3 The West Virginia Division of Highways will review the application, and then notify the applicant by email if the application has been approved or rejected. The applicant will then be required to create an online learning account. (See Section 4.)~~

~~4.~~3. CREATING AN ACCOUNT AND SCHEDULINE THE EXAM

~~4.1~~3.1 To create an online learning account, visit the How to create an online learning account[4] Page at the Materials Control, Soils and Testing Division website and follow the instructions. The applicant shall notify qaschoolscoordinator@wv.gov by email that the account has been established.

~~4.2~~3.2 ~~After (10) working days and notifying the~~ **Error! Hyperlink reference not valid.** ~~that the account has been established, the Provisional Applicant may schedule the exam. The exams will be held at locations determined by the WVDOH and the locations will be posted on the Materials Control, Soils and Testing Division website~~.

~~4.3~~3.3 After passing the exam, the Provisional Applicant may go to The technician certification search portal[5] at the Materials Control, Soils and Testing Division website and print out the Apprentice / Provisional Certification Card. The card may also be saved as a screenshot on a smart phone, which may be used in-lieu of a printed card.

Ronald L. Stanevich, P.E.
Director

~~[3]~~ **Error! Hyperlink reference not valid.**

[4] http://transportation.wv.gov/highways/mcst/Documents/Technician School Documents/Coursemill new account instructions.pdf

[5] https://transportation.wv.gov/highways/mcst/Pages/Technician-Directory-Portal.aspx

Materials Control, Soils and Testing Division

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WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

CURING CONCRETE TEST SPECIMENS IN THE FIELD

1. PURPOSE

1.1 The purpose of this procedure is to modify the curing requirements for cylindrical and prismatic specimens that have been made in the field.

2. BACKGROUND

2.1 The ~~Division's Standard Specifications~~WVDOH Standard Specifications for Roads and Bridges and/or Supplemental Specifications (501.4, 511.3.6.1, 514.4. ~~and~~ ,601.4, 603.6.4, 620.5.5, and 679.2.2) require that the making and curing of concrete test specimens in the field be done in accordance with AASHTO Designation ~~T 23~~R100.

2.2 Section ~~9~~10 of AASHTO Designation ~~T 23~~ R100 covers curing of the test specimens until time of test.

3. APPLICABLE DOCUMENT

3.1 *WVDOH Standard Specifications for Roads and Bridges and/or Supplemental Specifications*

~~3.1~~3.2 *AASHTO Designation ~~T 23~~R100*

4. PROCEDURE

4.1 Curing of cylindrical and prismatic specimens made in the field shall be in accordance with Section ~~9~~10 of AASHTO Designation ~~T 23~~R100 with modifications as follows.

4.1.1 Delete the section that covers initial curing (10.1.2 in ~~T23-04~~R100-21) and substitute the following:

10.1.2 Initial Curing - Immediately after molding and finishing, the specimens shall be stored for a period of 24 ± 8 hours in a temperature range from 60 to 80˚F ~~(16 to 27˚C)~~, and in an environment preventing moisture loss from the specimens. For concrete mixtures with a specified strength of 6000 psi ~~(40 MPa)~~ or greater, the initial curing temperature shall be between 68 and 78˚F ~~(20 and 26˚C)~~. Various procedures are capable of being used during the initial curing period to maintain the specified moisture and temperature conditions. An appropriate procedure or combination of procedures shall be used (Note ~~6~~8). Shield all specimens from direct sunlight and, if used, radiant heating devices. The storage temperature shall be controlled by the use of heating and cooling devices, as necessary. Record the temperature using a maximum-minimum thermometer. ~~If cardboard molds are used, protect the outside surface of the molds from contact with wet burlap or other sources of water.~~

4.2 Delete the section that covers transportation of specimens to the laboratory (11.1 in ~~T23-04~~R100-21) and substitute the following:

11.1 Prior to transporting, cure and protect specimens as required in Section ~~9~~10. When standard curing is used, specimens shall be transported within 24 ± 8 hours after molding. When field curing is used, specimens shall not be transported to the laboratory until just prior to testing. During transporting, protect the specimens with suitable cushioning material to prevent damage from jarring. During cold weather, protect the specimens from freezing with suitable insulation material. Prevent moisture loss during transportation by wrapping the specimens in plastic, wet burlap, by surrounding them with wet sand or tight-fitting plastic caps on plastic molds. Transportation time shall not exceed 4 hours.

Ronald L. Stanevich, P.E.
Director
Materials Control, Soils and Testing Division

MP 601.04.20 Steward – Cement and Concrete Section
RLS:T

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION
MATERIALS PROCEDURE

METHOD OF EVALUATION OF NON-STANDARD OR NON-CONFORMING MATERIALS IN CONSTRUCTION VIA DMIR

1. PURPOSE

1.1 Provide a method for evaluating material that does not meet the requirements of the Contract Documents ~~the above-mentioned documents~~ and is not otherwise~~-~~ addressed in those documents~~addressed in those documents~~.

1.2 Provide guidelines and/or a course of action~~/inaction~~ when a material test has not been performed or has been performed incorrectly.

2. DEFINITIONS

2.1 ST-1: Special Testing Form 1~~-~~ The ST-1 is a historic WVDOH document which has been used to provide an acceptance method for a material that does not have a prescribed acceptance method or is otherwise outside the scope of the normal acceptance procedure. ~~This form has evolved over the years but is still used for the original purpose.~~ An ST-1 is to be done before the material is placed.

2.2 DMIR: District Materials Inspection Report – A DMIR is an materials investigation, ~~typically~~ specifically into a material failure or ~~any other~~a situation where there is no prescribed method for the resolution of ~~a~~ failing material on a project. A DMIR can have several outcomes including, but not limited to: Remove and replace, a price reduction, or accept in place~~ etc~~.

2.3 AWP: (AASHTOWare Project Management Software) – This is the generic term for the suite of software used by the WVDOH to manage and process projects. This system manages contracts, samples, tests and other aspects of projects.

~~2.4 Authorize a Sample – This is a technical AWP term in which the user closes or locks the sample. Authoring a sample indicates that the sample has been resolved in the system and the system will allow the project to proceed through certification. This does not have any indication of whether the sample has passed or failed.~~

~~2.5~~2.4 Concur/Non-Concur of Sample – This is a technical AWP term in which the reviewer indicates their acceptance of a sample. A “Non-Concur” typically requires additional action to accept the material in the AWP system.

~~2.6~~2.5 District ~~Sample ID~~Lab Number – This is the tracking number and database ~~a technical AWP term which refers to the “key”~~ field for the WVDOH ~~a record in the~~materials management system ~~AWP database~~.

3. SCOPE

3.1 This procedure applies to situations where the resolution of a non-conformance ~~issue~~ is not clearly defined or described by ~~the Standard Specifications or other WVDOH documents, or if District wishes to diverge from these documents~~Contract Documents.

3.1.1 The DMIR shall be submitted to MCS&T for consideration and either concurrence/non-concurrence for the following situations:

3.1.1.1 The Material did not meet the Standard Specifications or other Division Testing Requirements.

3.1.1.2 The Material is not addressed in the Standard Specifications or other Division Documents and has been placed before testing (ST-1 or evaluation methods were not utilized).

3.1.1.3 Sampling and/or testing was not done correctly, samples or documentation was lost, or testing otherwise cannot be used to represent or accept the material.

3.1.1.4 The resolution of the material has not been addressed in a change order or other contractual document.

3.2 As per Section 105.3 of the Standard Specifications, the District may accept materials that do not conform to Contract Documents. In this instance, material acceptance shall be processed via DMIR.

~~**4. procedure**~~

~~**5.**~~**4.** DMIR Documentation and Submission to MCS&T

~~5.1~~4.1 The DMIR form is available on the WVDOH MCS&T Webpage[1]. All required fields must be completed before submitting the DMIR to MCS&T.

~~5.1.1~~4.1.1 The preparer of the DMIR, typically the Materials Supervisor or their designee, shall clearly state all details that initiated the DMIR and shall include the following categories of information:

1. General/Project information
2. Materials information
3. Type of deviation
4. Situation
5. Review
6. Conclusion
7. Review and Signatures from Construction Engineer and Materials Supervisor
8. Supporting Documentation

~~5.1.2~~4.1.2 A description of the material, known quantities, technical issues, or any requirement from the applicable Specifications, Contract Proposal, Project Plans, Material Procedures (MPs), Standard Details, Special Provisions, AASHTO, ASTM, or any Non-Specification issues shall be provided.

~~5.1.3~~4.1.3 A justification and any supporting and/or relevant detail shall be provided.

~~5.1.4~~4.1.4 The conclusion shall clearly state and justify the final price assessment resolution (which may be $0.00), including all applicable fees and penalties.

~~5.1.5~~4.1.5 The assessment fees should be listed individually and with a final total price assessment. Justification of the price assessment shall be provided.

~~5.1.6~~4.1.6 The ~~Supporting~~ supporting ~~Documentation~~ documentation shall provide the necessary information and evidence for the materials inspection.

4.2 The DMIR shall be sent to the ST-1/DMIR mailbox (St1dmir@wv.gov).

4.2.1 DMIR Request Email files shall be submitted in the following format for both the subject of the email and the file name for the submission: DMIR-District Lab Number-CID Contract ID. An example follows,

4.2.1.1 DMIR-MXZXXXX-CID 20XX00XXXX

~~5.2~~4.3 The sample shall be logged and sent to the applicable MCS&T section to review. If the subject material(s) meets the project requirements, MCS&T will concur with the sample and the reviewer will then ~~authorize the~~process sample in AWP.

~~5.2.1~~4.3.1 The District must electronically send the fillable PDF form. This cannot be hand-written and scanned (the Sample ID must be able to be selected for Copy and Paste).

4.4 After MCS&T has reviewed ~~and authorized~~ the DMIR ~~sample~~ (whether be concur or non-concur), the DMIR will be sent to Contract Administration Division for final evaluation. Contract Administration will finish processing the sample in AWP.

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Director
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RLS:B

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

BASIS OF CHARGES FOR ADDITIONAL ACCEPTANCE TESTING

1. SCOPE

1.1 To provide a unit cost per test to be assessed the Contractor when additional acceptance testing is performed by the Division on reworked LOTS and subLOTS, limited to those tests ~~listed~~ in ~~Table 9-1~~Attachment 1 of MP 109.20.00 (formerly Table 9-1) ~~of this procedure.~~ .

2. BASIS OF CHARGES

2.1 This procedure is applicable to those circumstances where a construction ~~item~~ material by necessity is sampled and/or tested for final acceptance by the Division in excess of what would be considered normal for that ~~item~~ material and is intended to reflect Division costs only. There is no inference in this procedure that charges by private firms offering the same tests are the same or comparable.

3. GENERAL

3.1 As stated in Section 106.3.1.2 of the Standard Specifications, it is the intent of the specifications that LOTS and sub LOTS of materials, products, items of construction or completed construction meet specification requirements at the time of submission. In this case submission refers to the time when the contractor has completed the work and offers the finished 'product' to the Division for final acceptance testing.

3.2 In those cases where final acceptance testing has shown that the product does not meet the Division's criteria of acceptance and the contractor elects to rework the product with the approval of the Engineer, the cost of any additional acceptance testing done by the Division on the reworked product will be assessed to the contractor in the form of a deduction from the amount due the contractor. The amount, or cost, for each additional acceptance test for the applicable ~~item~~ material is $700 per test. In the instance where a single test comprises of a prescribed series of sub-tests (typically 5), the cost of each infraction will be the standard rate divided by the total number of required sub-tests. This is only applicable in the certain circumstances as noted in Attachment 1~~is listed in Table 9-1.~~ of MP 109.20.00.

3.3 Also, the rate of $700, in conjunction with ~~Table 9-1~~Attachment 1 of MP 109.20.00 may be used as a guide for the amount, or cost~~,~~ for deduction in those cases where additional acceptance samples are needed for final acceptance of a construction ~~item~~ a material resulting from a special investigation.

_____
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Materials Control, Soils & Testing Division

MP 109.00.20 Steward – Materials Control Section
RLS:B

Proposed Spec Change

109.2.2-Basis of Charges for Additional Testing: When additional acceptance testing is performed by the Division for reworked lots or sublots in accordance with 106.3.1.2, the cost of such testing will be deducted on current estimates from the amount due the Contractor by the Division. The cost of such testing will be determined in accordance with ~~the unit costs per test as shown in Table 9-1, published in~~ MP 109.00.20.

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

NUCLEAR FIELD DENSITY - MOISTURE TEST FOR RANDOM MATERIAL HAVING LESS THAN 40% OF + 3/4 INCH ~~(+3/4 in. (+19 mm))~~ MATERIAL

1. PURPOSE

1.1 ~~The purpose of t~~This procedure is to determine the density and moisture content of random materials.

2. SCOPE

2.1 This method of testing is applicable to random materials used for embankments, subgrades, backfill, and soil cement base courses.

3. REFFERENCED DOCUMENTS

3.1 *AASHTO Standards:*

- AASHTO ~~T~~ T99, Method C

3.2 *Materials Procedures:*

- MP 712.21.26
- MP 717.04.21U.S.

4. EQUIPMENT

4.1 One complete nuclear density-moisture gauge unit meeting the requirements specified in MP 717.04.21. A copy of the manufacturer's print-out of standard counts is to be included.

4.2 One 1/30 ft^3 ~~(0.000943 m^3)~~ proctor mold assembly with a 5.5 LB ~~(2.5 kg)~~ rammer meeting the requirements of AASHTO ~~T~~ T99.

4.3 One steel foundation plate having minimum dimensions of 15 in. x 15 in. x 5/8 in. ~~(380 mm x 380 mm x 16 mm)~~ or a 200 LB ~~(91 kg)~~ block of concrete.

4.4 One extruder for removing specimens from proctor mold.

4.5 One balance having a capacity of at least 10 kg and sensitive to 1.0 g.

4.6 One stove for drying moisture samples.

4.7 One 32 oz. ~~(900 g)~~ ballpeen hammer or equivalent.

4.8 Two pans with a capacity to hold 10 LB (4500 g) of material.

4.9 One pan suitable for drying moisture samples.

4.10 One wire brush

4.11 One 3/4 in. ~~(19 mm)~~ U.S. Standard Sieve

4.12 One scoop

4.13 One ruler or tape measure

4.14 One measuring tape (should be a minimum of 50 ft ~~(15 m)~~)

4.15 One ~~2 in. (50 mm) approximate size~~ paint brush approximately 2" wide

4.16 One 18 in. ~~(450 mm)~~ chisel or equivalent

4.17 One draw knife

4.18 ~~Supply of~~ T-316 data sheets and attached tables

4.19 One appropriate vehicle for transporting nuclear gauge and test equipment

5. PERSONNEL TRAINING

5.1 All personnel performing the testing must have the minimum training requirements specified in MP 717.04.21.

5.2 All personnel must know and follow the requirements of the Nuclear Regulatory Commission.

6. ROUNDING OF DATA

6.1 Test values and calculations are to be rounded according to the following procedure:

6.1.1 If the figure following the last significant number to be retained is ~~larger than~~ five or larger, increase the last significant number to be retained by one.

~~6.1.2 If the figure following the last significant number to be retained is five, and there are no figures beyond five except zeros, the last significant number to be retained is increased by one if odd, or left unchanged if even.~~

~~6.1.3 If the figure following the last significant number to be retained is five and there are figures following the five, the last significant number to be retained is increased by one.~~

6.1.2 If the figure following the last significant number to be retained is less than five, the significant number is left unchanged.

~~6.1.4~~6.1.3 Test values and calculations shall be rounded to the following nearest significant digit.

Station Number: 1 ft. ~~(0.1 m)~~	
Offset:	1 ft. ~~(0.1 m)~~
Lift Thickness:	1/2 in. ~~(10 mm)~~
Depth Below Grade:	1 ft. ~~(0.1 m)~~
Dry Density (DA):	1 LB/ft^3 ~~(10 kg/m^3)~~
Moisture (MA): 1 LB/ft^3 ~~(10 kg/m^3)~~	
Dry Density - 3/4 in. ~~19 mm~~ material (DB):	1 LB/ft^3 ~~(10 kg/m^3)~~
Moisture (MB): 1%	
Excavated Material + Pan (CA):	1 g
Pan (CB):	1 g
Excavated Material (CC):	1 g
+3/4 in. ~~(+19 mm)~~ Material + Pan (CD):	1 g
Pan (CE):	1 g
+3/4 in. ~~(+19 mm)~~ Material (CF):	1 g
+3/4 in. ~~(+19 mm)~~ Material (CG):	1%
Weight of Soil + Mold (PA):	1 g
Mold (PC):	1 g
Weight of Soil (PD):	1 g
Wet Density (PE):	1 LB/ft^3 ~~(10 kg/m^3)~~
Dry Density (PF):	1 LB/ft^3 ~~(10 kg/m^3)~~
Wet Weight + Pan (SA):	1 g
Pan (SB):	1 g
Wet Weight (SC):	1 g
Dry Weight + Pan (SD):	1 g
Dry Weight (SE):1 g	
Moisture (SF):	1 g
Moisture (SG):	1%
Optimum Moisture (OA):	1%
Maximum Density (DC):	1 LB/ft^3 ~~(10 kg/m^3)~~
Relative Density (DE):	1%
Average DE (X):	0.1%
Target (T):	1%
Quality Index (L):	0.01
Within Tolerance (DF):	1%
Minimum Percent for 100% Pay (DG):	1%

7. PREPARATION FOR TESTING

7.1 Weigh the pans and proctor mold and record the weights on the sides of the equipment. The weights ~~should~~ shall be checked at least on a monthly basis.

7.2 All test data is to be recorded on the attached form T-316.

7.3 Standardization of the nuclear gauge

7.3.1 Warm up the gauge ~~for a minimum of 2 minutes~~ according to the manufacturer's specifications.

7.3.2 Standardization of the gauge must be performed away from metal and other objects.

7.3.3 Clean the top of the standard block and the bottom of the gauge with a cloth.

7.3.4 Place the gauge on the standard block with the gauge turned the correct way. For the Troxler 3400~~11~~ series gauges, the scaler end of the gauge must be tight against the standard block flange.

7.3.5 Make the necessary adjustments on the gauge ~~for standardization and take a four-minute count for density and moisture~~ and perform a standardization according to the manufacturer's specifications.

7.3.6 Compare the standard counts to the manufacturer's standard counts. The standard count must be within ±2% for density and ±4% for moisture from the manufacturer's standards.

7.3.7 If the gauge is not within the specified tolerances for either moisture or density, repeat Section 7.3.5 - 7.3.6. If the gauge will not standardize for either moisture or density after 4 attempts, ~~there is probably something wrong with the gauge~~ a different gauge shall be used. The gauge which failed to standardize may be used again in the future if the procedure referenced in Section 5.2.10 of ~~There may be electronics problems, the gauge needs calibrated, or a stability check needs to be performed. Refer to~~ MP 717.04.21 is followed and the gauge is found to be stable. ~~for a more detailed explanation. In any case, do not use a gauge for testing that will not properly standardize.~~

7.3.8 When a gauge is used for testing pipe or structure backfill in a trench, first check the standardization of the gauge according to Sections 7.3.1 - 7.3.6. If the gauge is functioning properly, then standardize the gauge in the trench. The standard counts in the trench are used for testing in the trench only and the tolerances ~~would~~ shall not be applied to the standard counts taken in the trench. When the gauge is moved to a non-trench condition for testing, new standard counts ~~would~~ shall be required.

7.3.9 Gauges ~~are to~~ shall be standardized before testing and at least every four hours during testing.

7.4 Record the contract ID, project number, item number, etc.

7.5 The lot number has the following prefix letter designations based on the use of the material:

Embankment - _____F
Subgrade - _____S
Base - _____B
Pipe and Structure Backfill - _P

7.6 Randomly locate the test site according to MP 712.21.26.

8. PROCEDURE

8.1 Density and moisture determination

8.1.1 Smooth the test site selected for testing. Fill any voids in the surface using the fines scraped from the surface. Avoid adding excessive fines that would form a build-up on the surface (no more than 1/8 in. ~~(3 mm)~~).

8.1.2 Place the guide plate on the test site. Next, place the drive rod in the plate guide and while standing on the plate, drive the rod at least 2 in. ~~(50 mm)~~ deeper than the location where the end of the gauge source rod will be when testing. The gauge source rod can be extended in 2 in. ~~(50 mm)~~ increments. The source rod must be as deep as possible within the lift but must not extend beyond the lift. For example, a 5 in. ~~inch~~ (125 mm) lift ~~would~~ shall be tested with the source rod in the 4 in. ~~100 mm~~ position and the hole shall ~~would~~ be ~~8 inch (150 mm)~~ 6 in. deep. Carefully remove the drive rod to prevent material from falling into the hole.

8.1.3 Place the gauge over the test site and insert the source rod to the desired depth. Pull the gauge tight against the side of the hole toward the scaler. Make sure the gauge is sitting flush on the material.

8.1.4 Take a one-minute density and moisture reading. Record the dry density (DA) and moisture (MA).

8.2 Determination of the percent of + 3/4 in. ~~(+3/4 in. (+19 mm))~~ material

8.2.1 Excavate approximately 4500 g (10 LB) of material immediately beneath the test site. Excavate the material from the test hole toward the scaler end of the gauge and to the depth of the position where the source rod was located. Keep the excavated material covered to prevent moisture loss.

8.2.2 Zero the scales. The scales ~~are to~~ shall be located in an enclosed area of the vehicle that is protected from air movement. The scales are to be checked for zero before each weighing. Weigh the excavated material (CA).

8.2.3 ~~All of t~~The material weighed in 8.2.2 shall be passed over the 3/4 in. ~~(19 mm)~~ sieve. Break up any clumps of soil that are retained on the sieve and clean the fines from the + 3/4 in. ~~(+3/4 in. (+19 mm))~~ material.

8.2.4 Weigh the +3/4 in. ~~(+19 mm)~~ material (CD) obtained in 8.2.3.

8.2.5 Calculate the percent of +3/4 in. ~~(+19 mm)~~ material (CG) by using the equations on ~~the~~ form T-316. If the percentage of +3/4 in. ~~(+19 mm)~~ material is 40% or more, terminate the test. Refer to MP 717.04.21 for instructions ~~for dealing with the material.~~

8.2.6 Determine the bulk specific gravity (CH) of the dominant +3/4 in. ~~(+19 mm)~~ material by using the values from the following table:

	Bulk Specific Gravity
Soft Shale:	2.4

Hard Shale:	2.5
Sandstone:	2.5
Gravel:	2.6
Limestone:	2.7
Red Shale (Iron Bearing)	2.7

8.3 Determination of the dry density of the -3/4 in. ~~(-19 mm)~~ material and percent field moisture.

8.3.1 The dry density of the -3/4 in. ~~(-19 mm)~~ material (DB) ~~can~~ shall be calculated by the equation on ~~the~~ form T-316 or obtained from the tables ~~for converting total dry density to density of the -3/4 in. (-19 mm) material~~ in attachment 3 of this document, using the specific gravity of the + 3/4 in. material (CH), the total dry density (DA), and the percentage of + 3/4 in. material (CG). ~~The index with the tables explains how to use the tables.~~

8.3.2 Calculate the percent field moisture (MB) by the equation on ~~the~~ form T-316.

8.4 One-point proctor

8.4.1 Place the proctor mold with collar and base attached on the foundation plate. The foundation plate must be firmly seated so that it does not rock when compacting the material. Mix the -3/4 in. ~~(-19 mm)~~ material obtained in 8.2.3. Form a specimen by compacting the material in the mold in three approximately equal layers totaling a minimum of 4 1/2 in. and a maximum of 5 in.~~(38 mm ± 7 mm)~~. Each layer is compacted by 25 uniformly distributed blows with the metal rammer dropped freely from a height of ~~305 mm~~ 12 in.. Stand on the edges of the mold base while compacting the specimen. The rammer must be held vertically.

8.4.2 After the specimen has been made, remove the extension collar. The sample must not extend more than 1/2 in. ~~13 mm~~ above nor be below the top of the mold. A new specimen shall be made ~~if it is too high or low~~ if these tolerances are not met. Carefully trim the material flush with the top of the mold by using the draw knife. Fill any voids in the surface with the fines obtained from the trimming. Use the paint brush to clean the fines from the outside of the mold. Remove the mold base and by holding the mold vertically, visually check the bottom of the mold to determine if the material extends beyond the mold. Do not turn the mold upside down nor trim the bottom. If the material extends beyond the bottom of the mold, perform another specimen with special precautions to seat and tighten the mold to the base.

8.4.3 Weigh the soil plus mold (PA). Record the value~~s~~ in the first column ~~(left of dashed line)~~ ~~in~~ of the one-point proctor section on Form T-316. Do not use the rerun column at this time.

8.4.4 Remove the specimen from the mold by using the extruder. Place the specimen back in the remaining -3/4 in. ~~(-19 mm)~~ material.

8.4.5 Perform the calculations using the equations on the form T-316 to determine the dry density of the one-point proctor (PE).

8.5 Determination of the maximum density and optimum moisture

8.5.1 To determine the maximum density and optimum moisture, plot the percent field moisture (MB) and the dry density of the one-point proctor (PE) on the maximum density-optimum moisture table (attachment 2~~copy attached~~). The values at the intersection of the density line and moisture column are the maximum density (DC) and optimum moisture (OA). If there are no values given, the sample is either too wet or too dry to determine the maximum density and optimum moisture. When the plotted point is to the right of the maximum densities and optimum moistures, the sample is too wet and when the plotted value is to the left, the sample is too dry.

8.5.2 If the sample is found to be too wet, air dry the -3/4 in. ~~(-19 mm)~~ material to decrease the moisture content to between four percentage points below optimum and optimum moisture. The sample is dried by spreading the sample on a ~~sheet of metal, canvas, etc~~ non-absorbent surface. Do not dry the sample on a stove. If the sample is too dry, add water to increase the moisture content to ~~the above moisture range~~ between four percentage points below optimum and optimum moisture. Care ~~should~~ shall be taken not to over dry or add too much water to the sample.

8.5.3 Rerun one-point proctor

8.5.3.1 Once the sample has been air dried or water added, thoroughly mix the sample, and perform another one-point proctor according to 8.4.1 - 8.4.4. Record the data in the second column (rerun~~right of dashed line~~) ~~in~~ of the one-point proctor section on form T-316.

8.5.3.2 Calculate the wet density of the rerun one-point proctor (PE) by using the equations on ~~the~~ form T-316.

8.5.4 Stove dried moisture

8.5.4.1 Scoop out a representative sample between 200 g and 400 g from the sample in 8.5.3.1. The moisture determination can be made in conjunction with making the rerun one-point proctor specimen. Place the sample in the pan for drying samples and determine the sample weight plus pan (SA).

8.5.4.2 Adjust the stove flame to a low heat so that the sample will not oxidize during drying. Occasionally stir the sample and be very careful not to lose any of the sample. Once the sample appears dry, weigh the sample, and record the weight. Place the sample back on the stove and dry for approximately two minutes. Weigh the sample and compare the two weights. The weights should be the same (constant). If there is a decrease in weight, reheat the sample again for two minutes and weigh. Continue this process until two consecutive ~~weighings~~ weights are obtained. Record this weight as ~~the same and this weight is~~ dry weight plus pan (SD).

8.5.4.3 By using the equations on ~~the~~ form T-316, calculate the percent moisture (SG).

8.5.5 Use the percent moisture (SG) from the stove dried moisture to calculate the dry density of the rerun one-point proctor (PE).

8.5.6 Plot the dry density of the rerun one-point proctor (PE) and the percent stove dried moisture (SG) on the maximum density-optimum moisture table to obtain the maximum density (DC) and the optimum moisture (OA).

9. MOISTURE EVALUATION

9.1 Obtain the ± moisture tolerance (OB) from the project's governing specifications. Normally this tolerance is +3/-4.

9.2 To determine the acceptable moisture range, add the plus tolerance and subtract the minus tolerance from the optimum moisture. The field moisture (MB) must be within this range for the moisture to meet specifications. If the moisture fails specifications, corrective action is required.

10. DENSITY EVALUATION

10.1 Calculate the percent relative density (DE) by the equation on ~~the~~ form T-316.

10.2 If the percent relative density (DE) is 105 or more, the test results may be in error. Plot the dry density of the -3/4 in. ~~(-19 mm)~~ material (DB) and the percent field moisture (MB) on the maximum density-optimum moisture table to check the validity of the test results. The plotted point should fall on or to the left of the darkened blocks (zero air voids). Another method of checking the test results is to calculate the maximum moisture content possible (zero air voids) by the following equation:

Maximum moisture content possible (English) = (62.4/DB - .373)100
~~Maximum moisture content possible (Metric) = (1000/DB - 0.373)100~~
When the test results are equal to or less than the above evaluation, the results are acceptable.

10.3 When the conditions in 10.2 are not met, perform another complete test, including a one-point proctor, at a new random location. The checks in 10.2 ~~would~~ shall again be made if the test results are 105% or more. If the conditions in 10.2 are still not met, obtain a sample, and determine the specific gravity of both the +3/4 in. ~~(+19 mm)~~ and -3/4 in. ~~(-19 mm)~~ material, performed separately. Then recalculate the test results using the specific gravity of the +3/4 in. ~~(+19 mm)~~ material to determine the dry density of the -3/4 in. ~~(-19 mm)~~ material (DB). If the percent relative density is still 105% or more, perform the following calculation using the specific gravity of the -3/4 in. ~~(-19 mm)~~ material.

Maximum moisture content = (62.4/DB - 1/Sp. Gr.)100
~~Maximum moisture content = (1000/DB - 1/Sp. Gr.)100~~
The field moisture (MB) must be equal to or less than the maximum moisture content (new zero air voids). If the test results still appear to be invalid, an immediate investigation must be conducted.

11. LOT EVALUATION

11.1 Five tests are required for a lot evaluation. Each test shall be performed according to previous sections of this procedure.

11.2 Calculate the average relative density (x) for the five tests in the lot.

11.3 Obtain the target percentage of dry density (T) from the project's governing specifications.

11.4 Determine the range (R) of the relative densities (DE) by subtracting the smallest value from the largest.

11.5 Calculate the quality index (QL) by using the equation on ~~the~~ form T-316.

11.6 Enter the table for estimating the percent of a lot within tolerance (attachment 1~~copy attached~~). Determine the percent within tolerance (DF) which corresponds to the QL value calculated in 11.5 above.

11.7 Obtain the minimum percent for 100% pay (DG) from the project's governing specifications.

11.8 ~~In order f~~For a lot to meet specifications for density, the percent within tolerance (DF) must be equal to or greater than the percent for 100% pay (DG). Corrective action is required to bring a failing lot into specification requirements.

12. GENERAL REQUIREMENTS

12.1 ~~In order f~~For a lot to meet specifications, the requirements in 9.2 and 11.8 must be met.

12.2 The maximum density, optimum moisture, and percentage of +3/4 in. ~~(+19 mm)~~ material may be used for subsequent tests in a lot if the -3/4 in. ~~(-19 mm)~~ material does not change. When the material changes, the determination of new control data is required. There must be at least one, one-point proctor, for each lot.

12.3 If the test results indicate that the material meets specifications and the material exhibits pumping or displacing action under the weight of construction equipment, ~~the test results are probably in error. O~~obtain a sample of the material and determine the maximum density and optimum moisture according to AASHTO T99, Method C. Until the laboratory test results are obtained, the material in question ~~would~~ shall be dried and re-compacted until the pumping stops. The area ~~would~~ shall then be retested, and this moisture content used as the upper limit for moisture during the interim period.

12.4 During the compaction of soil cement base course, if the material starts to shear, cease rolling even though the required specifications for compaction are not met. The material is accepted for compaction and the proper documentation in the project's records ~~would~~ shall be made.

12.5 Independent tests for similarity checks ~~can~~ shall be recorded on ~~the~~ form T-316. Use only the applicable sections of the form.

Ronald L. Stanevich, P.E.
Director
Materials Control, Soils and Testing Division

MP 207.07.20 Steward – Asphalt Section
RLS:J
ATTACHMENTS

Attachment 1 TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE

Quality Index (QL) Positive Values	Percent Within Tolerance
.66	99
.65	98
.62	97
.60	96
.58	95
.57	94
.55	93
.53	92
.51	91
.50	90
.48	89
.46	88
.45	87
.44	86
.42	85
.41	84
.40	83
.38	82
.37	81
.36	80
.34	79
.33	78
.32	77
.30	76
.29	75
.28	74
.27	73
.25	72
.24	71
.23	70
.22	69
.21	68
.19	67
.18	66
.17	65
.16	64
.15	63
.14	62
.13	61
.11	60
.10	59
.09	58
.08	57
.07	56
.06	55
.05	54
.04	53
.02	52
.01	51
.00	50

Quality Index (QL) Negative Values	Percent Within Tolerance
.00	50
.01	49
.02	48
.04	47
.05	46
.06	45
.07	44
.08	43
.09	42
.10	41
.11	40
.13	39
.14	38
.15	37
.16	36
.17	35
.18	34
.19	33
.21	32
.22	31
.23	30
.24	29
.25	28
.27	27
.28	26
.29	25
.30	24
.32	23
.33	22
.34	21
.36	20
.37	19
.38	18
.40	17
.41	16
.42	15
.44	14
.45	13
.46	12
.48	11
.50	10
.51	9
.53	8
.55	7
.57	6
.58	5
.60	4
.62	3
.63	2
.66	1

Attachment 2

MAXIMUM DENSITY-OPTIMUM MOISTURE TABLE

DRY DENSITY OF ONE POINT PROCTOR

	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
130			131 9																	
129		131 9	130 9	129 9																
128		130 9	130 9	128 10																
127	131 9	130 9	128 10	127 10	127 10															
126	131 9	130 9	128 10	127 10	126 10															
125	130 9	128 10	127 10	126 10	125 10															
124		128 10	126 10	125 11	125 11	124 11														
123		127 10	126 10	124 11	123 11	123 11														
122		126 10	125 11	124 11	123 11	122 12														
121		126 11	125 11	123 12	122 12	121 12	121 12													
120		125 11	124 11	122 12	121 12	120 12	120 12													
119			123 12	122 12	120 12	120 12	119 13													
118			122 12	120 12	120 12	119 13	118 13	118 13												
117				120 12	119 13	118 13	117 13	117 13												
116				119 13	118 13	117 13	117 13	116 14												
115				118 13	117 13	116 14	116 14	115 14	115 14											
114				117 13	116 14	116 14	115 14	114 14	114 14											
113					116 14	115 14	114 14	114 14	113 15											
112					115 14	115 14	113 15	113 15	112 15	112 15										
111					115 14	113 15	112 15	112 15	111 15	111 16										
110					113 15	112 15	112 15	111 15	111 16	110 16										
109						112 15	111 16	110 16	110 16	109 16	109 16									
108						111 16	110 16	110 16	109 16	109 17	108 17									
107							110 16	109 17	108 17	108 17	107 17	107 17								
106							109 17	108 17	107 17	107 17	106 18	106 18								
105							108 17	107 17	107 17	106 18	106 18	105 18	105 18							
104								107 17	106 18	105 18	105 18	104 19	104 19							
103								106 18	105 18	105 19	104 19	103 19	103 19	103 19						
102								105 18	105 19	104 19	103 19	103 20	102 20	102 20	102 20					
101									104 19	103 19	102 20	102 20	101 20	101 20	101 21					
100									103 19	102 20	101 20	101 21	100 21	100 21	100 21	100 21				
99									102 20	101 20	101 21	100 21	100 21	99 21	99 22	99 22				
98										100 21	100 21	99 221	99 22	98 22	98 22	98 22	98 22			
97										100 21	99 21	99 22	98 22	98 22	98 22	97 22	97 23			
96											99 22	98 22	98 22	98 22	97 23	97 23	96 23			
95											99 22	98 22	97 23	97 23	96 23	95 24	95 24	85 24		
94											98 22	97 23	96 23	95 24	95 24	95 24	94 24	94 24	94 24	
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

PERCENT MOISTURE

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
80	79	79	78	78	77	77	76	75	75	74
81	80	80	79	79	78	78	77	77	76	75
82	81	81	80	80	79	79	78	78	77	76
83	83	82	81	81	80	80	79	79	78	78
84	84	83	83	82	81	81	80	80	79	79
85	85	84	84	83	83	82	81	81	80	80
86	86	85	85	84	84	83	83	82	81	81
87	87	86	86	85	85	84	84	83	83	82
88	88	87	87	86	86	85	85	84	84	83
89	89	88	88	87	87	86	86	85	85	84
90	90	89	89	88	88	87	87	86	86	85
91	91	90	90	89	89	88	88	87	87	86
92	92	91	91	90	90	89	89	89	88	88
93	93	92	92	91	91	91	90	90	89	89
94	94	93	93	92	92	92	91	91	90	90
95	95	94	94	93	93	93	92	92	91	91
96	96	95	95	95	94	94	93	93	92	92
97	97	96	96	96	95	95	94	94	94	93
98	98	97	97	97	96	96	95	95	95	94
99	99	98	98	98	97	97	97	96	96	95
100	100	99	99	99	98	98	98	97	97	96
101	101	100	100	100	99	99	99	98	98	98
102	102	101	101	101	100	100	100	99	99	99
103	103	102	102	102	101	101	101	100	100	100
104	104	103	103	103	103	102	102	102	101	101
105	105	104	104	104	104	103	103	103	102	102
106	106	105	105	105	105	104	104	104	103	103
107	107	106	106	106	106	105	105	105	105	104
108	108	108	107	107	107	106	106	106	106	105
109	109	109	108	108	108	108	107	107	107	106
110	110	110	109	109	109	109	108	108	108	108
111	111	111	110	110	110	110	109	109	109	109
112	112	112	111	111	111	111	111	110	110	110
113	113	113	112	112	112	112	112	111	111	111
114	114	114	113	113	113	113	113	112	112	112
115	115	115	114	114	114	114	114	114	113	113
116	116	116	116	115	115	115	115	115	114	114
117	117	117	117	116	116	116	116	116	116	115
118	118	118	118	117	117	117	117	117	117	116
119	119	119	119	118	118	118	118	118	118	118
120	120	120	120	120	119	119	119	119	119	119

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
121	121	121	121	121	120	120	120	120	120	120
122	122	122	122	122	121	121	121	121	121	121
123	123	123	123	123	123	122	122	122	122	122
124	124	124	124	124	124	124	123	123	123	123
125	125	125	125	125	125	125	124	124	124	124
126	126	126	126	126	126	126	126	125	125	125
127	127	127	127	127	127	127	127	127	127	126
128	128	128	128	128	128	128	128	128	128	128
129	129	129	129	129	129	129	129	129	129	129
130	130	130	130	130	130	130	130	130	130	130
131	131	131	131	131	131	131	131	131	131	131
132	132	132	132	132	132	132	132	132	132	132
133	133	133	133	133	133	133	133	133	133	133
134	134	134	134	134	134	134	134	134	134	134
135	135	135	135	135	135	135	135	135	135	135
136	136	136	136	136	136	136	136	136	136	136
137	137	137	137	137	137	137	137	137	138	138
138	138	138	138	138	138	138	138	139	139	139
139	139	139	139	139	139	139	140	140	140	140
140	140	140	140	140	140	141	141	141	141	141
141	141	141	141	141	141	142	142	142	142	142
142	142	142	142	142	143	143	143	143	143	143
143	143	143	143	143	144	144	144	144	144	144
144	144	144	144	145	145	145	145	145	145	145
145	145	145	145	146	146	146	146	146	146	146
146	146	146	146	147	147	147	147	147	147	148
147	147	147	147	148	148	148	148	148	149	149
148	148	148	149	149	149	149	149	149	150	150
149	149	149	150	150	150	150	150	150	151	151
150	150	150	151	151	151	151	151	152	152	152
151	151	151	152	152	152	152	152	153	153	153
152	152	152	153	153	153	153	154	154	154	154
153	153	153	154	154	154	154	155	155	155	155
154	154	154	155	155	155	155	156	156	156	156
155	155	155	156	156	156	156	157	157	157	158
156	156	156	157	157	157	158	158	158	158	159
157	157	158	158	158	158	159	159	159	159	160
158	158	159	159	159	159	160	160	160	161	161
159	159	160	160	160	160	161	161	161	162	162
160	160	161	161	161	161	162	162	162	163	163

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
80	74	73	72	72	71	70	69	69	68	67
81	75	74	73	73	72	71	71	70	69	68
82	76	75	75	74	73	73	72	71	70	70
83	77	76	76	75	74	74	73	72	72	71
84	78	77	77	76	76	75	74	74	73	72
85	79	79	78	77	77	76	75	75	74	73
86	80	80	79	79	78	77	77	76	75	75
87	81	81	80	80	79	78	78	77	76	76
88	83	82	81	81	80	80	79	78	78	77
89	84	83	83	82	81	81	80	80	79	78
90	85	84	84	83	83	82	81	81	80	80
91	86	85	85	84	84	83	83	82	81	81
92	87	87	86	86	85	84	84	83	83	82
93	88	88	87	87	86	86	85	84	84	83
94	89	89	88	88	87	87	86	86	85	85
95	90	90	90	89	89	88	87	87	86	86
96	92	91	91	90	90	89	89	88	88	87
97	93	92	92	91	91	90	90	89	89	88
98	94	93	93	92	92	92	91	91	90	90
99	95	95	94	94	93	93	92	92	91	91
100	96	96	95	95	94	94	93	93	93	92
101	97	97	96	96	96	95	95	94	94	93
102	98	98	98	97	97	96	96	95	95	95
103	99	99	99	98	98	98	97	97	96	96
104	101	100	100	99	99	99	98	98	97	97
105	102	101	101	101	100	100	100	99	99	98
106	103	102	102	102	101	101	101	100	100	100
107	104	104	103	103	103	102	102	102	101	101
108	105	105	104	104	104	103	103	103	102	102
109	106	106	106	105	105	105	104	104	104	103
110	107	107	107	106	106	106	106	105	105	105
111	108	108	108	108	107	107	107	106	106	106
112	110	109	109	109	109	108	108	108	107	107
113	111	110	110	110	110	109	109	109	109	108
114	112	112	111	111	111	111	110	110	110	110
115	113	113	112	112	112	112	112	111	111	111
116	114	114	114	113	113	113	113	113	112	112
117	115	115	115	115	114	114	114	114	114	113
118	116	116	116	116	116	115	115	115	115	115
119	117	117	117	117	117	117	116	116	116	116
120	119	118	118	118	118	118	118	117	117	117

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
121	120	120	119	119	119	119	119	119	118	118
122	121	121	121	120	120	120	120	120	120	120
123	122	122	122	122	121	121	121	121	121	121
124	123	123	123	123	123	123	122	122	122	122
125	124	124	124	124	124	124	124	124	123	123
126	125	125	125	125	125	125	125	125	125	125
127	126	126	126	126	126	126	126	126	126	126
128	128	127	127	127	127	127	127	127	127	127
129	129	129	129	129	129	128	128	128	128	128
130	130	130	130	130	130	130	130	130	130	130
131	131	131	131	131	131	131	131	131	131	131
132	132	132	132	132	132	132	132	132	132	132
133	133	133	133	133	133	133	133	133	133	133
134	134	134	134	134	134	134	134	134	135	135
135	135	135	135	136	136	136	136	136	136	136
136	137	137	137	137	137	137	137	137	137	137
137	138	138	138	138	138	138	138	138	138	138
138	139	139	139	139	139	139	139	139	139	140
139	140	140	140	140	140	140	140	141	141	141
140	141	141	141	141	141	142	142	142	142	142
141	142	142	142	142	143	143	143	143	143	143
142	143	143	144	144	144	144	144	144	144	145
143	144	145	145	145	145	145	145	145	146	146
144	146	146	146	146	146	146	147	147	147	147
145	147	147	147	147	147	148	148	148	148	148
146	148	148	148	148	149	149	149	149	149	150
147	149	149	149	149	150	150	150	150	151	151
148	150	150	150	151	151	151	151	152	152	152
149	151	151	152	152	152	152	153	153	153	153
150	152	152	153	153	153	153	154	154	154	155
151	153	154	154	154	154	155	155	155	156	156
152	154	155	155	155	156	156	156	156	157	157
153	156	156	156	156	157	157	157	158	158	158
154	157	157	157	158	158	158	159	159	159	160
155	158	158	158	159	159	159	160	160	160	161
156	159	159	160	160	160	161	161	161	162	162
157	160	160	161	161	161	162	162	163	163	163
158	161	162	162	162	163	163	163	164	164	165
159	162	163	163	163	164	164	165	165	165	166
160	163	164	164	165	165	165	166	166	167	167

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
80	66	65	65	64	63	62	61	60	59	58
81	67	67	66	65	64	63	62	61	60	59
82	69	68	67	66	65	65	64	63	62	61
83	70	69	68	68	67	66	65	64	63	62
84	71	71	70	69	68	67	66	65	64	64
85	73	72	71	70	69	69	68	67	66	65
86	74	73	72	72	71	70	69	68	67	66
87	75	74	74	73	72	71	70	70	69	68
88	76	76	75	74	73	73	72	71	70	69
89	78	77	76	75	75	74	73	72	72	71
90	79	78	78	77	76	75	75	74	73	72
91	80	79	79	78	77	77	76	75	74	74
92	81	81	80	79	79	78	77	77	76	75
93	83	82	81	81	80	79	79	78	77	76
94	84	83	83	82	81	81	80	79	79	78
95	85	85	84	83	83	82	81	81	80	79
96	86	86	85	85	84	83	83	82	81	81
97	88	87	87	86	85	85	84	83	83	82
98	89	88	88	87	87	86	86	85	84	84
99	90	90	89	89	88	87	87	86	86	85
100	92	91	91	90	89	89	88	88	87	86
101	93	92	92	91	91	90	90	89	88	88
102	94	94	93	93	92	92	91	90	90	89
103	95	95	94	94	93	93	92	92	91	91
104	97	96	96	95	95	94	94	93	93	92
105	98	97	97	97	96	96	95	95	94	94
106	99	99	98	98	97	97	96	96	95	95
107	100	100	100	99	99	98	98	97	97	96
108	102	101	101	100	100	100	99	99	98	98
109	103	103	102	102	101	101	101	100	100	99
110	104	104	103	103	103	102	102	102	101	101
111	105	105	105	104	104	104	103	103	103	102
112	107	106	106	106	105	105	105	104	104	104
113	108	108	107	107	107	106	106	106	105	105
114	109	109	109	108	108	108	107	107	107	106
115	111	110	110	110	109	109	109	108	108	108
116	112	112	111	111	111	110	110	110	110	109
117	113	113	113	112	112	112	112	111	111	111
118	114	114	114	114	113	113	113	113	112	112
119	116	115	115	115	115	115	114	114	114	114
120	117	117	116	116	116	116	116	115	115	115

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
121	118	118	118	118	117	117	117	117	117	116
122	119	119	119	119	119	119	118	118	118	118
123	121	121	120	120	120	120	120	120	119	119
124	122	122	122	122	121	121	121	121	121	121
125	123	123	123	123	123	123	122	122	122	122
126	124	124	124	124	124	124	124	124	124	124
127	126	126	126	125	125	125	125	125	125	125
128	127	127	127	127	127	127	127	127	126	126
129	128	128	128	128	128	128	128	128	128	128
130	130	129	129	129	129	129	129	129	129	129
131	131	131	131	131	131	131	131	131	131	131
132	132	132	132	132	132	132	132	132	132	132
133	133	133	133	133	133	133	133	133	133	134
134	135	135	135	135	135	135	135	135	135	135
135	136	136	136	136	136	136	136	136	136	136
136	137	137	137	137	137	137	138	138	138	138
137	138	138	139	139	139	139	139	139	139	139
138	140	140	140	140	140	140	140	140	141	141
139	141	141	141	141	141	142	142	142	142	142
140	142	142	142	143	143	143	143	143	143	144
141	143	144	144	144	144	144	144	145	145	145
142	145	145	145	145	145	146	146	146	146	146
143	146	146	146	147	147	147	147	147	148	148
144	147	147	148	148	148	148	149	149	149	149
145	149	149	149	149	149	150	150	150	150	151
146	150	150	150	150	151	151	151	152	152	152
147	151	151	152	152	152	152	153	153	153	154
148	152	153	153	153	153	154	154	154	155	155
149	154	154	154	154	155	155	155	156	156	156
150	155	155	155	156	156	156	157	157	157	158
151	156	156	157	157	157	158	158	158	159	159
152	157	158	158	158	159	159	159	160	160	161
153	159	159	159	160	160	160	161	161	162	162
154	160	160	161	161	161	162	162	163	163	164
155	161	162	162	162	163	163	164	164	164	165
156	162	163	163	164	164	165	165	165	166	166
157	164	164	165	165	165	166	166	167	167	168
158	165	165	166	166	167	167	168	168	169	169
159	166	167	167	168	168	169	169	170	170	171
160	167	168	168	169	169	170	170	171	172	172

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
80	57	56	54	53	52	51	50	48	47	45
81	58	57	56	55	54	52	51	50	49	47
82	60	59	57	56	55	54	53	51	50	49
83	61	60	59	58	57	56	54	53	52	50
84	63	62	60	59	58	57	56	55	53	52
85	64	63	62	61	60	59	58	56	55	54
86	65	64	63	62	61	60	59	58	57	55
87	67	66	65	64	63	62	61	60	58	57
88	68	67	66	65	64	63	62	61	60	59
89	70	69	68	67	66	65	64	63	62	60
90	71	70	69	68	67	66	65	64	63	62
91	73	72	71	70	69	68	67	66	65	64
92	74	73	72	72	71	70	69	68	67	65
93	76	75	74	73	72	71	70	69	68	67
94	77	76	75	75	74	73	72	71	70	69
95	78	78	77	76	75	74	73	72	71	70
96	80	79	78	78	77	76	75	74	73	72
97	81	81	80	79	78	77	77	76	75	74
98	83	82	81	81	80	79	78	77	76	75
99	84	84	83	82	81	81	80	79	78	77
100	86	85	84	84	83	82	81	81	80	79
101	87	87	86	85	84	84	83	82	81	80
102	89	88	87	87	86	85	85	84	83	82
103	90	89	89	88	87	87	86	85	85	84
104	92	91	90	90	89	88	88	87	86	85
105	93	92	92	91	91	90	89	89	88	87
106	94	94	93	93	92	91	91	90	90	89
107	96	95	95	94	94	93	92	92	91	90
108	97	97	96	96	95	95	94	93	93	92
109	99	98	98	97	97	96	96	95	94	94
110	100	100	99	99	98	98	97	97	96	95
111	102	101	101	100	100	99	99	98	98	97
112	103	103	102	102	101	101	100	100	99	99
113	105	104	104	103	103	102	102	101	101	100
114	106	106	105	105	104	104	104	103	103	102
115	107	107	107	106	106	106	105	105	104	104
116	109	109	108	108	107	107	107	106	106	105
117	110	110	110	109	109	109	108	108	108	107
118	112	112	111	111	111	110	110	110	109	109
119	113	113	113	112	112	112	111	111	111	110
120	115	114	114	114	114	113	113	113	112	112

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
121	116	116	116	115	115	115	115	114	114	114
122	118	117	117	117	117	116	116	116	116	115
123	119	119	119	118	118	118	118	118	117	117
124	121	120	120	120	120	120	119	119	119	119
125	122	122	122	122	121	121	121	121	121	120
126	123	123	123	123	123	123	123	122	122	122
127	125	125	125	125	124	124	124	124	124	124
128	126	126	126	126	126	126	126	126	126	125
129	128	128	128	128	127	127	127	127	127	127
130	129	129	129	129	129	129	129	129	129	129
131	131	131	131	131	131	131	131	131	130	130
132	132	132	132	132	132	132	132	132	132	132
133	134	134	134	134	134	134	134	134	134	134
134	135	135	135	135	135	135	135	135	135	135
135	136	137	137	137	137	137	137	137	137	137
136	138	138	138	138	138	138	138	139	139	139
137	139	139	140	140	140	140	140	140	140	140
138	141	141	141	141	141	141	142	142	142	142
139	142	142	143	143	143	143	143	143	144	144
140	144	144	144	144	144	145	145	145	145	145
141	145	145	146	146	146	146	146	147	147	147
142	147	147	147	147	147	148	148	148	149	149
143	148	148	149	149	149	149	150	150	150	150
144	149	150	150	150	151	151	151	151	152	152
145	151	151	152	152	152	152	153	153	153	154
146	152	153	153	153	154	154	154	155	155	155
147	154	154	154	155	155	156	156	156	157	157
148	155	156	156	156	157	157	158	158	158	159
149	157	157	157	158	158	159	159	160	160	160
150	158	159	159	159	160	160	161	161	162	162
151	160	160	160	161	161	162	162	163	163	164
152	161	162	162	162	163	163	164	164	165	165
153	163	163	163	164	164	165	165	166	167	167
154	164	164	165	165	166	166	167	168	168	169
155	165	166	166	167	167	168	169	169	170	170
156	167	167	168	168	169	170	170	171	171	172
157	168	169	169	170	171	171	172	172	173	174
158	170	170	171	172	172	173	173	174	175	175
159	171	172	172	173	174	174	175	176	176	177
160	173	173	174	175	175	176	177	177	178	179

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
80	79	79	78	78	77	76	76	75	74	74
81	80	80	79	79	78	77	77	76	75	75
82	81	81	80	80	79	78	78	77	77	76
83	82	82	81	81	80	80	79	78	78	77
84	83	83	82	82	81	81	80	79	79	78
85	84	84	83	83	82	82	81	80	80	79
86	85	85	84	84	83	83	82	82	81	80
87	86	86	85	85	84	84	83	83	82	81
88	88	87	86	86	85	85	84	84	83	83
89	89	88	88	87	86	86	85	85	84	84
90	90	89	89	88	88	87	86	86	85	85
91	91	90	90	89	89	88	88	87	86	86
92	92	91	91	90	90	89	89	88	88	87
93	93	92	92	91	91	90	90	89	89	88
94	94	93	93	92	92	91	91	90	90	89
95	95	94	94	93	93	92	92	91	91	90
96	96	95	95	94	94	93	93	92	92	91
97	97	96	96	95	95	94	94	93	93	93
98	98	97	97	96	96	95	95	95	94	94
99	99	98	98	97	97	97	96	96	95	95
100	100	99	99	98	98	98	97	97	96	96
101	101	100	100	99	99	99	98	98	97	97
102	102	101	101	101	100	100	99	99	99	98
103	103	102	102	102	101	101	100	100	100	99
104	104	103	103	103	102	102	101	101	101	100
105	105	104	104	104	103	103	103	102	102	101
106	106	105	105	105	104	104	104	103	103	103
107	107	106	106	106	105	105	105	104	104	104
108	108	107	107	107	106	106	106	105	105	105
109	109	108	108	108	108	107	107	107	106	106
110	110	109	109	109	109	108	108	108	107	107
111	111	110	110	110	110	109	109	109	108	108
112	112	111	111	111	111	110	110	110	109	109
113	113	113	112	112	112	111	111	111	111	110
114	114	114	113	113	113	113	112	112	112	111
115	115	115	114	114	114	114	113	113	113	113
116	116	116	115	115	115	115	114	114	114	114
117	117	117	116	116	116	116	115	115	115	115
118	118	118	117	117	117	117	117	116	116	116
119	119	119	118	118	118	118	118	117	117	117
120	120	120	119	119	119	119	119	118	118	118

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
121	121	121	120	120	120	120	120	120	119	119
122	122	122	122	121	121	121	121	121	120	120
123	123	123	123	122	122	122	122	122	122	121
124	124	124	124	123	123	123	123	123	123	123
125	125	125	125	124	124	124	124	124	124	124
126	126	126	126	126	125	125	125	125	125	125
127	127	127	127	127	126	126	126	126	126	126
128	128	128	128	128	128	127	127	127	127	127
129	129	129	129	129	129	128	128	128	128	128
130	130	130	130	130	130	130	129	129	129	129
131	131	131	131	131	131	131	131	130	130	130
132	132	132	132	132	132	132	132	132	131	131
133	133	133	133	133	133	133	133	133	133	133
134	134	134	134	134	134	134	134	134	134	134
135	135	135	135	135	135	135	135	135	135	135
136	136	136	136	136	136	136	136	136	136	136
137	137	137	137	137	137	137	137	137	137	137
138	138	138	138	138	138	138	138	138	138	138
139	139	139	139	139	139	139	139	139	139	139
140	140	140	140	140	140	140	140	140	140	140
141	141	141	141	141	141	141	141	141	141	141
142	142	142	142	142	142	142	142	142	142	143
143	143	143	143	143	143	143	143	143	144	144
144	144	144	144	144	144	144	145	145	145	145
145	145	145	145	145	145	145	146	146	146	146
146	146	146	146	146	146	147	147	147	147	147
147	147	147	147	147	148	148	148	148	148	148
148	148	148	148	148	149	149	149	149	149	149
149	149	149	149	149	150	150	150	150	150	150
150	150	150	150	151	151	151	151	151	151	151
151	151	151	151	152	152	152	152	152	152	153
152	152	152	152	153	153	153	153	153	153	154
153	153	153	153	154	154	154	154	154	155	155
154	154	154	155	155	155	155	155	155	156	156
155	155	155	156	156	156	156	156	157	157	157
156	156	156	157	157	157	157	157	158	158	158
157	157	157	158	158	158	158	158	159	159	159
158	158	158	159	159	159	159	160	160	160	160
159	159	159	160	160	160	160	161	161	161	161
160	160	160	161	161	161	161	162	162	162	163

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
80	73	72	71	71	70	69	68	67	67	66
81	74	73	73	72	71	70	69	69	68	67
82	75	74	74	73	72	71	71	70	69	68
83	76	76	75	74	73	73	72	71	70	69
84	77	77	76	75	75	74	73	72	72	71
85	79	78	77	76	76	75	74	74	73	72
86	80	79	78	78	77	76	75	75	74	73
87	81	80	79	79	78	77	77	76	75	74
88	82	81	81	80	79	79	78	77	76	76
89	83	82	82	81	80	80	79	78	78	77
90	84	84	83	82	82	81	80	80	79	78
91	85	85	84	83	83	82	82	81	80	79
92	86	86	85	85	84	83	83	82	81	81
93	88	87	86	86	85	85	84	83	83	82
94	89	88	88	87	86	86	85	84	84	83
95	90	89	89	88	88	87	86	86	85	84
96	91	90	90	89	89	88	88	87	86	86
97	92	92	91	90	90	89	89	88	88	87
98	93	93	92	92	91	91	90	89	89	88
99	94	94	93	93	92	92	91	91	90	89
100	95	95	94	94	93	93	92	92	91	91
101	97	96	96	95	95	94	94	93	92	92
102	98	97	97	96	96	95	95	94	94	93
103	99	98	98	97	97	96	96	95	95	94
104	100	99	99	99	98	98	97	97	96	96
105	101	101	100	100	99	99	98	98	97	97
106	102	102	101	101	100	100	100	99	99	98
107	103	103	102	102	102	101	101	100	100	99
108	104	104	104	103	103	102	102	102	101	101
109	106	105	105	104	104	104	103	103	102	102
110	107	106	106	106	105	105	104	104	104	103
111	108	107	107	107	106	106	106	105	105	104
112	109	109	108	108	108	107	107	106	106	106
113	110	110	109	109	109	108	108	108	107	107
114	111	111	111	110	110	110	109	109	109	108
115	112	112	112	111	111	111	110	110	110	109
116	113	113	113	113	112	112	112	111	111	111
117	114	114	114	114	113	113	113	113	112	112
118	116	115	115	115	115	114	114	114	113	113
119	117	117	116	116	116	116	115	115	115	114
120	118	118	117	117	117	117	116	116	116	116

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
121	119	119	119	118	118	118	118	117	117	117
122	120	120	120	120	119	119	119	119	118	118
123	121	121	121	121	120	120	120	120	120	119
124	122	122	122	122	122	121	121	121	121	121
125	123	123	123	123	123	123	122	122	122	122
126	125	124	124	124	124	124	124	124	123	123
127	126	126	125	125	125	125	125	125	125	124
128	127	127	127	126	126	126	126	126	126	126
129	128	128	128	128	128	127	127	127	127	127
130	129	129	129	129	129	129	129	128	128	128
131	130	130	130	130	130	130	130	130	130	129
132	131	131	131	131	131	131	131	131	131	131
133	132	132	132	132	132	132	132	132	132	132
134	134	134	134	133	133	133	133	133	133	133
135	135	135	135	135	135	135	135	134	134	134
136	136	136	136	136	136	136	136	136	136	136
137	137	137	137	137	137	137	137	137	137	137
138	138	138	138	138	138	138	138	138	138	138
139	139	139	139	139	139	139	139	139	139	139
140	140	140	140	140	140	141	141	141	141	141
141	141	142	142	142	142	142	142	142	142	142
142	143	143	143	143	143	143	143	143	143	143
143	144	144	144	144	144	144	144	144	144	144
144	145	145	145	145	145	145	145	145	146	146
145	146	146	146	146	146	146	147	147	147	147
146	147	147	147	147	148	148	148	148	148	148
147	148	148	148	149	149	149	149	149	149	149
148	149	149	150	150	150	150	150	150	151	151
149	150	151	151	151	151	151	151	152	152	152
150	152	152	152	152	152	152	153	153	153	153
151	153	153	153	153	153	154	154	154	154	154
152	154	154	154	154	155	155	155	155	155	156
153	155	155	155	156	156	156	156	156	157	157
154	156	156	156	157	157	157	157	158	158	158
155	157	157	158	158	158	158	159	159	159	159
156	158	159	159	159	159	160	160	160	160	161
157	159	160	160	160	160	161	161	161	162	162
158	161	161	161	161	162	162	162	163	163	163
159	162	162	162	163	163	163	163	164	164	164
160	163	163	163	164	164	164	165	165	165	166

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
80	65	64	63	62	61	60	59	58	57	55
81	66	65	64	63	62	61	60	59	58	57
82	67	66	65	65	64	63	62	61	59	58
83	69	68	67	66	65	64	63	62	61	60
84	70	69	68	67	66	65	64	63	62	61
85	71	70	69	68	68	67	66	65	64	63
86	72	72	71	70	69	68	67	66	65	64
87	74	73	72	71	70	69	68	67	66	65
88	75	74	73	72	72	71	70	69	68	67
89	76	75	75	74	73	72	71	70	69	68
90	77	77	76	75	74	73	73	72	71	70
91	79	78	77	76	76	75	74	73	72	71
92	80	79	78	78	77	76	75	74	74	73
93	81	81	80	79	78	77	77	76	75	74
94	82	82	81	80	80	79	78	77	76	75
95	84	83	82	82	81	80	79	79	78	77
96	85	84	84	83	82	81	81	80	79	78
97	86	86	85	84	84	83	82	81	81	80
98	88	87	86	86	85	84	83	83	82	81
99	89	88	88	87	86	86	85	84	83	83
100	90	89	89	88	88	87	86	86	85	84
101	91	91	90	90	89	88	88	87	86	85
102	93	92	91	91	90	90	89	88	88	87
103	94	93	93	92	92	91	90	90	89	88
104	95	95	94	93	93	92	92	91	90	90
105	96	96	95	95	94	94	93	92	92	91
106	98	97	97	96	96	95	94	94	93	93
107	99	98	98	97	97	96	96	95	95	94
108	100	100	99	99	98	98	97	97	96	95
109	101	101	101	100	100	99	99	98	97	97
110	103	102	102	101	101	100	100	99	99	98
111	104	104	103	103	102	102	101	101	100	100
112	105	105	104	104	104	103	103	102	102	101
113	107	106	106	105	105	104	104	104	103	103
114	108	107	107	107	106	106	105	105	104	104
115	109	109	108	108	108	107	107	106	106	105
116	110	110	110	109	109	109	108	108	107	107
117	112	111	111	111	110	110	109	109	109	108
118	113	113	112	112	112	111	111	111	110	110
119	114	114	114	113	113	113	112	112	112	111
120	115	115	115	115	114	114	114	113	113	113

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
121	117	116	116	116	116	115	115	115	114	114
122	118	118	117	117	117	117	116	116	116	115
123	119	119	119	118	118	118	118	117	117	117
124	120	120	120	120	120	119	119	119	119	118
125	122	122	121	121	121	121	120	120	120	120
126	123	123	123	122	122	122	122	122	121	121
127	124	124	124	124	124	123	123	123	123	123
128	126	125	125	125	125	125	125	124	124	124
129	127	127	127	126	126	126	126	126	126	125
130	128	128	128	128	128	127	127	127	127	127
131	129	129	129	129	129	129	129	129	128	128
132	131	131	130	130	130	130	130	130	130	130
133	132	132	132	132	132	131	131	131	131	131
134	133	133	133	133	133	133	133	133	133	133
135	134	134	134	134	134	134	134	134	134	134
136	136	136	136	136	136	136	136	136	135	135
137	137	137	137	137	137	137	137	137	137	137
138	138	138	138	138	138	138	138	138	138	138
139	139	139	140	140	140	140	140	140	140	140
140	141	141	141	141	141	141	141	141	141	141
141	142	142	142	142	142	142	142	142	143	143
142	143	143	143	143	144	144	144	144	144	144
143	145	145	145	145	145	145	145	145	145	145
144	146	146	146	146	146	146	146	147	147	147
145	147	147	147	147	148	148	148	148	148	148
146	148	148	149	149	149	149	149	149	150	150
147	150	150	150	150	150	150	151	151	151	151
148	151	151	151	151	152	152	152	152	152	153
149	152	152	153	153	153	153	153	154	154	154
150	153	154	154	154	154	154	155	155	155	155
151	155	155	155	155	156	156	156	156	157	157
152	156	156	156	157	157	157	157	158	158	158
153	157	157	158	158	158	159	159	159	159	160
154	158	159	159	159	160	160	160	161	161	161
155	160	160	160	161	161	161	162	162	162	163
156	161	161	162	162	162	163	163	163	164	164
157	162	163	163	163	164	164	164	165	165	165
158	164	164	164	165	165	165	166	166	166	167
159	165	165	165	166	166	167	167	167	168	168
160	166	166	167	167	168	168	168	169	169	170

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
80	54	53	52	50	49	48	46	45	43	42
81	56	55	53	52	51	49	48	47	45	43
82	57	56	55	54	52	51	50	48	47	45
83	59	57	56	55	54	52	51	50	48	47
84	60	59	58	57	55	54	53	51	50	48
85	62	60	59	58	57	56	54	53	52	50
86	63	62	61	60	58	57	56	55	53	52
87	64	63	62	61	60	59	57	56	55	53
88	66	65	64	63	61	60	59	58	56	55
89	67	66	65	64	63	62	61	59	58	57
90	69	68	67	66	65	63	62	61	60	58
91	70	69	68	67	66	65	64	63	61	60
92	72	71	70	69	68	67	65	64	63	62
93	73	72	71	70	69	68	67	66	65	63
94	75	74	73	72	71	70	69	67	66	65
95	76	75	74	73	72	71	70	69	68	67
96	77	77	76	75	74	73	72	71	70	68
97	79	78	77	76	75	74	73	72	71	70
98	80	80	79	78	77	76	75	74	73	72
99	82	81	80	79	78	77	77	76	75	73
100	83	82	82	81	80	79	78	77	76	75
101	85	84	83	82	81	81	80	79	78	77
102	86	85	85	84	83	82	81	80	79	78
103	88	87	86	85	85	84	83	82	81	80
104	89	88	88	87	86	85	84	84	83	82
105	90	90	89	88	88	87	86	85	84	83
106	92	91	91	90	89	88	88	87	86	85
107	93	93	92	91	91	90	89	88	88	87
108	95	94	94	93	92	92	91	90	89	88
109	96	96	95	94	94	93	92	92	91	90
110	98	97	97	96	95	95	94	93	93	92
111	99	99	98	97	97	96	96	95	94	93
112	101	100	100	99	98	98	97	97	96	95
113	102	102	101	100	100	99	99	98	97	97
114	104	103	103	102	101	101	100	100	99	98
115	105	105	104	104	103	102	102	101	101	100
116	106	106	106	105	105	104	104	103	102	102
117	108	107	107	107	106	106	105	105	104	103
118	109	109	109	108	108	107	107	106	106	105
119	111	110	110	110	109	109	108	108	107	107
120	112	112	111	111	111	110	110	109	109	108

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
121	114	113	113	113	112	112	111	111	111	110
122	115	115	114	114	114	113	113	113	112	112
123	117	116	116	116	115	115	115	114	114	113
124	118	118	117	117	117	117	116	116	116	115
125	119	119	119	119	118	118	118	117	117	117
126	121	121	120	120	120	120	119	119	119	118
127	122	122	122	122	121	121	121	121	120	120
128	124	124	123	123	123	123	123	122	122	122
129	125	125	125	125	125	124	124	124	124	123
130	127	127	126	126	126	126	126	126	125	125
131	128	128	128	128	128	127	127	127	127	127
132	130	130	129	129	129	129	129	129	129	128
133	131	131	131	131	131	131	130	130	130	130
134	133	132	132	132	132	132	132	132	132	132
135	134	134	134	134	134	134	134	134	134	133
136	135	135	135	135	135	135	135	135	135	135
137	137	137	137	137	137	137	137	137	137	137
138	138	138	138	138	138	138	138	138	138	138
139	140	140	140	140	140	140	140	140	140	140
140	141	141	141	141	141	142	142	142	142	142
141	143	143	143	143	143	143	143	143	143	143
142	144	144	144	144	145	145	145	145	145	145
143	146	146	146	146	146	146	146	147	147	147
144	147	147	147	147	148	148	148	148	148	148
145	148	149	149	149	149	149	150	150	150	150
146	150	150	150	150	151	151	151	151	152	152
147	151	152	152	152	152	152	153	153	153	153
148	153	153	153	154	154	154	154	155	155	155
149	154	155	155	155	155	156	156	156	156	157
150	156	156	156	157	157	157	157	158	158	158
151	157	157	158	158	158	159	159	159	160	160
152	159	159	159	160	160	160	161	161	161	162
153	160	160	161	161	161	162	162	163	163	163
154	162	162	162	163	163	163	164	164	165	165
155	163	163	164	164	165	165	165	166	166	167
156	164	165	165	166	166	167	167	167	168	168
157	166	166	167	167	168	168	169	169	170	170
158	167	168	168	169	169	170	170	171	171	172
159	169	169	170	170	171	171	172	172	173	173
160	170	171	171	172	172	173	173	174	175	175

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
80	79	79	78	77	77	76	75	75	74	73
81	80	80	79	78	78	77	76	76	75	74
82	81	81	80	79	79	78	77	77	76	75
83	82	82	81	81	80	79	79	78	77	76
84	83	83	82	82	81	80	80	79	78	77
85	84	84	83	83	82	81	81	80	79	79
86	85	85	84	84	83	82	82	81	80	80
87	86	86	85	85	84	83	83	82	81	81
88	87	87	86	86	85	85	84	83	83	82
89	88	88	87	87	86	86	85	84	84	83
90	89	89	88	88	87	87	86	85	85	84
91	90	90	89	89	88	88	87	86	86	85
92	91	91	90	90	89	89	88	88	87	86
93	92	92	91	91	90	90	89	89	88	87
94	94	93	92	92	91	91	90	90	89	89
95	95	94	94	93	92	92	91	91	90	90
96	96	95	95	94	94	93	92	92	91	91
97	97	96	96	95	95	94	94	93	92	92
98	98	97	97	96	96	95	95	94	94	93
99	99	98	98	97	97	96	96	95	95	94
100	100	99	99	98	98	97	97	96	96	95
101	101	100	100	99	99	98	98	97	97	96
102	102	101	101	100	100	99	99	98	98	97
103	103	102	102	101	101	100	100	100	99	99
104	104	103	103	102	102	102	101	101	100	100
105	105	104	104	103	103	103	102	102	101	101
106	106	105	105	104	104	104	103	103	102	102
107	107	106	106	106	105	105	104	104	103	103
108	108	107	107	107	106	106	105	105	105	104
109	109	108	108	108	107	107	106	106	106	105
110	110	109	109	109	108	108	108	107	107	106
111	111	110	110	110	109	109	109	108	108	107
112	112	111	111	111	110	110	110	109	109	109
113	113	112	112	112	111	111	111	110	110	110
114	114	113	113	113	112	112	112	111	111	111
115	115	114	114	114	114	113	113	113	112	112
116	116	115	115	115	115	114	114	114	113	113
117	117	116	116	116	116	115	115	115	114	114
118	118	117	117	117	117	116	116	116	116	115
119	119	119	118	118	118	117	117	117	117	116
120	120	120	119	119	119	119	118	118	118	117

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
121	121	121	120	120	120	120	119	119	119	119
122	122	122	121	121	121	121	120	120	120	120
123	123	123	122	122	122	122	122	121	121	121
124	124	124	123	123	123	123	123	122	122	122
125	125	125	124	124	124	124	124	123	123	123
126	126	126	125	125	125	125	125	125	124	124
127	127	127	127	126	126	126	126	126	125	125
128	128	128	128	127	127	127	127	127	127	126
129	129	129	129	128	128	128	128	128	128	127
130	130	130	130	129	129	129	129	129	129	129
131	131	131	131	131	130	130	130	130	130	130
132	132	132	132	132	131	131	131	131	131	131
133	133	133	133	133	132	132	132	132	132	132
134	134	134	134	134	134	133	133	133	133	133
135	135	135	135	135	135	135	134	134	134	134
136	136	136	136	136	136	136	135	135	135	135
137	137	137	137	137	137	137	137	136	136	136
138	138	138	138	138	138	138	138	138	138	137
139	139	139	139	139	139	139	139	139	139	139
140	140	140	140	140	140	140	140	140	140	140
141	141	141	141	141	141	141	141	141	141	141
142	142	142	142	142	142	142	142	142	142	142
143	143	143	143	143	143	143	143	143	143	143
144	144	144	144	144	144	144	144	144	144	144
145	145	145	145	145	145	145	145	145	145	145
146	146	146	146	146	146	146	146	146	146	146
147	147	147	147	147	147	147	147	147	147	147
148	148	148	148	148	148	148	148	148	149	149
149	149	149	149	149	149	149	149	150	150	150
150	150	150	150	150	150	150	151	151	151	151
151	151	151	151	151	151	152	152	152	152	152
152	152	152	152	152	152	153	153	153	153	153
153	153	153	153	153	154	154	154	154	154	154
154	154	154	154	154	155	155	155	155	155	155
155	155	155	155	156	156	156	156	156	156	156
156	156	156	156	157	157	157	157	157	157	157
157	157	157	157	158	158	158	158	158	158	159
158	158	158	158	159	159	159	159	159	160	160
159	159	159	160	160	160	160	160	160	161	161
160	160	160	161	161	161	161	161	161	162	162

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
80	72	71	71	70	69	68	67	66	65	64
81	73	73	72	71	70	69	68	67	67	66
82	74	74	73	72	71	70	70	69	68	67
83	76	75	74	73	72	72	71	70	69	68
84	77	76	75	74	74	73	72	71	70	69
85	78	77	76	76	75	74	73	72	71	71
86	79	78	78	77	76	75	74	74	73	72
87	80	79	79	78	77	76	76	75	74	73
88	81	81	80	79	78	78	77	76	75	74
89	82	82	81	80	80	79	78	77	76	76
90	83	83	82	81	81	80	79	78	78	77
91	85	84	83	83	82	81	80	80	79	78
92	86	85	84	84	83	82	82	81	80	79
93	87	86	86	85	84	84	83	82	81	81
94	88	87	87	86	85	85	84	83	83	82
95	89	88	88	87	87	86	85	85	84	83
96	90	90	89	88	88	87	86	86	85	84
97	91	91	90	90	89	88	88	87	86	86
98	92	92	91	91	90	89	89	88	87	87
99	94	93	92	92	91	91	90	89	89	88
100	95	94	94	93	92	92	91	91	90	89
101	96	95	95	94	94	93	92	92	91	91
102	97	96	96	95	95	94	94	93	92	92
103	98	98	97	97	96	95	95	94	94	93
104	99	99	98	98	97	97	96	95	95	94
105	100	100	99	99	98	98	97	97	96	96
106	101	101	101	100	100	99	98	98	97	97
107	103	102	102	101	101	100	100	99	99	98
108	104	103	103	102	102	101	101	100	100	99
109	105	104	104	104	103	103	102	102	101	101
110	106	106	105	105	104	104	103	103	102	102
111	107	107	106	106	105	105	104	104	104	103
112	108	108	107	107	107	106	106	105	105	104
113	109	109	109	108	108	107	107	106	106	106
114	110	110	110	109	109	109	108	108	107	107
115	112	111	111	110	110	110	109	109	108	108
116	113	112	112	112	111	111	111	110	110	109
117	114	113	113	113	112	112	112	111	111	111
118	115	115	114	114	114	113	113	113	112	112
119	116	116	115	115	115	114	114	114	113	113
120	117	117	117	116	116	116	115	115	115	114

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
121	118	118	118	117	117	117	117	116	116	116
122	119	119	119	119	118	118	118	117	117	117
123	121	120	120	120	120	119	119	119	118	118
124	122	121	121	121	121	120	120	120	120	119
125	123	123	122	122	122	122	121	121	121	121
126	124	124	123	123	123	123	123	122	122	122
127	125	125	125	124	124	124	124	124	123	123
128	126	126	126	126	125	125	125	125	125	124
129	127	127	127	127	127	126	126	126	126	126
130	128	128	128	128	128	128	127	127	127	127
131	130	129	129	129	129	129	129	128	128	128
132	131	131	130	130	130	130	130	130	129	129
133	132	132	132	131	131	131	131	131	131	131
134	133	133	133	133	132	132	132	132	132	132
135	134	134	134	134	134	134	133	133	133	133
136	135	135	135	135	135	135	135	135	134	134
137	136	136	136	136	136	136	136	136	136	136
138	137	137	137	137	137	137	137	137	137	137
139	139	138	138	138	138	138	138	138	138	138
140	140	140	140	140	140	139	139	139	139	139
141	141	141	141	141	141	141	141	141	141	141
142	142	142	142	142	142	142	142	142	142	142
143	143	143	143	143	143	143	143	143	143	143
144	144	144	144	144	144	144	144	144	144	144
145	145	145	145	145	145	145	145	145	146	146
146	146	146	146	147	147	147	147	147	147	147
147	148	148	148	148	148	148	148	148	148	148
148	149	149	149	149	149	149	149	149	149	149
149	150	150	150	150	150	150	150	150	150	151
150	151	151	151	151	151	151	151	152	152	152
151	152	152	152	152	152	153	153	153	153	153
152	153	153	153	154	154	154	154	154	154	154
153	154	154	155	155	155	155	155	155	155	156
154	155	156	156	156	156	156	156	156	157	157
155	157	157	157	157	157	157	158	158	158	158
156	158	158	158	158	158	159	159	159	159	159
157	159	159	159	159	160	160	160	160	160	161
158	160	160	160	160	161	161	161	161	162	162
159	161	161	161	162	162	162	162	163	163	163
160	162	162	163	163	163	163	164	164	164	164

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
80	63	62	61	60	59	58	57	56	54	53
81	65	64	63	61	60	59	58	57	56	55
82	66	65	64	63	62	61	60	58	57	56
83	67	66	65	64	63	62	61	60	59	57
84	68	67	66	65	64	63	62	61	60	59
85	70	69	68	67	66	65	64	63	61	60
86	71	70	69	68	67	66	65	64	63	62
87	72	71	70	69	68	67	66	65	64	63
88	73	73	72	71	70	69	68	67	66	65
89	75	74	73	72	71	70	69	68	67	66
90	76	75	74	73	72	71	70	69	68	67
91	77	76	76	75	74	73	72	71	70	69
92	79	78	77	76	75	74	73	72	71	70
93	80	79	78	77	76	76	75	74	73	72
94	81	80	79	79	78	77	76	75	74	73
95	82	82	81	80	79	78	77	76	75	75
96	84	83	82	81	80	80	79	78	77	76
97	85	84	83	83	82	81	80	79	78	77
98	86	85	85	84	83	82	81	81	80	79
99	87	87	86	85	84	84	83	82	81	80
100	89	88	87	86	86	85	84	83	83	82
101	90	89	89	88	87	86	86	85	84	83
102	91	91	90	89	88	88	87	86	85	85
103	92	92	91	90	90	89	88	88	87	86
104	94	93	92	92	91	90	90	89	88	87
105	95	94	94	93	92	92	91	90	90	89
106	96	96	95	94	94	93	92	92	91	90
107	97	97	96	96	95	94	94	93	92	92
108	99	98	98	97	96	96	95	94	94	93
109	100	99	99	98	98	97	97	96	95	95
110	101	101	100	100	99	98	98	97	97	96
111	103	102	102	101	100	100	99	99	98	97
112	104	103	103	102	102	101	101	100	99	99
113	105	105	104	104	103	103	102	101	101	100
114	106	106	105	105	104	104	103	103	102	102
115	108	107	107	106	106	105	105	104	104	103
116	109	108	108	108	107	107	106	106	105	105
117	110	110	109	109	108	108	107	107	106	106
118	111	111	111	110	110	109	109	108	108	107
119	113	112	112	111	111	111	110	110	109	109
120	114	114	113	113	112	112	112	111	111	110

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
121	115	115	114	114	114	113	113	113	112	112
122	116	116	116	115	115	115	114	114	114	113
123	118	117	117	117	116	116	116	115	115	115
124	119	119	118	118	118	117	117	117	116	116
125	120	120	120	119	119	119	118	118	118	117
126	122	121	121	121	120	120	120	119	119	119
127	123	123	122	122	122	121	121	121	121	120
128	124	124	124	123	123	123	123	122	122	122
129	125	125	125	125	124	124	124	124	123	123
130	127	126	126	126	126	126	125	125	125	125
131	128	128	127	127	127	127	127	126	126	126
132	129	129	129	129	128	128	128	128	128	127
133	130	130	130	130	130	130	129	129	129	129
134	132	132	131	131	131	131	131	131	130	130
135	133	133	133	133	132	132	132	132	132	132
136	134	134	134	134	134	134	133	133	133	133
137	135	135	135	135	135	135	135	135	135	135
138	137	137	137	136	136	136	136	136	136	136
139	138	138	138	138	138	138	138	138	137	137
140	139	139	139	139	139	139	139	139	139	139
141	141	141	140	140	140	140	140	140	140	140
142	142	142	142	142	142	142	142	142	142	142
143	143	143	143	143	143	143	143	143	143	143
144	144	144	144	144	144	144	144	144	145	145
145	146	146	146	146	146	146	146	146	146	146
146	147	147	147	147	147	147	147	147	147	147
147	148	148	148	148	148	148	149	149	149	149
148	149	149	150	150	150	150	150	150	150	150
149	151	151	151	151	151	151	151	151	152	152
150	152	152	152	152	152	153	153	153	153	153
151	153	153	153	154	154	154	154	154	154	155
152	154	155	155	155	155	155	155	156	156	156
153	156	156	156	156	156	157	157	157	157	157
154	157	157	157	158	158	158	158	158	159	159
155	158	158	159	159	159	159	160	160	160	160
156	160	160	160	160	160	161	161	161	161	162
157	161	161	161	161	162	162	162	163	163	163
158	162	162	163	163	163	163	164	164	164	165
159	163	164	164	164	164	165	165	165	166	166
160	165	165	165	165	166	166	166	167	167	167

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
80	52	50	49	48	46	45	43	42	40	38
81	53	52	51	49	48	46	45	43	42	40
82	55	53	52	51	49	48	46	45	43	41
83	56	55	54	52	51	49	48	46	45	43
84	58	56	55	54	52	51	49	48	46	45
85	59	58	57	55	54	53	51	50	48	46
86	60	59	58	57	55	54	53	51	50	48
87	62	61	60	58	57	56	54	53	51	50
88	63	62	61	60	59	57	56	54	53	51
89	65	64	63	61	60	59	57	56	55	53
90	66	65	64	63	62	60	59	58	56	55
91	68	67	66	64	63	62	61	59	58	56
92	69	68	67	66	65	63	62	61	60	58
93	71	70	68	67	66	65	64	62	61	60
94	72	71	70	69	68	67	65	64	63	61
95	74	73	71	70	69	68	67	66	64	63
96	75	74	73	72	71	70	69	67	66	65
97	76	75	74	73	72	71	70	69	68	66
98	78	77	76	75	74	73	72	71	69	68
99	79	78	77	76	75	74	73	72	71	70
100	81	80	79	78	77	76	75	74	73	71
101	82	81	80	79	79	78	76	75	74	73
102	84	83	82	81	80	79	78	77	76	75
103	85	84	83	83	82	81	80	79	78	76
104	87	86	85	84	83	82	81	80	79	78
105	88	87	86	86	85	84	83	82	81	80
106	89	89	88	87	86	85	84	83	82	81
107	91	90	89	89	88	87	86	85	84	83
108	92	92	91	90	89	88	88	87	86	85
109	94	93	92	92	91	90	89	88	87	86
110	95	95	94	93	92	92	91	90	89	88
111	97	96	95	95	94	93	92	92	91	90
112	98	98	97	96	95	95	94	93	92	91
113	100	99	98	98	97	96	96	95	94	93
114	101	100	100	99	99	98	97	96	96	95
115	103	102	101	101	100	99	99	98	97	96
116	104	103	103	102	102	101	100	100	99	98
117	105	105	104	104	103	103	102	101	101	100
118	107	106	106	105	105	104	103	103	102	101
119	108	108	107	107	106	106	105	104	104	103
120	110	109	109	108	108	107	107	106	105	105

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
121	111	111	110	110	109	109	108	108	107	106
122	113	112	112	111	111	110	110	109	109	108
123	114	114	113	113	112	112	111	111	110	110
124	116	115	115	114	114	113	113	112	112	111
125	117	117	116	116	115	115	115	114	114	113
126	118	118	118	117	117	117	116	116	115	115
127	120	120	119	119	119	118	118	117	117	116
128	121	121	121	120	120	120	119	119	119	118
129	123	123	122	122	122	121	121	121	120	120
130	124	124	124	123	123	123	122	122	122	121
131	126	125	125	125	125	124	124	124	123	123
132	127	127	127	126	126	126	126	125	125	125
133	129	128	128	128	128	128	127	127	127	126
134	130	130	130	129	129	129	129	129	128	128
135	132	131	131	131	131	131	130	130	130	130
136	133	133	133	133	132	132	132	132	132	131
137	134	134	134	134	134	134	134	133	133	133
138	136	136	136	136	135	135	135	135	135	135
139	137	137	137	137	137	137	137	137	137	136
140	139	139	139	139	139	138	138	138	138	138
141	140	140	140	140	140	140	140	140	140	140
142	142	142	142	142	142	142	142	142	142	141
143	143	143	143	143	143	143	143	143	143	143
144	145	145	145	145	145	145	145	145	145	145
145	146	146	146	146	146	146	146	146	146	146
146	147	148	148	148	148	148	148	148	148	148
147	149	149	149	149	149	149	149	150	150	150
148	150	150	151	151	151	151	151	151	151	151
149	152	152	152	152	152	153	153	153	153	153
150	153	153	154	154	154	154	154	154	155	155
151	155	155	155	155	155	156	156	156	156	156
152	156	156	157	157	157	157	157	158	158	158
153	158	158	158	158	159	159	159	159	160	160
154	159	159	160	160	160	160	161	161	161	161
155	160	161	161	161	162	162	162	162	163	163
156	162	162	163	163	163	163	164	164	164	165
157	163	164	164	164	165	165	165	166	166	166
158	165	165	166	166	166	167	167	167	168	168
159	166	167	167	167	168	168	169	169	169	170
160	168	168	168	169	169	170	170	171	171	171

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
80	79	79	78	77	76	76	75	74	73	72
81	80	80	79	78	77	77	76	75	74	74
82	81	81	80	79	79	78	77	76	75	75
83	82	82	81	80	80	79	78	77	77	76
84	83	83	82	81	81	80	79	78	78	77
85	84	84	83	82	82	81	80	79	79	78
86	85	85	84	83	83	82	81	81	80	79
87	86	86	85	84	84	83	82	82	81	80
88	87	87	86	85	85	84	83	83	82	81
89	88	88	87	87	86	85	85	84	83	82
90	89	89	88	88	87	86	86	85	84	84
91	90	90	89	89	88	87	87	86	85	85
92	91	91	90	90	89	88	88	87	86	86
93	92	92	91	91	90	89	89	88	88	87
94	93	93	92	92	91	91	90	89	89	88
95	94	94	93	93	92	92	91	90	90	89
96	95	95	94	94	93	93	92	91	91	90
97	96	96	95	95	94	94	93	93	92	91
98	97	97	96	96	95	95	94	94	93	92
99	99	98	97	97	96	96	95	95	94	94
100	100	99	99	98	97	97	96	96	95	95
101	101	100	100	99	99	98	97	97	96	96
102	102	101	101	100	100	99	99	98	97	97
103	103	102	102	101	101	100	100	99	99	98
104	104	103	103	102	102	101	101	100	100	99
105	105	104	104	103	103	102	102	101	101	100
106	106	105	105	104	104	103	103	102	102	101
107	107	106	106	105	105	104	104	103	103	102
108	108	107	107	106	106	105	105	104	104	104
109	109	108	108	107	107	106	106	106	105	105
110	110	109	109	108	108	108	107	107	106	106
111	111	110	110	109	109	109	108	108	107	107
112	112	111	111	110	110	110	109	109	108	108
113	113	112	112	112	111	111	110	110	110	109
114	114	113	113	113	112	112	111	111	111	110
115	115	114	114	114	113	113	112	112	112	111
116	116	115	115	115	114	114	114	113	113	112
117	117	116	116	116	115	115	115	114	114	114
118	118	117	117	117	116	116	116	115	115	115
119	119	118	118	118	117	117	117	116	116	116
120	120	119	119	119	119	118	118	118	117	117

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
121	121	120	120	120	120	119	119	119	118	118
122	122	121	121	121	121	120	120	120	119	119
123	123	122	122	122	122	121	121	121	121	120
124	124	124	123	123	123	122	122	122	122	121
125	125	125	124	124	124	124	123	123	123	122
126	126	126	125	125	125	125	124	124	124	124
127	127	127	126	126	126	126	125	125	125	125
128	128	128	127	127	127	127	126	126	126	126
129	129	129	128	128	128	128	128	127	127	127
130	130	130	129	129	129	129	129	128	128	128
131	131	131	130	130	130	130	130	129	129	129
132	132	132	131	131	131	131	131	131	130	130
133	133	133	133	132	132	132	132	132	131	131
134	134	134	134	133	133	133	133	133	133	132
135	135	135	135	134	134	134	134	134	134	134
136	136	136	136	135	135	135	135	135	135	135
137	137	137	137	137	136	136	136	136	136	136
138	138	138	138	138	137	137	137	137	137	137
139	139	139	139	139	139	138	138	138	138	138
140	140	140	140	140	140	139	139	139	139	139
141	141	141	141	141	141	141	140	140	140	140
142	142	142	142	142	142	142	142	141	141	141
143	143	143	143	143	143	143	143	143	142	142
144	144	144	144	144	144	144	144	144	144	144
145	145	145	145	145	145	145	145	145	145	145
146	146	146	146	146	146	146	146	146	146	146
147	147	147	147	147	147	147	147	147	147	147
148	148	148	148	148	148	148	148	148	148	148
149	149	149	149	149	149	149	149	149	149	149
150	150	150	150	150	150	150	150	150	150	150
151	151	151	151	151	151	151	151	151	151	151
152	152	152	152	152	152	152	152	152	152	152
153	153	153	153	153	153	153	153	153	153	154
154	154	154	154	154	154	154	154	154	155	155
155	155	155	155	155	155	155	156	156	156	156
156	156	156	156	156	156	156	157	157	157	157
157	157	157	157	157	157	158	158	158	158	158
158	158	158	158	158	159	159	159	159	159	159
159	159	159	159	159	160	160	160	160	160	160
160	160	160	160	160	161	161	161	161	161	161

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
80	72	71	70	69	68	67	66	65	64	63
81	73	72	71	70	69	68	67	66	65	64
82	74	73	72	71	70	69	68	67	66	65
83	75	74	73	72	71	71	70	69	68	67
84	76	75	74	74	73	72	71	70	69	68
85	77	76	76	75	74	73	72	71	70	69
86	78	78	77	76	75	74	73	72	71	70
87	79	79	78	77	76	75	74	74	73	72
88	81	80	79	78	77	77	76	75	74	73
89	82	81	80	79	79	78	77	76	75	74
90	83	82	81	81	80	79	78	77	76	75
91	84	83	82	82	81	80	79	78	78	77
92	85	84	84	83	82	81	80	80	79	78
93	86	85	85	84	83	82	82	81	80	79
94	87	87	86	85	84	84	83	82	81	80
95	88	88	87	86	86	85	84	83	83	82
96	90	89	88	87	87	86	85	85	84	83
97	91	90	89	89	88	87	87	86	85	84
98	92	91	90	90	89	88	88	87	86	85
99	93	92	92	91	90	90	89	88	87	87
100	94	93	93	92	91	91	90	89	89	88
101	95	95	94	93	93	92	91	91	90	89
102	96	96	95	94	94	93	93	92	91	90
103	97	97	96	96	95	94	94	93	92	92
104	99	98	97	97	96	96	95	94	94	93
105	100	99	99	98	97	97	96	96	95	94
106	101	100	100	99	99	98	97	97	96	95
107	102	101	101	100	100	99	99	98	97	97
108	103	103	102	101	101	100	100	99	99	98
109	104	104	103	103	102	102	101	100	100	99
110	105	105	104	104	103	103	102	102	101	100
111	106	106	105	105	104	104	103	103	102	102
112	108	107	107	106	106	105	105	104	103	103
113	109	108	108	107	107	106	106	105	105	104
114	110	109	109	108	108	107	107	106	106	105
115	111	110	110	110	109	109	108	108	107	107
116	112	112	111	111	110	110	109	109	108	108
117	113	113	112	112	111	111	111	110	110	109
118	114	114	113	113	113	112	112	111	111	110
119	115	115	115	114	114	113	113	113	112	112
120	117	116	116	115	115	115	114	114	113	113

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
121	118	117	117	117	116	116	115	115	115	114
122	119	118	118	118	117	117	117	116	116	115
123	120	120	119	119	119	118	118	117	117	117
124	121	121	120	120	120	119	119	119	118	118
125	122	122	122	121	121	121	120	120	120	119
126	123	123	123	122	122	122	121	121	121	120
127	124	124	124	124	123	123	123	122	122	122
128	125	125	125	125	124	124	124	124	123	123
129	127	126	126	126	126	125	125	125	124	124
130	128	128	127	127	127	127	126	126	126	125
131	129	129	128	128	128	128	127	127	127	127
132	130	130	130	129	129	129	129	128	128	128
133	131	131	131	131	130	130	130	130	129	129
134	132	132	132	132	131	131	131	131	131	130
135	133	133	133	133	133	132	132	132	132	132
136	134	134	134	134	134	134	133	133	133	133
137	136	135	135	135	135	135	135	135	134	134
138	137	137	136	136	136	136	136	136	136	135
139	138	138	138	137	137	137	137	137	137	137
140	139	139	139	139	139	138	138	138	138	138
141	140	140	140	140	140	140	140	139	139	139
142	141	141	141	141	141	141	141	141	141	140
143	142	142	142	142	142	142	142	142	142	142
144	143	143	143	143	143	143	143	143	143	143
145	145	145	145	144	144	144	144	144	144	144
146	146	146	146	146	146	146	146	146	145	145
147	147	147	147	147	147	147	147	147	147	147
148	148	148	148	148	148	148	148	148	148	148
149	149	149	149	149	149	149	149	149	149	149
150	150	150	150	150	150	150	150	150	150	150
151	151	151	151	151	151	152	152	152	152	152
152	152	153	153	153	153	153	153	153	153	153
153	154	154	154	154	154	154	154	154	154	154
154	155	155	155	155	155	155	155	155	155	155
155	156	156	156	156	156	156	156	156	157	157
156	157	157	157	157	157	157	158	158	158	158
157	158	158	158	158	159	159	159	159	159	159
158	159	159	159	160	160	160	160	160	160	160
159	160	160	161	161	161	161	161	161	162	162
160	161	162	162	162	162	162	162	163	163	163

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
80	62	61	60	58	57	56	55	53	52	51
81	63	62	61	60	59	57	56	55	54	52
82	64	63	62	61	60	59	57	56	55	54
83	66	65	64	62	61	60	59	58	56	55
84	67	66	65	64	63	61	60	59	58	56
85	68	67	66	65	64	63	62	60	59	58
86	69	68	67	66	65	64	63	62	61	59
87	71	70	69	68	67	65	64	63	62	61
88	72	71	70	69	68	67	66	65	63	62
89	73	72	71	70	69	68	67	66	65	64
90	75	74	73	72	71	70	68	67	66	65
91	76	75	74	73	72	71	70	69	68	66
92	77	76	75	74	73	72	71	70	69	68
93	78	77	76	76	75	74	73	72	70	69
94	80	79	78	77	76	75	74	73	72	71
95	81	80	79	78	77	76	75	74	73	72
96	82	81	80	79	79	78	77	76	75	74
97	83	83	82	81	80	79	78	77	76	75
98	85	84	83	82	81	80	79	78	77	76
99	86	85	84	83	83	82	81	80	79	78
100	87	86	86	85	84	83	82	81	80	79
101	88	88	87	86	85	84	84	83	82	81
102	90	89	88	87	87	86	85	84	83	82
103	91	90	89	89	88	87	86	85	85	84
104	92	92	91	90	89	88	88	87	86	85
105	93	93	92	91	91	90	89	88	87	86
106	95	94	93	93	92	91	90	90	89	88
107	96	95	95	94	93	93	92	91	90	89
108	97	97	96	95	95	94	93	92	92	91
109	99	98	97	97	96	95	94	94	93	92
110	100	99	99	98	97	97	96	95	94	94
111	101	100	100	99	99	98	97	97	96	95
112	102	102	101	101	100	99	99	98	97	96
113	104	103	102	102	101	101	100	99	99	98
114	105	104	104	103	103	102	101	101	100	99
115	106	106	105	104	104	103	103	102	101	101
116	107	107	106	106	105	105	104	103	103	102
117	109	108	108	107	107	106	105	105	104	104
118	110	109	109	108	108	107	107	106	106	105
119	111	111	110	110	109	109	108	108	107	106
120	112	112	112	111	111	110	110	109	108	108

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
121	114	113	113	112	112	111	111	110	110	109
122	115	115	114	114	113	113	112	112	111	111
123	116	116	115	115	115	114	114	113	113	112
124	118	117	117	116	116	115	115	115	114	114
125	119	118	118	118	117	117	116	116	115	115
126	120	120	119	119	119	118	118	117	117	116
127	121	121	121	120	120	120	119	119	118	118
128	123	122	122	122	121	121	121	120	120	119
129	124	124	123	123	123	122	122	122	121	121
130	125	125	125	124	124	124	123	123	123	122
131	126	126	126	126	125	125	125	124	124	124
132	128	127	127	127	127	126	126	126	125	125
133	129	129	128	128	128	128	127	127	127	126
134	130	130	130	129	129	129	129	128	128	128
135	131	131	131	131	131	130	130	130	130	129
136	133	133	132	132	132	132	131	131	131	131
137	134	134	134	133	133	133	133	133	132	132
138	135	135	135	135	135	134	134	134	134	134
139	137	136	136	136	136	136	136	135	135	135
140	138	138	138	137	137	137	137	137	137	136
141	139	139	139	139	139	138	138	138	138	138
142	140	140	140	140	140	140	140	140	139	139
143	142	142	141	141	141	141	141	141	141	141
144	143	143	143	143	143	143	142	142	142	142
145	144	144	144	144	144	144	144	144	144	144
146	145	145	145	145	145	145	145	145	145	145
147	147	147	147	147	147	147	147	147	146	146
148	148	148	148	148	148	148	148	148	148	148
149	149	149	149	149	149	149	149	149	149	149
150	150	150	151	151	151	151	151	151	151	151
151	152	152	152	152	152	152	152	152	152	152
152	153	153	153	153	153	153	153	153	154	154
153	154	154	154	154	155	155	155	155	155	155
154	156	156	156	156	156	156	156	156	156	156
155	157	157	157	157	157	157	157	158	158	158
156	158	158	158	158	159	159	159	159	159	159
157	159	159	160	160	160	160	160	160	161	161
158	161	161	161	161	161	161	162	162	162	162
159	162	162	162	162	163	163	163	163	163	164
160	163	163	164	164	164	164	164	165	165	165

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
80	49	48	46	45	43	42	40	38	36	34
81	51	49	48	46	45	43	41	40	38	36
82	52	51	49	48	46	45	43	41	40	38
83	54	52	51	49	48	46	45	43	41	39
84	55	54	52	51	49	48	46	45	43	41
85	57	55	54	52	51	49	48	46	45	43
86	58	57	55	54	52	51	49	48	46	44
87	59	58	57	55	54	53	51	49	48	46
88	61	60	58	57	56	54	53	51	49	48
89	62	61	60	58	57	56	54	53	51	49
90	64	63	61	60	59	57	56	54	53	51
91	65	64	63	62	60	59	57	56	54	53
92	67	66	64	63	62	60	59	58	56	54
93	68	67	66	65	63	62	61	59	58	56
94	70	68	67	66	65	63	62	61	59	58
95	71	70	69	68	66	65	64	62	61	59
96	73	71	70	69	68	67	65	64	63	61
97	74	73	72	71	69	68	67	66	64	63
98	75	74	73	72	71	70	68	67	66	64
99	77	76	75	74	72	71	70	69	68	66
100	78	77	76	75	74	73	72	70	69	68
101	80	79	78	77	76	74	73	72	71	69
102	81	80	79	78	77	76	75	74	72	71
103	83	82	81	80	79	78	76	75	74	73
104	84	83	82	81	80	79	78	77	76	74
105	86	85	84	83	82	81	80	78	77	76
106	87	86	85	84	83	82	81	80	79	78
107	88	88	87	86	85	84	83	82	81	79
108	90	89	88	87	86	85	84	83	82	81
109	91	91	90	89	88	87	86	85	84	83
110	93	92	91	90	89	88	88	87	86	84
111	94	93	93	92	91	90	89	88	87	86
112	96	95	94	93	92	92	91	90	89	88
113	97	96	96	95	94	93	92	91	90	89
114	99	98	97	96	96	95	94	93	92	91
115	100	99	99	98	97	96	95	95	94	93
116	102	101	100	99	99	98	97	96	95	94
117	103	102	102	101	100	99	99	98	97	96
118	104	104	103	102	102	101	100	99	99	98
119	106	105	105	104	103	103	102	101	100	99
120	107	107	106	105	105	104	103	103	102	101

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
121	109	108	108	107	106	106	105	104	104	103
122	110	110	109	108	108	107	107	106	105	104
123	112	111	111	110	109	109	108	108	107	106
124	113	113	112	112	111	110	110	109	108	108
125	115	114	114	113	112	112	111	111	110	109
126	116	116	115	115	114	113	113	112	112	111
127	117	117	117	116	116	115	115	114	113	113
128	119	118	118	118	117	117	116	116	115	114
129	120	120	120	119	119	118	118	117	117	116
130	122	121	121	121	120	120	119	119	118	118
131	123	123	122	122	122	121	121	120	120	119
132	125	124	124	124	123	123	122	122	122	121
133	126	126	125	125	125	124	124	124	123	123
134	128	127	127	127	126	126	126	125	125	124
135	129	129	128	128	128	128	127	127	127	126
136	130	130	130	130	129	129	129	128	128	128
137	132	132	131	131	131	131	130	130	130	129
138	133	133	133	133	132	132	132	132	131	131
139	135	135	134	134	134	134	134	133	133	133
140	136	136	136	136	136	135	135	135	135	134
141	138	138	137	137	137	137	137	137	136	136
142	139	139	139	139	139	138	138	138	138	138
143	141	141	140	140	140	140	140	140	140	139
144	142	142	142	142	142	142	141	141	141	141
145	144	143	143	143	143	143	143	143	143	143
146	145	145	145	145	145	145	145	145	145	144
147	146	146	146	146	146	146	146	146	146	146
148	148	148	148	148	148	148	148	148	148	148
149	149	149	149	149	149	149	149	149	149	149
150	151	151	151	151	151	151	151	151	151	151
151	152	152	152	152	152	153	153	153	153	153
152	154	154	154	154	154	154	154	154	154	154
153	155	155	155	155	156	156	156	156	156	156
154	157	157	157	157	157	157	157	158	158	158
155	158	158	158	158	159	159	159	159	159	159
156	159	160	160	160	160	160	161	161	161	161
157	161	161	161	162	162	162	162	162	163	163
158	162	163	163	163	163	163	164	164	164	164
159	164	164	164	165	165	165	165	166	166	166
160	165	166	166	166	166	167	167	167	168	168

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

FORM T-316
MP 207.07.20
REV. 08-22

LAB NUMBER _____
AUTHORIZATION NUMBER _____
PROJECT NUMBER _____
DISTRICT _____
LOT NUMBER _____
ITEM NUMBER _____

GAUGE NUMBER		TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY		STATION NUMBER	ft.					
MOISTURE		OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY		LIFT THICKNESS	ft.					
MOISTURE		DEPTH OF SOURCE	ft.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3											
		MA	MOISTURE	lb/ft3											
		DB	DRY DENSITY -3/4	lb/ft3											
MB = $\frac{MA(100)}{DB}$		**MB**	MOISTURE	%											
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams											
CC = CA - CB		**CB**	PAN	grams											
CF = CD - CE		**CC**	EXCAVATED MAT.	grams											
CG = $\frac{CF(100)}{CC}$		**CD**	PLUS +3/4 MAT. + PAN	grams											
		CE	PAN	grams											
PC = PA - PB		**CF**	PLUS 3/4 MAT	grams											
PD = PC (0.066)		**CG**	PLUS 3/4 MAT	%											
PE = $\frac{PD(100)}{100+MB}$		**CH**	SPECIFIC GRAVITY												
					RERUN		RERUN		RERUN		RERUN		RERUN		
PE (RERUN) = $\frac{PD(100)}{100+SG}$	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams											
		PB	MOLD	grams											
RERUN PROCTOR		**PC**	WEIGHT OF SOIL	grams											
		PD	WET DENSITY	lb/ft^3											
		PE	DRY DENSITY	lb/ft3											
SC = SA - SB	STOVE DRIED MOISTURE	**SA**	WET WEIGHT + PAN	grams											
SE = SD - SB		**SB**	PAN	grams											
SF = SC - SE		**SC**	WET WEIGHT	grams											
SG = $\frac{SF(100)}{SE}$		**SD**	DRY WEIGHT + PAN	grams											
		SE	DRY WEIGHT	grams											
DE = $\frac{DB(100)}{DC}$		**SF**	MOISTURE	grams											
		SG	MOISTURE	%											
$\bar{X}$ = $\frac{\sum DE}{5}$	MOIST. EVAL	**OA**	OPTIMUM MOISTURE	%											
		OB	PLUS / MINUS TOLER.												
		OC	PASS / FAIL												
QL = $\frac{\bar{X}-T}{R}$	DEN EVAL	**DC**	MAXIMUM DENSITY	lb/ft3											
		DE	RELATIVE DENSITY	%											
	LOT EVALUATION	$\bar{X}$	AVERAGE **DE**	%											
		T	TARGET	%											
		QL	QUALITY INDEX												
		DF	WITHIN TOLERANCE	%											
		DG	MIN. FOR 100% PAY	%											
		DH	PASS / FAIL												

INSPECTORS NAME:

INSPECTORS SIGNATURE:

PROJECT'S EVALUATION

CHECKED BY:

DATE:

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

CALIBRATION OF THERMOMETERS AND PYROMETERS AT ~~BITUMINOUS~~ ASPHALT CONCRETE MIXING PLANTS

1. PURPOSE

1.1 To provide a test procedure for field calibration of thermometers and pyrometers used at bituminous concrete mix in the truck.

2. SCOPE

2.1 This procedure is applicable to devices used to measure temperature in liquid binder ~~bituminous material~~ lines, material temperatures within the plant ~~aggregate dryers~~, and temperature of the completed mix on the truck.

3. CALIBRATION

3.1 Thermometers and pyrometers shall be calibrated at least once per year.

4. CALIBRATION TEMPERATURE RANGE

4.1 Devices used to measure temperature in the liquid binder ~~bituminous material~~ lines and within the plant shall be checked at a minimum of three different temperatures, over a range extending from approximately 25°F below to 25°F above the normal ~~dryer~~ operating temperature.

4.2 Devices used to measure the temperature of the mix in the truck shall be checked at intervals of approximately 25°F through the range of temperature permitted by the specifications for the type of materials to be produced.

5. TEST PROCEDURES

5.1 The following materials will be needed: a sample can or other suitable container of at least ~~two-gallon~~ two-gallon capacity; sufficient oil, asphalt or sand to fill the container; a source of heat, such as a hot plate, propane stove or oven; and a calibrated thermometer. Calibrated thermometers may be obtained from the Materials Control, Soils and Testing Division.

5.2 Fill the container with sand, oil, or asphalt. Sand is preferable, if the test is to be conducted outdoors, since it retains heat longer than oil or asphalt. ~~In order to~~To reduce testing time, hot asphalt from the storage tank, or hot sand from the dryer may be used.

5.3 Heat the material to the first test temperature and remove form the heat source.

5.3.1 If using sand, stir the sand thoroughly, and place the calibrated thermometer and the device being tested in the sand, positioned so that the temperature measuring elements are as close together as possible and are located near the center of the container.

5.3.2 If using oil or asphalt, place both the calibrated thermometer and the device being calibrated in the container, positioned so that the temperature sensing elements are located as close together as possible, and stir the oil or asphalt to equalize the temperature.

5.4 If a pyrometer is being tested, leave the protective shield in place, and be sure that the temperature sensing element is completely immersed in the liquid or sand.

5.5 Wait until the temperature indicated by both devices has stopped rising and either remains constant or begins to drop slightly. Then record the temperature indicated by both devices.

5.5.1 If there is an excessive temperature drop (more than two degrees per minute) it will be difficult to obtain accurate test results, especially if one thermometer responds to a change in temperature faster than the other. ~~In order to~~To decrease the temperature loss, place the container on a hot plate or propane stove and apply sufficient heat to reduce the rate of temperature decrease.

5.5.2 ~~In order to~~To obtain greatest accuracy, the temperature should be recorded as soon as both temperature measuring devices have reached equilibrium. It does not matter if this is not exactly the temperature specified, since the temperatures specified in Section 4 of this MP are approximate.

5.6 Heat, or cool the material to the next test temperature. Repeat the test procedure. When using sand, be especially sure to stir thoroughly ~~in order to~~to equalize the temperature throughout the containers.

5.7 Apply correction factors to the temperatures recorded for the calibrated thermometer. These are obtained from the calibration chart which is furnished with the calibrated thermometer.

5.8 Plot the test data on graph paper. An example is shown in Attachment 1.

6. USE CALIBRATION DATA

6.1 Asphalt Concrete ~~Bituminous~~ Mixture Thermometers

6.1.1 These thermometers are used to determine compliance with temperature specifications, and therefore, it is important that they be accurate. Correction factors, from the calibration graph, should be applied when determining compliance with temperature specifications.

6.2 Liquid Binder ~~Bituminous~~ Line Thermometer

6.2.1 The primary reason for checking this thermometer is to see that it is working properly and is reasonably accurate. If the thermometer does not operate properly,

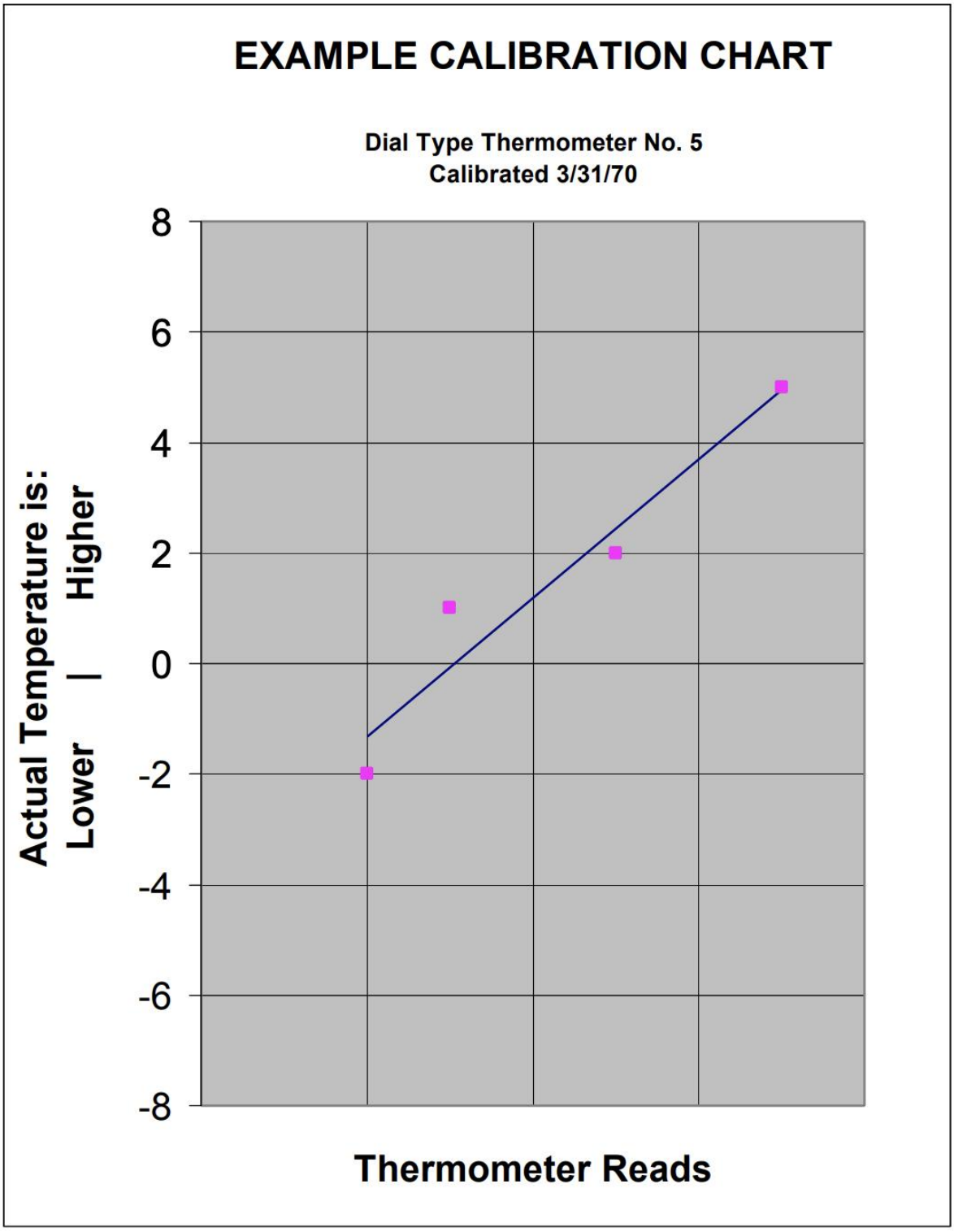
it should be repaired or replaced. If it does not operate properly, but there is a significant error in the temperature, the error should be taken into account when setting the binder ~~bitumen~~ temperature.

6.3 Dryer Pyrometer -

6.3.1 A properly adjusted pyrometer is probably more accurate than the thermometer used to check it. A slight temperature difference between pyrometer and calibrated, thermometer is considered insignificant and may be ignored. However, in such cases, the calibration graph should be drawn and kept on file to show that the pyrometer was checked and found to be accurate. If there is a large difference in temperature between pyrometer and calibrated thermometer, it should be assumed that the pyrometer is in error, and this error should either be taken into account when setting the dryer temperature, or the pyrometer should be adjusted.

Ronald L. Stanevich, P.E.
Director
Materials Control, Soils and Testing Division

MP 401.02.21 Steward – Asphalt Section
RLS:J
ATTACHMENT


EXAMPLE CALIBRATION CHART
Dial Type Thermometer No. 5
Calibrated 3/31/70
Actual Temperature is:
Lower | Higher
8
6
4
2
0
-2
-4
-6
-8
Thermometer Reads

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

GUIDE TO DESIGNING ~~HOT-MIX~~ ASPHALT MIXTURES USING THE MARSHALL DESIGN METHOD

1. PURPOSE

1.1 To establish an approved Marshall design method, test procedures, and evaluation criteria for ~~hot-mix~~ asphalt mixtures ~~(HMA)~~. If reclaimed asphalt pavement (RAP) is used in the design, refer to Materials Procedure (MP) 401.02.24 for additional guidelines.

2. SCOPE

2.1 This procedure is applicable to design tests conducted for the purpose of establishing ~~mixture~~ proportions for asphalt mixtures ~~HMA~~ using the Marshall mix design method. Marshall designs that have already been approved under the previous version of this MP may still be used as long as the mix design verification and quality control requirements of MP 401.02.27 can be met using Tables 1, 2, and 3 of this MP as the reference design criteria. Note that Table 1 has slightly modified the air void design criteria for Base-I so verification and quality control for older designs will be based on the new value.

2.2 Any approved mix design that exhibits poor field performance may be rejected from further use by the Division.

3. REFERENCED DOCUMENTS

3.1 *AASHTO Standards:*

- R 30, Mixture Conditioning of ~~Hot Mix~~ Asphalt ~~Mixtrures~~Mixtures ~~(HMA)~~
- T 30, Mechanical Analysis of Extracted Aggregate
- T 164, Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA)
- T 166, Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
- T 209, Theoretical Maximum Specific Gravity and Density of ~~Hot Mix~~ Asphalt Mixtures ~~(HMA)~~

- T 245, Resistance to Plastic Flow of Asphalt ~~Bituminous~~ Mixtures Using Marshall Apparatus
- T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
- T 308, Determining the Asphalt Binder Content of ~~Hot Mix~~ Asphalt Mixtures ~~(HMA)~~ by the Ignition Method

3.2 *ASTM Standards:*

- D 5581, Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (6 inch-Diameter Specimen)

3.3 *Asphalt Institute:*

- MS-2 Manual, Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types – This well written Asphalt Institute reference guide explains the entire Marshall Method design process in a logical order. The mix designer must still adhere to WVDOH design property requirements and procedures, and they must use the latest AASHTO and ASTM test methods.

3.4 *Material Procedures:*

- MP 401.02.24, Guide to Designing ~~Hot Mix~~ Asphalt Mixtures with Reclaimed Asphalt Pavement.
- MP 401.02.27, Guide for Contractor Quality Control of ~~Hot Mix~~ Asphalt Mixtures
- MP 700.00.06, Aggregate Sampling Procedures
- MP 700.00.54, Procedure for Evaluating Quality Control Sample Test Results with Verification Sample Test Results

4. TESTING REQUIREMENTS

4.1 The laboratory performing the design shall be a Division approved laboratory. To obtain Division approval, a laboratory must demonstrate that they are equipped, staffed, and managed, for batching and testing ~~HMA~~ asphalt mixtures in accordance with this MP. This shall be accomplished by submitting a copy of their latest report of inspection by the AASHTO re:source ~~Materials Reference Laboratory (AMRL)~~ to the District Materials Section. The laboratory must also submit a letter detailing the actions taken to correct any deficiencies noted in the test procedures listed below. The District will forward this information to Materials Control, Soils and Testing Division (MCS&T). It is also required that the laboratory request to be included on the AASHTO re:source ~~AMRL's~~ routine schedule of inspections, which is usually every 18 to 24 months ~~in order to~~to maintain their approval status.

4.1.1 AASHTO Test Procedures

- T 245, Resistance to Plastic Flow of ~~Bituminous~~ Asphalt Mixtures Using Marshall Apparatus
- T 166, Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
- T 209, Theoretical Maximum Specific Gravity and Density of ~~Hot Mix~~ Asphalt Mixtures ~~(HMA)~~
- T 27**,** Sieve Analysis of Fine and Coarse Aggregates**(Note 1)**
- T 11**,** Materials Finer Than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing**(Note 1)**
- T 84, Specific Gravity and Absorption of Fine Aggregate
- T 85, Specific Gravity and Absorption of Coarse Aggregate

Note 1: T 30, Mechanical Analysis of Extracted Aggregate, may be substituted for T 27 and T 11 if the laboratory is using T 308, Determining the Asphalt Binder Content of ~~Hot Mix~~ Asphalt Mixtures ~~(HMA)~~ by the Ignition Method or T 164, Quantitative Extraction of Asphalt Binder from Hot Mix Asphalt (HMA).

4.2 The laboratory is required to have a technician who has attended and successfully completed a Division approved Marshall mix design class. In addition to the class that is offered through the West Virginia University Asphalt Technology Program, hands-on Marshall mix design classes offered by the Asphalt Institute, National Center for Asphalt Technology (NCAT), National Asphalt Pavement Association (NAPA), Chicago Testing Laboratory, and various state DOTs have been approved. Proof of successful completion of all class requirements (including a written examination) must be provided. Approval of an older design class that did not require a written examination will be on a case-by-case basis including a review of the designer's experience. MCS&T will maintain a list of the approved design laboratories and design technicians.

4.3 The required mix design properties are:

4.3.1 Stability and Flow: AASHTO T 245 or ASTM D 5581 as applicable.

4.3.2 Air Voids: AASHTO T 269

4.3.3 Voids in Mineral Aggregate (VMA): Asphalt Institute MS-2 Manual

4.3.4 Voids Filled With Asphalt (VFA): Asphalt Institute MS-2 Manual

4.3.5 Fines to asphalt (FA) ratio: Asphalt Institute MS-2 Manual

4.4 The design PG Binder shall normally be selected in accordance with Section 401.2 of the Standard Specifications. However, the laboratory's mix designer should refer to the contract documents to determine if a nonstandard binder has been specified for the project.

4.5 A series of test specimens shall be prepared for a range of different asphalt contents so that the test data curves show a well-defined "optimum" value. Samples shall be fabricated to include a range of asphalt contents of at least 2 percent at intervals not to exceed 0.5 percent.

4.6 Test specimens shall be fabricated from materials of the same sources and types as proposed in the job mix formula (JMF). The gradation of the combined aggregates used in the test samples shall be the same as that proposed in the plant mix formula and shall meet the requirements of Table 401.4.2A of the Standard Specifications. The percent passing each sieve contained in Table 401.4.2A, from one sieve larger than the nominal maximum size down to the 75 µm (No. 200) sieve, shall be included in all gradation calculations.

4.7 The gradation of each aggregate size from each source used in the mix design shall be determined from an average of at least three individual gradations of each material from the stockpile at the plant or from material supplied by the aggregate producer. The aggregates shall be sampled in accordance with MP 700.00.06.

4.8 If a mix contains reclaimed asphalt pavement (RAP), the asphalt must be removed from the RAP for gradation analysis by the ignition oven method (T 308) or a solvent extraction process (T 164). If the T 164 solvent extraction test method is used, a non-chlorinated solvent may be substituted for the standard specified solvent, and the test method may be modified as per the recommendations of the solvent supplier. The solvent must be a product that has been tested for use in extracting asphalt from asphalt mixtures ~~HMA~~. The RAP used for designing a mix must come from the plant stockpile from which it will be produced.

4.9 A minimum of three compacted test specimens for each combination of aggregates and asphalt content are required.

4.10 The maximum specific gravity shall be based on the average of two samples prepared at the estimated optimum asphalt content.

4.11 Immediately after mixing each of the Marshall bulk specific gravity samples and the maximum specific gravity samples, age the samples for 2 hours ± 5 minutes in accordance with AASHTO R30 before further testing.

4.12 Mixtures shall be designed in accordance with the criteria set forth in Table 1, 2, and 3 unless otherwise indicated in a special provision or as a note in the contract documents.

TABLE 1—Marshall Method Mix Design Criteria

Design Criteria	Medium Traffic Design (Note 2 and 3)	Heavy Traffic Design	Base-I Design (Note 4)
Compaction, number of blows each end of specimen	50	75	112
Stability (Newtons) (minimum)	5,300	8,000	13,300
Flow (0.25 mm) (Note 5)	8 to16	8 to 14	12 to 21
Percent Air Voids	4.0	4.0	4.0
Percent Voids Filled With Asphalt (Note 6)	65 to 80	65 to 78	64 to 73
Fines-to-Asphalt Ratio		~~0~~.6 to 1.2	

Note 2: If the traffic type is not provided in the contract documents, contact the District to obtain this information before developing the mix designs.

Note 3: All Wearing-III mixes shall be designed as a 50-blow mix regardless of traffic type.

Note 4: All Base-I mixes will be designed and tested using 112 blows with six-inch diameter specimens in accordance with ASTM D 5581.

Note 5: When using a recording chart to determine the flow value, the flow is normally read at the point of maximum stability just before it begins to decrease. This approach works fine when the stability plot is a reasonably smooth rounded curve. Some mixes comprised of very angular aggregates may exhibit aggregate interlocking which causes the plot to produce a flat line at the peak stability before it begins to drop. This type of plot is often difficult to interpret, and sometimes the stability will even start increasing again after the initial flat line peak. When such a stability plot occurs, the stability and flow value shall be read at the initial point of peak stability.

Note 6: A Wearing-I heavy traffic design shall have a VFA range of 73–78 percent. A Wearing-III mix shall have a VFA range of 75–81 percent.

1.1 TABLE 2—Percent Voids in Mineral Aggregate (Note 7)

Mix Type	Nominal Size Sieve	Percent Voids in Mineral Aggregate (VMA) (minimum)
Wearing-III & Scratch-III	4.75 mm (No. 4)	17.0
Wearing-I & Scratch-I	9.5 mm (⅜ in.)	15.0
Base-II, P&L & Wearing-IV	19 mm (¾ in.)	13.0
Base-I	37.5 mm (1 ½ in.)	11.0

Note 7: Mixtures designed with the VMA exceeding the minimum value by more than two percent may be susceptible to flushing and rutting problems, especially when used on pavements subjected to slow moving traffic conditions. They may also be difficult to compact as they often have a tendency to shove under the roller.

TABLE 3—Design Aggregate Gradation Requirements for Marshall Mixtures (Note 8)

TYPE OF MIX	Base-I	Base-II (Patch & Level)	Wearing-IV (Note 9)	Wearing-I (Scratch-I)	Wearing-III (Scratch-III)
SIEVE SIZE	Nominal Maximum Size				
	1 ½ in (37.5 mm)	¾ in (19 mm)	¾ in (19 mm)	3/8 in (9.5 mm)	No. 4 (4.75 mm)
2 in (50 mm)	100				
1 ½ in (37.5mm)	90 - 100				
1 in (25 mm)	90 max	100	100		
¾ in (19 mm)	-	90 – 100	90 – 100		
½ in (12.5 mm)	-	90 max	90 max	100	
3/8 in (9.5 mm)	-	-	-	85 - 100	100
No. 4 (4.75 mm)	-	-	47 min	80 max	90 - 100
No. 8 (2.36 mm)	15 – 36	20 – 50	20 – 50	30 – 55	90 max
No. 16 (1.18 mm)	-	-	-	-	40 - 65
No. 30 (600 µm)	-	-	-	-	-
No. 50 (300 µm)	-	-	-	-	-
No. 200 (75 µm)	1.0 – 6.0	2.0 – 8.0	2.0 – 8.0	2.0 – 9.0	3.0 – 11.0

Note 8: For quality control of the mixture the allowable tolerances for each JMF shall be the specified design control points shown in Table-3 with the exception that a Wearing-III mix shall have a tolerance limit of the JMF ± 5% on the 1.18 mm (No. 16) sieve, and all other mix types shall have a tolerance limit of the JMF ± 6% on the 2.36 mm (No.8) sieve. These tolerances shall also be applied to the mix design and shall be documented on the T-400 Form. The tolerances shall not fall outside of the specified control points of Table-3.

Note 9: In addition, a Wearing-IV mix shall have a tolerance limit of the JMF ± 5% on the 4.75 mm (No. 4) sieve, but not below the minimum requirement.

5. DETERMINING THE OPTIMUM ASPHALT CONTENT

5.1 Prepare a graphical plot of the following relationships:

- Asphalt Content vs. Percent Air Voids

- Asphalt Content vs. Stability
- Asphalt Content vs. Flow
- Asphalt Content vs. VMA
- Asphalt Content vs. VFA

5.2 From the plot of asphalt content vs. percent air voids, pick the asphalt content that corresponds to the 4.0 percent air voids.

5.3 If the corresponding stability, flow, VMA, and VFA values are within the specified design criteria at the asphalt content determined in Section 5.2, then this asphalt content shall be considered the optimum asphalt content for the mix.

5.4 If the design property values determined as per Section 5.3 do not meet the specified criteria at the percent asphalt content determined in Section 5.2, then new mix proportions must be determined, and new test data developed.

5.5 Full mix design testing will not be required when a mix design is developed using the same sources, exact aggregate structure ~~types~~, and compaction level as a prior Division approved design, along with a different neat binder grade. The designer may instead select to make a set of bulk specific gravity test specimens and a maximum specific gravity test specimen with the approved aggregate structure and the new binder grade at the optimum asphalt content of the approved design. Since these samples are laboratory produced design specimens, they must be oven aged for 2 hours ± 5 minutes before testing in accordance with R 30. Mix and compaction temperature will be based on the requirements of the new binder grade. The percent air voids must be 4.0 ± 0.3 percent. The voids-in-mineral aggregate must be within ± 0.5 percent of the original approved job mix formula design target (but not outside of the design limits of this MP). All other mix design criteria must be within the design limits specified in this MP (including stability and flow). If the mix design meets all of these requirements, then this test data may be submitted along with a new T400 form for approval as a new mix design. A copy of the approved T400 on which this new design is based should also be included. If the mix design fails to meet all of the requirements, then a new mix design must be developed.

6. REPORT

6.1 The T-400 JMF form shall include the design property information required in Section 401.4 of the Standard Specifications. The JMF package shall include the following:

6.1.1 A summary sheet (Marshall Mix Design Package Attachment #1, Optimum Asphalt Content Determination) showing the proposed asphalt content determination plus

the design properties compared to the design criteria of Table 1. This attachment shall be signed and dated by the mix design technician.

6.1.2 The chart showing the plots described in Section 5.1 used to determine the optimum asphalt content (Attachment #2).

6.1.3 A Summary of Marshall Mix Design Data worksheet (Attachment #3).

6.1.4 Worksheet for calculating the effective gravity of the blended aggregates (Attachment #4 or #4A).

6.1.5 Worksheets showing calculations for maximum specific gravities of the mix at different asphalt contents (Attachment #5). For any mix design that contains any single coarse aggregate component with the water absorption of 1.5 percent or greater, follow the supplemental procedure of T 209 to determine if a dry-back is necessary. Because the dry-back procedure is addressing an aggregate coating issue, this same supplemental procedure shall be used on quality control and verification samples of mixes containing these high absorptive aggregates to determine if the dry-back procedure is necessary.

6.1.6 Worksheet for calculating the bulk and apparent specific gravities of the total aggregate, and the percent VMA in the compacted mixture (Attachment #6 or #6A).

6.1.7 Worksheet for determining the maximum specific gravity of the mixture, including the dry-back procedure when required (Attachment #7).

6.1.8 Worksheets showing calculation for bulk and apparent specific gravities and absorption of the coarse and fine aggregates used in the mix design (Attachments #8 and #8A).

6.1.9 The 0.45 power gradation chart (Attachment #9) developed for each mix design. This chart shall include the maximum density line, aggregate control points, and a gradation plot showing each screen used in the design.

6.1.10 A worksheet showing the calculations for the combined aggregate of the mix design (Attachment #10).

6.1.11 Worksheets showing the washed sieve analysis results for each aggregate used in the mix design (Attachment #11).

6.1.12 The temperature-viscosity chart for the asphalt used in the mix design. An asphalt supplier issued chart or document containing the mix and compaction temperature recommended for the specific grade of asphalt will be acceptable.

6.2 The entire ~~printed~~ JMF package shall be submitted to the local District Materials Section in which the ~~HMA~~ plant is located. After reviewing, the District shall

attach a memo to the JMF package requesting approval of the design and submit it to the MCS&T Asphalt Section.

6.2.1 The JMF package ~~can also~~ shall be submitted electronically ~~by scanning it into an Adobe Acrobat Reader file and~~ via e-mail~~ing~~ ~~the file~~, in Excel format, to the appropriate District Materials Section ~~and the MCS&T Asphalt Section~~. After reviewing the JMF package, the District will send the JMF package along with the District Checklist ~~an~~ via e-mail to the MCS&T Asphalt Section (DOHAsphalt@wv.gov) verifying that the JMF package has been reviewed. The District will also note any problems that they find with the JMF. The MCS&T Asphalt Section will conduct a final review on the design package and assign a laboratory number to each approved mix design. MCS&T will contact the mix designer if there are any problems or concerns with the JMF package that will delay final approval. An electronic copy of the approved T400 form shall be e-mailed to the District and Producer for distribution.

6.3 All applicable mix design worksheets can be found on the MCS&T's Webpage[1] under the "Toolbox."

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Director
Materials Control, Soils & Testing Division

MP 401.02.22 Steward – Asphalt Section
RLS:J

[1] http://www.transportation.wv.gov/highways/mcst

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

GUIDE TO DESIGNING ~~HOT-MIX~~ ASPHALT MIXTURES WITH RECYCLED ASPHALT PAVEMENT

1. PURPOSE

1.1 To establish criteria for designing ~~hot-mix~~ asphalt mixtures ~~(HMA)~~ which contain~~s~~ recycled asphalt pavement (RAP) and Performance Graded (PG) Binders.

2. SCOPE

2.1 This procedure is applicable to all ~~hot-mix~~ asphalt mixture designs which contain both RAP and PG Binders.

3. GENERAL

3.1 This MP does not alter the design specification requirements of the 401 Specification or MP 401.02.22. It is to be used only as a supplement to the specifications when designing RAP mixtures~~es~~. It does not affect RAP mixtures~~es~~ which were designed through previously approved methods prior to issuance of this MP.

4. APPLICABLE DOCUMENTS

4.1 MP 401.02.22

5. GUIDELINES

5.1 The following guidelines shall apply to all new mix designs which incorporate RAP with PG Binders.

5.2 For design purposes, the specific gravity of the virgin PG Binder shall be used as the specific gravity of the asphalt binder in the RAP. Also, the effective specific gravity of the aggregate in the RAP shall be determined and used as the bulk specific gravity of the RAP aggregate for calculation purposes.

5.3 If the amount of RAP in the mix is equal to or less than 15 percent, then the selected PG Binder to be used as the virgin asphalt shall be the same as the specified PG Binder for the region where the mix will be used. For example, if the specified PG Binder for the region is a PG 64S-22 then the PG Binder used in the RAP design shall be a PG 64S-22.

5.4 If the amount of RAP in the mix is 16 to 25 percent, then the selected PG Binder to be used as the virgin asphalt shall be one grade below both the high and low temperature grade of the specified PG Binder for the region where the mix will be

used. For example, if the specified PG Binder for the region is a PG 64S-22 then the PG Binder used in the RAP design shall be a PG 58S-28.

5.5 If the amount of RAP in the mix is more than 25 percent, then the blending chart described in Section 6.0 of this MP shall be used to select the high temperature grade of the virgin asphalt. The low temperature grade shall be at least one grade lower than the binder grade specified for the area where the mix will be used. The binder test data and the blending chart must be submitted along with the mix design package (JMF).

6. EXAMPLE USE OF BLENDING CHART

6.1 The dynamic shear rheometer (DSR) can be used to look at permanent deformation (rutting factor) of the binder, which is governed by limiting G*/sin d at the test temperature. The maximum allowable value of the rutting factor shall be 2.0 kPa. A blending chart, similar to the viscosity blending charts used with viscosity graded asphalts, has been developed which plots G*/sin d on a log-log scale on the y-axis as a replacement test for viscosity. Both the recovered asphalt and the virgin asphalt are tested at the high temperature of the specified binder to be used in the design. The test value G*/sin d for each asphalt is plotted on the chart (the recovered asphalt result on the left and the virgin asphalt on the right) and connected with a straight line. The point on the chart where the plot of G*/sin d intersects the y-axis (G*/sin d, kPa, at test temperature) at 2.0 kPa is represented on the x-axis (% virgin binder) as the minimum percentage of virgin binder to be used in the RAP design.

6.2 The attached example illustrates how the blending chart shall be used. The standard binder for the design in this example is a PG 64S-22. Test measurements for both the recovered asphalt and the virgin binder are taken at 64 °C. Point A on the chart represents the G*/sin d value for the recovered asphalt. Point B represents the G*/sin d test value for the PG 64S-22 binder which has a minimum requirement of 1.0 kPa. The line connecting points A and B intersects the 2.0 kPa rutting factor value at approximately 87% on the x-axis. This means that the minimum amount of virgin asphalt (PG 64S-22) ~~that must be~~ used in the RAP design ~~will~~ shall be 87%. ~~MP 401.02.24 ORIGINAL ISSUANCE: JANUARY, 1998~~

6.3 Now look at point C on the example chart. This point represents G*/sin d for a PG 58S-28 Binder which has been tested at 64 °C. A PG 58S-28 Binder would normally be tested at 58 °C and would have a minimum G*/sin d value of 1.0 kPa. However, because we are using this material where the required binder is a PG 64S-22, the virgin binder must be tested at 64 °C. The higher test temperature results in a test value of less than 1.0 kPa, as illustrated on the chart attachment. The line connecting points A and C intersects the 2.0 kPa rutting factor value at approximately 75% on the x-axis. This means that the minimum amount of virgin asphalt (PG 58S-28) ~~that must be~~ used in the RAP design ~~will~~ shall be 75%.

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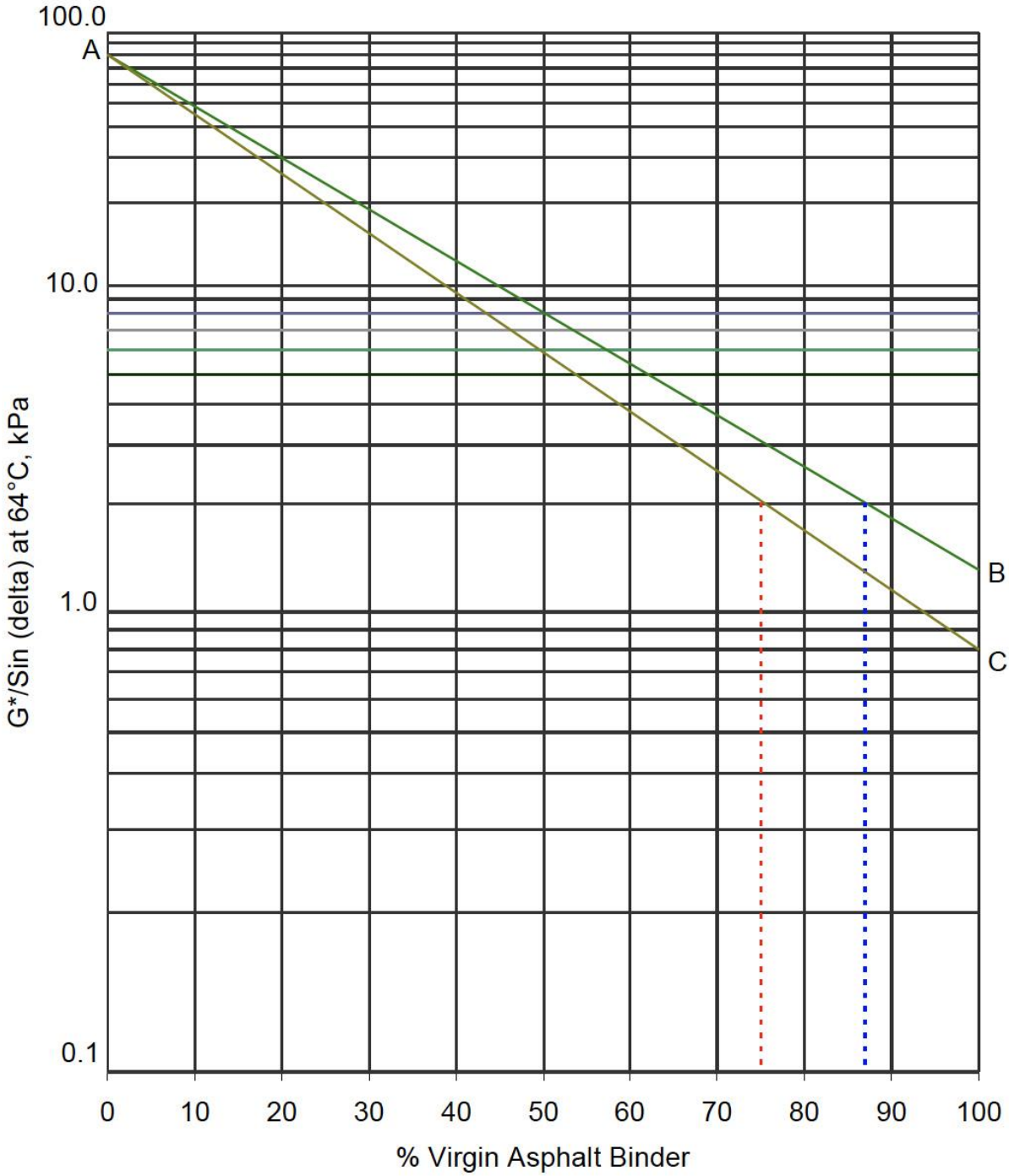
MP 401.02.24 Steward – Asphalt Section
RLS:J
ATTACHMENT

PG Binder/RAP Blending Chart



WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

GUIDE TO DESIGNING ~~HOT-MIX~~ ASPHALT MIXTURES USING THE SUPERPAVE VOLUMETRIC DESIGN METHOD

1. PURPOSE

1.1 To establish an approved Superpave volumetric design method, test procedures, and evaluation criteria for ~~hot-mix~~ asphalt mixtures ~~(HMA)~~. If reclaimed asphalt pavement (RAP) is used in the design, refer to Materials Procedure (MP) 401.02.24 for additional guidelines.

2. SCOPE

2.1 This procedure is applicable to design tests conducted for the purpose of establishing mixture proportions for ~~HMA~~ asphalt mixtures using the Superpave mix design method. Superpave designs previously approved under the March 2000 version of this MP may continue to be used only if they were designed and approved within the volumetric and gradation parameters of Table 1, Table 2, and Table 3, and the quality control requirements of MP 401.02.29 can ~~continue to~~ be maintained.

2.2 Any approved mix design that exhibits poor field performance may be rejected from further use by the Division.

3. REFERENCED DOCUMENTS

3.1 *AASHTO Standards:*

- M-323, Superpave Volumetric Mix Design
- R-30, Mixture Conditioning of ~~Hot Mix~~ Asphalt Mixtures ~~(HMA)~~
- R-35, Standard Practice for Superpave Volumetric Design for ~~Hot Mix~~ Asphalt Mixtures ~~(HMA)~~
- T-11, Materials Finer Than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing
- T-27, Sieve Analysis of Fine and Coarse Aggregates
- T-30, Mechanical Analysis of Extracted Aggregate
- T-84, Specific Gravity and Absorption of Fine Aggregate
- T85, Specific Gravity and Absorption of Coarse Aggregate
- T-166, Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using

Saturated Surface-Dry Specimens

- T-176, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
- T-209, Theoretical Maximum Specific Gravity and Density of ~~Hot Mix~~ Asphalt Mixtures ~~(HMA)~~
- T-269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
- T-283, Resistance of Compacted ~~Hot Mix~~ Asphalt Mixtures ~~(HMA)~~ to Moisture-Induced Damage
- T-304, Uncompacted Void Content of Fine Aggregate
- T-308, Determining the Asphalt Binder Content of ~~Hot Mix~~ Asphalt Mixtures ~~(HMA)~~ by the Ignition Method (Test Method A)
- T-312, Preparing and Determining the Density of ~~Hot Mix~~ Asphalt Mixture ~~(HMA)~~ Specimens by Means of the Superpave Gyratory Compactor

3.2 *ASTM Standards*

- D-4791, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

3.3 *Material Procedures*

- MP 401.02.24, Guide To Designing ~~Hot-Mix~~ Asphalt Mixtures with Reclaimed Asphalt Pavement
- MP 401.02.29, Guide for Quality Control and Acceptance Requirements for Superpave ~~Hot-Mix~~ Asphalt Mixtures

4. TESTING REQUIREMENTS

4.1 The laboratory performing the design shall be a Division approved laboratory. To obtain Division approval, a laboratory must demonstrate that they are equipped, staffed, and managed for batching and testing asphalt mixtures ~~HMA~~ in accordance with this MP. This shall be accomplished by submitting a copy of their latest report of inspection by ~~the~~ AASHTO re:source ~~Materials Reference Laboratory (AMRL)~~ to the District Materials Section. The laboratory must also submit a letter detailing the

actions taken to correct any deficiencies noted in the test procedures listed below. The District will forward this information to Materials Control, Soils and Testing Division (MCS&T). It is also required that the design laboratory request to be included on the ~~AMRL's~~ routine schedule of inspections by AASHTO re:source, which ~~is~~ are usually every 18 to 24 months ~~in order~~ to maintain their approval status.

4.1.1 AASHTO Test Procedures

- T-30, Mechanical Analysis of Extracted Aggregate
- T-84, Specific Gravity and Absorption of Fine Aggregate
- T85, Specific Gravity and Absorption of Coarse Aggregate
- T-166, Bulk Specific Gravity of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry Specimens
- T-209, Theoretical Maximum Specific Gravity and Density of ~~Hot Mix~~ Asphalt Mixtures ~~(HMA)~~
- T-283, Resistance of Compacted ~~Hot Mix~~ Asphalt Mixtures ~~(HMA)~~ to Moisture-Induced Damage (specimens prepared using T-312)
- T-308, Determining the Asphalt Binder Content of ~~Hot Mix~~ Asphalt Mixtures ~~(HMA)~~ by the Ignition Method (Test Method A)
- T-312, Preparing and Determining the Density of ~~Hot Mix~~ Asphalt Mixture (HMA) Specimens by Means of the Superpave Gyratory Compactor

4.2 The laboratory is required to have a technician who has attended and successfully completed a Division approved Superpave mix design class. In addition to the class ~~that is~~ offered through the Division in conjunction with the Asphalt Pavement Association (APA) of West Virginia ~~University Asphalt Technology Program~~, hands-on Superpave mix design classes offered by the Asphalt Institute, National Center for Asphalt Technology (NCAT), and National Asphalt Pavement Association (NAPA)~~, Chicago Testing Laboratory, and various state DOTs~~ have been approved. ~~Also,~~ Superpave design classes offered by ~~all of the~~ other state DOTs ~~that border West Virginia are~~ may be approved at the discretion of the Division. Classes offered by other state DOTs ~~may~~ will be evaluated for approval, as needed. Proof of successful completion of all class requirements (including a written examination) must be provided. Approval of an older design class that did not require a written examination will be on a case-by-case basis including a review of the designer's experience. MCS&T will maintain a list of the approved design laboratories and design technicians.

4.3 The mix design properties shall meet the requirements of Table 1, and shall consist of the following:

4.3.1 Percent Air Voids: T-269

4.3.2 Percent Voids in Mineral Aggregate (VMA): R-35

4.3.3 Percent Voids Filled With Asphalt (VFA): R-35

4.3.4 Fines to effective asphalt (FA) ratio: R-35

4.3.5 Tensile Strength: T-283

TABLE 1—SUPERPAVE METHOD VOLUMETRIC MIX DESIGN CRITERIA

Design air void content, percent	4.0
Fines-to-effective asphalt (FA) ratio (Note 1)	0.6 – 1.2
Tensile strength ratio, percent (T-283) (Note 2)	80 (minimum)

	Nominal Maximum Size, mm (in.)					
	37.5 (1½)	25 (1)	19 (¾)	12.5 (½)	9.5 (⅜)	4.75 (No.4)
Percent Voids in Mineral Aggregate (VMA) (Note 3)	11.5	12.5	13.5	14.5	15.5	16.5
Percent Voids Filled with Asphalt (VFA)	65 – 75	68 – 76	70 – 78	72 – 79	74 – 80	75 – 81

Note 1: When the design aggregate gradation falls within the coarse graded requirement of Table 4, the FA ratio criteria shall be 0.8 – 1.6. For all 4.75 mm (No. 4) mixes, the FA ratio shall be 0.9 - 2.0.

Note 2: Test specimens shall be compacted using a gyratory compactor in accordance with T-312. If the 80 percent minimum tensile strength ratio is not met, a new design will be required. A Division approved antistripping additive, such as hydrated lime, conforming to the requirements of M-303 or a liquid antistripping additive, may be added to the mixture if needed. The additive must be identified on the T400~~SP~~ Form. T-283 shall be waived when a new mix design is developed using ~~all of~~ the exact aggregate sizes, percentages, and sources of a previously approved mix design that has met the required tensile strength ratio of at least 85 percent. This waiver information should be noted on the submitted design package along with the previously approved design T400~~SP~~ number to inform ~~the~~ MCS&T why T-283 test data has not been included. If the approved design contained an antistripping additive, then the new design must also contain this additive. MCS&T may request the tensile strength ratio be checked at any time on any design that is shown to exhibit signs of stripping.

Note 3: Mixtures designed with the VMA exceeding the minimum value by more than two percent may be susceptible to flushing and rutting, especially when used on pavements subjected to slow moving traffic conditions. They may also be difficult to compact as they often have a tendency to shove under the roller.

4.4 The mix design shall be developed using the volumetric design guidelines provided in M-323 and R-35 with the exception of any variations or additions that are noted in this MP. All laboratory prepared design test specimens shall be conditioned in an oven for 2 hours ± 5 minutes in accordance with R30. The gyratory compaction criteria shall be in accordance with Table 2 based on the projected 20-year design traffic ESAL value supplied in the contract documents. If the traffic ESAL value is not supplied in the contract documents, contact the District to obtain this information. The design PG Binder shall normally be selected in accordance with Section 401.2 of the Standard Specifications. However, the laboratory's mix designer should refer to the contract documents to see if a nonstandard binder grade has been specified for the project.

TABLE 2 - GYRATORY COMPACTION CRITERIA (NOTE 4)

20-Year Projected design ESALs (millions)	Compaction Parameters	
	Gyration Level-1	Gyration Level-2
	N_{design} for Binder < PG 64E76-XX	N_{design} for Binders ≥ PG 64E76-XX or Mixes Below Top Two Lifts(Note 5)
< 0.3	50	50
0.3 to < 3	65	65
3 to < 30	80	65
≥ 30	100	80

Note 4: Unless otherwise specified in the contract documents, a PG 64S-22 binder shall be used in mixtures located below the top two pavement lifts. The use of a different binder grade must be approved by the Engineer.

Note 5: The Gyration Level-2 criteria for mixes placed below the top two lifts applies only to mainline paving. Multi-lift base failure and other pavement repairs shall fall under the criteria of Gyration Level-1 unless otherwise specified in the contract documents.

4.5 The design gradation shall meet the requirements of Table 3 for the specified mix type. Table 4 shall be used to distinguish between the gradation criteria for each mix type. The percent passing each sieve listed in Table 3, from one sieve larger than the nominal maximum size down to the 75 µm (No. 200), shall be included in all gradation calculations.

TABLE 3– DESIGN AGGREGATE GRADATION REQUIREMENTS FOR SUPERPAVE MIXTURES (NOTE 7)

Type of Mix	37.5	25	19 (Patch & Level)	12.5	9.5 (Scratch)	4.75 (Scratch)
Standard Sieve Size	Nominal Maximum Size					
	37.5 mm (1 ½ inch)	25 mm (1 inch)	19 mm (3/4 inch)	12.5 mm (1/2 inch)	9.5 mm (3/8 inch)	4.75 mm (No. 4)
50 mm (2")	100					
37.5 mm (1½")	90 – 100	100				
25 mm (1")	90 max	90 – 100	100			
19 mm (3/4")		90 max	90 – 100	100		
12.5 mm (1/2")			90 max	90 – 100	100	100
9.5 mm (3/8")				90 max	90 – 100	95 – 100
4.75 mm (No.4)			(Note 6)		90 max	90 – 100
2.36 mm (No.8)	15 – 41	19 – 45	23 – 49	28 - 58	32 - 67	
1.18 mm (No.16)						30 – 60
600 µm (No.30)						
300 µm (No. 50)						
75 µm (No.200)	0.0 – 6.0	1.0 - 7.0	2.0 – 8.0	2.0 - 10.0	2.0 - 10.0	6.0 – 12.0

Note-6: When a 19 mm mix is specified for use as a heavy-duty surface mix, it shall be designed as a fine-graded mix with the additional requirement of a minimum of 47% passing the 4.75 mm (No.4) ~~screen~~ sieve. The allowable tolerance limit shall be the JMF ± 5% on the 4.75 mm (No.4) sieve, but not below the minimum requirement.

Note 7: For quality control of the mixture, the allowable tolerances for each JMF shall be the specified design control points shown in Table-3 with the exception that a 4.75 mm mix shall have a tolerance limit of the JMF ± 5% on the 1.18 mm (No. 16) sieve and all other mix types shall have a tolerance limit of the JMF ± 6% on the 2.36 mm (No.8) sieve. These tolerances shall also be applied to the mix design and shall be documented on the T-400~~SP~~ Form. The tolerances shall not fall outside of the specified control points of Table-3.

TABLE 4–COARSE AND FINE GRADED ~~HMA~~ MIXTURE CRITERIA

Mixture Nominal Maximum Size	Coarse Graded % Passing / Sieve Size	Fine Graded % Passing / Sieve Size
37.5 (1½)	< 47% / 9.5 mm	≥ 47% / 9.5 mm
25 (1)	< 40% / 4.75 mm	≥ 40% / 4.75 mm
19 (¾)	< 47% / 4.75 mm	≥ 47% / 4.75 mm
12.5 (½)	< 39% / 2.36 mm	≥ 39% / 2.36 mm
9.5 (3/8)	< 47% / 2.36 mm	≥ 47% / 2.36 mm
4.75 (No. 4)	No distinction between coarse and fine grading	

4.6 The aggregate used in the mix design shall meet the requirements of Sections 702.3, 702.4, 703.1, 703.2, and 703.3 of the Standard Specifications with exceptions and additions as noted in Table 5. If a mix contains reclaimed asphalt pavement (RAP), the asphalt must be removed from the RAP for gradation analysis by the ignition oven method (T-308) or a solvent extraction process (T-164). If the T-164 solvent extraction test method is used, a non-chlorinated solvent may be substituted for the standard specified solvent, and the test method may be modified as per the recommendations of the solvent supplier. The solvent must be a product that has been tested for use in extracting asphalt from ~~HMA~~ asphalt mixtures. The RAP aggregate shall be proportionally blended into the samples submitted to MCS&T as described in Section 4.8. The RAP used for designing a mix must come from the plant stockpile from which it will be produced.

4.7 Test results for fine aggregate angularity, recorded on Design Attachment Number 13, shall be submitted along with the mix design package (JMF). Testing shall be conducted in accordance with T-304 (Method A) on a sample blended in accordance with the methods described in Section 4.8.1 and 4.8.2. This testing may be performed by a WVDOH certified Aasphalt Plant Ttechnician or Aaggregate Iinspector. The name of the testing laboratory and the technician conducting the test shall be indicated on the worksheets.

4.8 Other than the exception noted in Section 4.9, to obtain final approval of the mix design, coarse and fine aggregate samples ~~must~~ shall be submitted to ~~the~~ MCS&T through the District Materials Section. These samples ~~will~~ shall be tested and used as part of the overall approval process for the mix design, therefore, they should be submitted well in advance of the earliest anticipated use of the mix. The aggregate property requirements of Table 5 shall be applied to the blend of coarse and fine aggregates within the mixture.

4.8.1 For each mix design, a minimum 30,000-gram sample (40,000-gram sample for a 37.5 mm mix) of the coarse and fine aggregates shall be blended to the mix design proportions. The blended sample shall then be separated into plus 4.75 mm (No. 4) and minus 4.75 mm (No. 4) portions. The fine aggregate sample shall then be further prepared in accordance with Section 4.8.2. Mixtures shall be designed in accordance

with the criteria set forth in Table 1, 2 and 3 unless otherwise indicated in a special provision or as a note in the contract documents. All samples shall be submitted by the design laboratory in appropriate containers to prevent sample loss or contamination.

4.8.2 Fine Aggregate Sampling Procedure: The minus 4.75 mm (No. 4) portion of the blended aggregate sample shall be split into two separate samples. One of these split samples shall be bagged and labeled as the unwashed portion of the fine aggregate blended sample. The other split sample shall be washed, oven dried, and graded to remove all plus 2.36 mm (No. 8) and minus 150 µm (No. 100) material. This washed sample shall then be split and placed into two sample bags. One bag shall be labeled as washed fine aggregate specific gravity sample and the other shall be labeled as washed fine aggregate angularity sample.

4.9 If a new mix design uses the exact aggregate design structure and sources as a previously approved mix design, the aggregate evaluation used to accept the previous mix design will apply to the new mix design. A note of the testing waiver along with the T400~~SP~~ lab number from the previous design shall be included in the remarks of the T400~~SP~~ worksheet submitted along with the documentation of the new mix design.

TABLE 5 – AGGREGATE CONSENSUS PROPERTY REQUIREMENTS

20 Year Projected Design ESALs (millions)	Coarse Agg. Angularity (% Minimum) ASTM D5821 (Note 8)		Fine Agg. Angularity (% Minimum) AASHTO T304, Method A (Note 10)		Fine Agg. Sand Equivalent AASHTO T176	Coarse Agg. Flat and Elongated ASTM D4791
	Top Two Pavement Lifts (Note 9)	Below Top Two Pavement Lifts	Top Two Pavement Lifts	Below Top Two Pavement Lifts	% Minimum	% Maximum (Note 13)
< 0.3 (Note 11)	55 / -	- / -	-	-	40	-
0.3 to < 3 (Note 11)	75 / -	50 / -	40	40	40	10
3 to < 10	85 / 80	60 / -	45	40	45	10
10 to < 20 (Note 12)	90 / 85	80 / 75	45	40	45	10
20 to < 30	95 / 90	80 / 75	45	40	45	10
≥ 30	100/100	100/100	45	45	50	10

Note 8: "85/80" denotes that a minimum of 85 percent of the coarse aggregate has one fractured face and a minimum of 80 percent has two fractured faces.

Note 9: The referenced "top two pavement lifts" does not include a scratch course or patching-and- leveling course that may be placed between these lifts. When a scratch or patching-and-leveling course is placed between the top two lifts, the aggregate requirements for the mix shall fall under the "top two pavement lifts" criteria.

Note 10: For design traffic levels of 3 million ESALs or greater, any mix composed of a 100 percent crushed aggregate blend that will be used in the top two lifts of the pavement structure will be acceptable with an FAA value of 43 percent or greater. The 43 percent FAA criteria shall also apply to the 30 million or greater traffic level for mixtures below the top two lifts. It shall also apply to 100 percent crushed aggregate blends that contain no more than 15 percent RAP.

Note 11: The minimum requirement for coarse aggregate angularity for any Section 402 skid resistant mix design with a projected ESAL value of 0.3 to less than 3 million shall be 85/80. For skid resistant mix designs with a projected ESAL value of less than 0.3 million it shall be 75/-.

Note 12: The 10 to less than 20 million design ESAL aggregate criteria only applies to Section 402 skid resistant mix designs.

Note 13: Flat and elongated particles in coarse aggregates shall be tested in accordance with D–4791 with the exception that the material passing the 9.5 mm (⅜ in.) sieve and retained on the 4.75 mm (No. 4) sieve shall be included. The aggregate shall be measured using the ratio of 5:1, comparing the length (longest dimension) to the thickness (smallest dimension) of the aggregate particles.

4.10 At the beginning of each paving season in subsequent years the aggregate consensus properties of Table 5 shall be tested on blended aggregate samples prepared in accordance with Section 4.8. These tests may be conducted by a WVDOH certified Aasphalt Plant Ttechnician or Aaggregate Iinspector. These test results shall be submitted to the District Materials Section for the purpose of maintaining approval of the mix design. The name of the testing laboratory, date tested, and signature of the technician conducting the tests shall be indicated on the worksheets. These test results must be submitted before the mix is used on any Division project each year.

4.10.1 During the time that the annual aggregate consensus testing is being performed, the Division may periodically request that a duplicate set of blended aggregate samples be prepared for submittal to MCS&T for testing. The Division will identify the mix design in advance so that sufficient material is obtained for preparation of duplicate samples. Nonconforming test results on these samples will require further investigation by the Division. No corrective action will be required by the Contractor unless the investigation concludes that it is necessary. If corrective action is required, the contractor will be notified, and further use of the mix design shall be discontinued until the Division has determined that the problem has been properly addressed.

4.11 If the aggregate consensus property test results submitted to the District~~s~~ meet~~s~~ specification requirements, the District shall forward the results to MCS&T for the purpose of maintaining approval of the mix design. If any of the required aggregate tests fail to meet specification requirements, retesting by the contractor will be permitted, and the District shall submit a sample of the blended aggregate to MCS&T to verify the consensus property test that failed.

4.12 If the mix is comprised of 100 percent crushed blended aggregates that contain no more than 15 percent RAP, and it met both the coarse and fine aggregate angularity requirements, the flat-and-elongated requirement, and the sand equivalent requirement during the initial design approval, and any annual follow-up testing, then retesting each year by MCS&T will not be required. However, fine aggregate samples of mixes containing rounded natural sand and/or greater than 15 percent RAP must be prepared by a certified A~~a~~sphalt Plant T~~t~~echnician in accordance with Section 4.8 and 4.8.1, and a sample of sufficient size required for testing the fine aggregate angularity shall be submitted to MCS&T on an annual basis.

4.13 Full mix design testing will not be required when a mix design is developed using the exact aggregate structure, sources, and compaction level as a prior Division approved design, along with a different neat binder grade. The designer may instead ~~s~~elect to make a set of bulk specific gravity test specimens and a maximum specific gravity test specimen with the approved aggregate structure and the new binder grade at the optimum asphalt content of the approved design. Since these samples are laboratory produced design specimens, they must be oven aged for 2 hours ± 5 minutes before testing in accordance with R-30 (Mix Conditioning of Asphalt Mixtures~~HMA~~) as specified in R-35 (Superpave Volumetric Design for Asphalt Mixtures~~HMA~~). Mix and compaction temperature will be based on the requirements of the new binder grade. The percent air voids shall ~~must~~ be 4.0 ± 0.3 percent. The voids-in-mineral aggregate shall ~~must~~ be within ± 0.5 percent of the original approved job mix formula design target (but not outside of the limits of this MP). All other mix design criteria shall ~~must~~ be within the limits specified in this MP. If the mix design meets all of these requirements, then this test data may be submitted along with a new T400~~SP~~ form for approval as a new mix design. A copy of the approved T400~~SP~~ on which this new design is based shall ~~should~~ also be included. If the mix design fails to meet all of the requirements, then a new mix design shall ~~must~~ be developed.

5. REPORT

5.1 The T-400~~SP~~ JMF form shall include the design property information required in Section 401.4 of the Standard Specification. JMF submittals shall include all Superpave mix design software printouts from the specimen compaction and analysis covering the required mix properties. In addition, if not automatically generated through the mix design software, the following information shall ~~must~~ be included.

5.1.1 A summary sheet (Superpave Package Attachment #1) showing the optimum asphalt content determination plus the design properties compared to the design

criteria of Table 1. This attachment shall be signed and dated by the mix design technician.

5.1.2 Worksheet for calculating the effective gravity of the blended aggregates (Attachment #4 or #4A).

5.1.3 Worksheets showing calculations for maximum specific gravities of the mix at the different asphalt contents (Attachment #5). For any mix that contains any single coarse aggregate component with the water absorption of 1.5 percent or greater, follow the supplemental procedure of T-209 to determine if a dry-back is necessary. Because the dry-back procedure is addressing an aggregate coating issue, this same supplemental procedure shall be used on quality control and verification samples of mixes containing these high absorptive aggregates to determine if the dry--back procedure is necessary.

5.1.4 Worksheet for calculating the bulk and apparent specific gravities of the total aggregate, and the percent VMA in the compacted mixture (Attachment #6 or #6A).

5.1.5 Worksheet for determining the maximum specific gravity of the mixture, including the dry-back procedure when required (Attachment #7). Note that AASHTO R-35 specifies that the maximum specific gravity shall be based on the average of at least two tests.

5.1.6 Worksheets showing calculation for bulk and apparent specific gravities and absorption of the coarse and fine aggregates used in the mix design (Attachments #8 or #8A).

5.1.7 The 0.45 power gradation chart (Attachment #9) developed for each mix design. This chart shall include the maximum density line, aggregate control points, and a gradation plot showing each screen used in the design.

5.1.8 A worksheet showing the calculations for the combined aggregate of the mix design (Attachment #10).

5.1.9 Worksheets showing the washed sieve analysis results for each aggregate used in the mix design (Attachment #11).

5.1.10 A worksheet showing the calculations for the fine aggregate angularity test (Attachment #13).

5.1.11 A worksheet showing the calculations for absorbed asphalt and effective asphalt content (Attachment #14).

5.1.12 The temperature-viscosity chart for the asphalt used in the mix design. A supplier issued chart or document containing the mix and compaction temperature recommended for the specific grade of asphalt will be acceptable.

5.2 The entire ~~printed~~ T400 JMF package shall be submitted, in Excel format, to the local District Materials Section in which the ~~HMA~~ mixtures plant is located. After reviewing, the District shall attach a memo to the JMF package requesting approval of the

design and submit it electronically to the MCS&T Asphalt Section (DOHAsphalt@wv.gov).

5.2.1 ~~The JMF package can also be submitted electronically by scanning it into an Adobe Acrobat Reader file and e-mailing the file to the appropriate District Materials Section and the MCS&T Asphalt Section. After reviewing the JMF package, the District will send an e-mail to the MCS&T Asphalt Section verifying that the JMF package has been reviewed. The District will also note any problems that they find with the JMF.~~ The MCS&T Asphalt Section will conduct a final review of~~n~~ the design package and assign a laboratory number to each approved mix design. MCS&T will contact the mix designer if there are any problems or concerns with the JMF package that will delay final approval. An electronic copy of the approved T400~~SP~~ form shall be e-mailed to the District and Producer for distribution.

5.3 All applicable mix design worksheets can be found on the MCS&T's Webpage[1] under the "Toolbox."

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MP 401.02.28 Steward – Asphalt Section
RLS:J

[1] http://www.transportation.wv.gov/highways/mcst

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

GUIDE FOR QUALITY CONTROL AND ACCEPTANCE REQUIREMENTS FOR SUPERPAVE ~~HOT-MIX~~ ASPHALT MIXTURES

1. PURPOSE

1.1 To provide a method for daily monitoring and quality assurance of Superpave ~~hot-mix~~ asphalt mixtures ~~(HMA)~~.

1.2 To provide guidelines for adequate acceptance plans.

1.3 To provide plant personnel with criteria upon which to base decisions of continuing or ceasing plant production.

1.4 To provide field personnel with criteria upon which to base decisions of accepting or rejecting material.

1.5 To provide an equitable and uniform method for determining price adjustments in those instances where adequate production control has not been maintained and non-specification material has found its way into the completed work.

2. SCOPE

2.1 This acceptance procedure shall be applicable to all Superpave ~~hot-mix~~ asphalt mixture types relative to compliance with job mix formula (JMF) acceptance limits as specified in the governing specifications.

3. DEFINITIONS

3.1 Job Mix Formula – The specification for a single mix produced at a single plant. This mix may be used on a single project or on multiple projects if the basic design criteria (design compaction level and PG Binder grade) are the same.

3.2 Lot - The quantity of material represented by the average of four (4) consecutive test values.

3.3 Sublot – The quantity of material represented by an individual test value within the Lot.

3.4 Field Design Verification Samples and Tests - Those samples taken, and tests conducted by the contractor to verify that a mix design can be produced within the limits of the criteria set forth by this Materials Procedure. These samples are taken during the initial use of each mix design or whenever circumstances described in this MP require a new field design ~~re~~verification. These samples should not be confused with the Division verification samples that are used to determine specification compliance.

3.5 Quality Control Samples and Tests - Those samples taken, and tests conducted by the Producer/Contractor to monitor and control the production of this product.

3.6 Verification Samples and Tests - Those samples taken, and tests conducted by the Division to determine specification compliance.

4. DOCUMENTATION

4.1 The Contractor shall maintain adequate records of all testing and records of any production changes required to control their product. The records shall indicate the nature and number of observations made, the number and types of deficiencies found, and the nature of corrective actions taken. The Contractor's documentation procedures will be subject to the review and approval of the Division and shall be available to the Division at any time during the progress of the work being performed.

4.2 Forms and Distribution: All test data shall be documented on forms provided by the Division. The original copy of the form shall be delivered to the District Materials Supervisor. One copy of each completed form is to be retained by the contractor until the project is completed. Testing shall be conducted using only the approved test methods listed in Section 401.5.1 of the Specification unless specified otherwise in contract documents. Asphalt content and gradation test results shall be recorded on form T417. Mix design property test results shall be recorded on form T419. To ~~be~~ maintain an effective quality control program, tests shall ~~must~~ be completed in a regular and timely manner. If QC test results are not completed and submitted within 48 working hours, the Division will reserve the right to stop further production until tests are completed, submitted, and reviewed by District Materials staff. Verification test results must be performed and submitted daily during production.

4.3 The Contractor shall take prompt action to correct conditions that have resulted, or could result, in the submission to the Division of materials and products that do not conform to the requirements of the applicable Specifications, Materials Procedures, or Contract documents. The Contractor shall establish a detailed plan of action regarding the disposition of non-specification material. In the event that non-specification material is incorporated into the project, the Division shall be notified immediately.

4.4 All asphalt mixture ~~HMA~~ component materials shipped to the plant must have proper documentation which identifies the type and source of each material. This information shall be made accessible to the Division for review at any time.

5. JOB MIX FORMULA FIELD DESIGN VERIFICATION

5.1 For each JMF, a field design verification shall be conducted during the first days of plant production for the purpose of demonstrating that the mix can be produced within the specified tolerances set forth in this MP.

5.2 This field design verification shall consist of a randomly selected HMA sample taken in accordance with AASHTO T168 for each three hours of production, with no more than three samples in one day. A minimum of three samples are required for verification, however, three additional samples are required if none of the first three samples are completely within the specification limits. Samples used for gradation analysis during

the verification process shall be obtained from the asphalt ignition oven samples (AASHTO T308~~, formerly TP53~~). If there is a problem with major aggregate breakdown affecting the gradation test results when using the ignition oven, gradation samples may be obtained from hot bins, cold feeds, or extracted HMA samples.

5.3 Field design verification testing shall not be conducted if less than 200 tons ~~(180 Mg)~~ of material is to be produced in a single day. In such cases daily quality control testing shall be conducted in accordance with Section 6.0 and the sample shall meet the gradation requirements set forth in Table 401.02.29B. The sample shall also meet the design asphalt content within ± 0.4%, a minimum VMA of 0.5% below the design criteria, and the VFA design criteria specified in MP 401.02.28.

5.4 The percent air voids shall be within the range of 2.8 – 5.2 percent.

5.5 The field design verification mix property requirements are listed in Table 401.02.29A. Field design verification test results shall be documented on Form T419.

TABLE 401.02.29A
Mix Property Field Design Verification Requirements

Property	Field Verification Tolerances
Asphalt Content (%)	JMF ± 0.4 %
Air Voids (%)	3.0 – 5.0 %
Voids in Mineral Aggregate (VMA) %	Min. of 0.5% Below Design Criteria
Voids Filled With Asphalt (VFA) %	Limits of Design Criteria

5.6 Gradation requirements for the field design verification samples shall be as indicated in Table 401.02.29B. The gradation results shall fall within the limits of each listed control point with the exceptions as noted on the 2.36 mm (No. 8) sieve. The gradation must also pass beneath the restricted zone as described in Table 401.02.29B. Gradation results for all sieves listed in this table for each mix type shall be documented on Form T421.

5.7 After each of the field design verification samples are ~~is~~ tested, the results shall be evaluated to determine conformance to the requirements of Tables 401.02.29A and 401.02.29B. If any test results fall outside the allowable tolerance limits, then steps must be taken to make any necessary production adjustments to bring the mix back to within specification limits. If, after three samples the design criteria and gradation requirements of at least one of the samples is within all of the allowable tolerance limits then verification of the design is complete. If the criteria are not met, then three additional samples shall be tested. If, after six samples, the Division determines that the mix cannot be produced within specification limits, the~~n~~ mix design shall be rejected, and a new mix design will be required. If the mix design is rejected the average percent asphalt and the average percent air voids of the six verification samples shall be determined. If either or both average values are outside the allowable tolerance limits of Table 401.02.29C then the material represented by these samples shall have its price reduced in accordance

with the schedule set forth in Section 7.0. District Materials shall notify MCS&T immediately upon the rejection of any mix design.

TABLE 401.02.29B
Design Aggregate Gradation Requirements (Note 1)

Nominal Max. Size	37.5 mm (1 ½ inch)	25 mm (1 inch)	19 mm (3/4 inch)	12.5 mm (1/2 inch)	9.5 mm (3/8 inch)	Gradation Tolerances Shall Be The Design Control Points With Exception As Noted Below
Standard Sieve Size	**Base-I**		**Base-II (P&L) Wearing-IV**		**Wearing-I (Scratch)**	
50 mm (2")	100.0					-
37.5 mm (1½")	90.0 – 100.0	100				-
25 mm (1")	90.0 max	90.0 – 100.0	100.0			-
19 mm (3/4")		90.0 max	90.0 – 100.0	100.0		-
12.5 mm (1/2")			90.0 max	90.0 – 100.0	100.0	-
9.5 mm (3/8")				90.0 max	90.0 – 100.0	-
4.75 mm (No.4)					90.0 max	-
2.36 mm (No.8)	15.0 – 41.0	19.0 - 45.0	23.0 - 49.0	28.0 - 58.0	32.0 - 67.0	JMF ± 6
1.18 mm (No.16)						-
600 µm (No.30)						-
300 µm (No. 50)						-
75 µm (No.200)	0.0 - 6.0	1.0 - 7.0	2.0 - 8.0	2.0 - 10.0	2.0 - 10.0	-

Sieve Size	Restricted Zone					
	37.5 mm (1 ½ inch)	**25 mm (1 inch)**	**19 mm (3/4 inch)**	**12.5 mm (1/2 inch)**	**9.5 mm (3/8 inch)**	
4.75 mm (No.4)	34.7	39.5				Mix gradation 45 power plot must fall below the restricted zone
2.36 mm (No.8)	23.3 - 27.3	26.8 – 30.8	34.6	39.1	47.2	
1.18 mm (No.16)	15.5 - 21.5	18.1 – 24.1	22.3 - 28.3	25.6 – 31.6	31.6 - 37.6	
600 µm (No.30)	11.7 - 15.7	13.6 - 17.6	16.7 - 20.7	19.1 – 23.1	23.5 - 27.5	
300 µm (No. 50)	10.0	11.4	13.7	15.5	18.7	

Note 1: Allowable tolerances for each JMF shall be the specified design control points shown in Table 401.02.29A with the exception as indicated on the 2.36 mm (No.8) sieve. These tolerances shall be applied to both the field verification testing of the JMF and the daily contractor quality control testing. The gradation of the mix shall also continue to pass beneath the restricted zone.

5.8 Volumetric production targets shall be established at the end of the field design verification process. The production target asphalt content shall be selected at a value within ± 0.2 % of the approved design asphalt content using the results of the field verification testing to determine the appropriate value. The VMA production target shall be determined from the field verification test data at a value which also provided an air void content that was at or near the JMF target air void content. This VMA value may be adjusted to optimize the ± 1.0 % tolerance of Table 401.02.29C if the result is near the minimum allowable requirement. The production target for VFA shall be the limits of the design criteria. The production target for air voids shall remain at 4.0 %.

5.9 When new plant production targets are established from the field verification process, a new target maximum density shall also be determined for compaction control by averaging the maximum density results of all of the samples used for verification of the mix. The District shall ~~will~~ forward the verification test data to MCS&T ~~the~~ Division.

5.10 An approved mix design (JMF) may be used on other projects during the year without reverification if all of the mix design criteria are the same.

5.11 The maximum allowable blend change for a mix design shall be ten percent on any single aggregate component. If an aggregate blend change of more than five percent on any single aggregate component is required, the Contractor shall evaluate the mix to determine whether ~~or not~~ the volumetric properties, FA ratio, and aggregate properties (coarse and fine aggregate angularity, clay content, and flat and elongated particles) are adversely affected by the change in blended aggregates. The Contractor shall also determine whether ~~or not~~ the aggregate gradation still passes between the control points and beneath the restricted zone. The calculations used in this evaluation shall be provided to the District. The District shall ~~will~~ review and verify the results of this evaluation. If the District determines ~~that~~ any of the above-mentioned properties are adversely affected by the blend adjustment, ~~then~~ they may revoke the change in the JMF. If the JMF volumetric properties cannot be maintained without these changes, then the contractor will be required to provide a new mix design.

5.12 After the field design verification has been successfully completed and quality control testing (as described in Section 6.0) has begun, the Contractor shall monitor the maximum specific gravity of the mix for any consistent change. If, over a five-sample period, there is an average change in the maximum specific gravity of ± 0.02 or greater from the verified value of the mix then a field design reverification may be required. A reverification shall not be conducted if the averages of the % asphalt, % air voids, % VMA, and % VFA of the five quality control samples do not meet the requirements of Table 401.02.27C. The District will review the Contractor's test data, compare it to their verification sample test data, and determine if a reverification is necessary. If the District

determines that a reverification of the mix is needed, a new blended aggregate bulk specific gravity shall also be determined for the mix before the field reverification begins. The District will forward the reverification and bulk aggregate specific gravity test results to MCS&T ~~the~~ Division.

5.13 All approved mix designs shall be reverified on the first project on which they are used in any subsequent years as long as there are no changes to the design specifications that would require a new mix design. In addition, the blended aggregate bulk specific gravity shall be determined before reverification begins.

6. QUALITY CONTROL REQUIREMENTS

6.1 After the field design verification has been successfully completed, quality control sampling and testing shall begin. If production is to continue for four hours or more after the last field design verification sample was taken, then the first randomly selected quality control sample shall be taken within that remaining time period. If production continues for less than four hours after the last field design verification sample was taken, then the first randomly selected quality control sample will not be required until the next production day.

6.2 The material produced shall conform to the verified plant production target values established and controlled within the tolerances of Table 401.02.29C. The aggregate gradation shall conform to the requirements of Table 401.02.29B.

6.3 Adjustments to the accepted JMF aggregate proportions shall be made only for the purpose of maintaining the gradation requirements of Table 401.02.29B and/or the design properties of Table 401.02.29C. The maximum allowable adjustment shall be as indicated in Section 5.10. The minimum sample requirements of the approved quality control plan will be sufficient when the allowable adjustments are made as a result of deficient or borderline test properties of the previous test sample.

TABLE 401.02.29C
Quality Control Mix Property Tolerances

Property	Production Tolerances
Asphalt Content (%)	Verified JMF ± 0.4 %
Air Voids (%)	4.0 ± 1.2 %
Voids in Mineral Aggregate (VMA) %	Verified JMF ± 1.0 % with a minimum of 0.5% below the minimum design criteria
Voids Filled With Asphalt (VFA) %	Design Criteria ± 2 %

6.4 If the previous test sample meets all specification requirements, but the Contractor later determines that the gradation of the material entering the plant has changed, then an aggregate proportion adjustment up to two percent will be allowed without requiring an additional test sample. However, if more than one such change is made during the production day, then an additional test sample beyond that specified in the approved quality control plan will be required for each adjustment.

6.5 Minimum Sampling and Testing Frequency: During each day of plant production a minimum of one sample shall be taken for production periods of six hours or less. When the production period exceeds six hours, a minimum of one sample for each half of the production period shall be taken. If the production period exceeds twelve hours, a third sample shall be taken. The Contractor's sampling frequency shall be in accordance with their approved Quality Control Plan.

6.6 For the purpose of administration, the quantity of material represented by an individual test shall be determined as follows: the first sample taken after the field design verification has been approved shall represent the quantity produced from the beginning of production after field design verification until the time the sample was taken. The second sample shall represent the material produced between the time that the first and second samples were taken and so on. The last sample taken prior to a halt in production under a given JMF shall represent that quantity of material produced from the time that the next to last sample was taken until production was stopped.

6.7 Sampling and testing for evaluation of compliance with the verified JMF shall be as follows: Obtain a sample large enough for determining the percent asphalt, percent air voids, percent VMA, percent VFA, and gradation of the mix in accordance with the specified test methods listed in Section 401.5.1 of the Specifications. If excessive aggregate breakdown in the ignition oven prevents proper gradation analysis, aggregate samples may be obtained from hot bins, cold feeds, or extracted HMA samples.

6.8 A four-sample average shall be used for the purpose of determining whether or not the material meets specification requirements. The test results of the first four

samples shall be averaged. After the fifth sample is taken a four-sample moving average shall begin. This first moving average shall consist of the average of the second through fifth test samples. Each time a new sample is taken a new moving average shall be calculated by averaging the new sample with the previous three samples. The moving average shall continue through a single paving season (one calendar year).

6.9 In cases where production is limited and less than four samples of the specified mix design are taken, then the average shall consist of the total number of samples taken during the paving season in accordance with the Quality Control Plan. A new four sample average shall be established at the first startup of a new paving season after the field design verification has been completed.

6.10 The Contractor shall maintain control charts for percent asphalt, percent air voids, percent VMA, and percent VFA. These control charts shall be prepared in accordance with the guidelines of MP 300.00.51. As an alternative method, the control charts may be prepared with a personal computer using software that can generate such charts and provide a distinct graphic representation of all data points. Data points required on the control charts are the daily individual Contractor quality control tests, district verification sample tests, and the moving average of every four Contractor quality control tests. VFA data points shall be calculated to the nearest one percent and all other data points shall be calculated to the nearest 0.1 percent.

6.11 For hand drawn charts, the quality control test data points shall be represented by a small blue circle symbol "O" and connected by a dashed line. The four-sample moving average data points shall be represented by a small red square symbol "■" and connected by a solid line. District verification sample test data points shall be represented by a small red circle symbol "O" but shall not be connected. The upper and lower tolerance limits of the test properties which were established through the field design verification described in Section 6.0 shall be represented by solid horizontal lines.

6.12 If the computer-generated control chart cannot be produced using the symbols and lines described above, then a graph legend shall be included which shall indicate the graphic symbols used to represent the required data points and lines.

6.13 The quality control charts shall be ~~kept up to~~ updated daily and placed in a location that is easily accessible to the Division for review at any time.

7. DEGREE OF NONCONFORMANCE

7.1 Should the four-sample average of test values for percent asphalt, percent air voids, percent VMA, or percent VFA fall outside the verified JMF tolerances by more than the allowable deviation of Table 401.02.29C then production shall be halted until the Contractor takes necessary steps to bring production under control. Production shall also be halted if three consecutive aggregate gradation tests fall outside the tolerance limits of Table 401.02.29B. Actions taken by the Contractor to bring production back in control shall be documented in the plant diary.

7.2 When the four-sample average of the Contractor's quality control tests for percent asphalt and/or percent air voids falls outside the JMF tolerances of Table 401.02.29C, the Sublot of material represented by the last individual test value in the moving average shall have its price reduced in accordance with the schedule set forth in Section 7.3. In the case where the average is nonconforming and the last tested Sublot is conforming, then there would be no price adjustment.

7.3 The degree of nonconformance shall be determined using the following relationship:

When the moving average is greater than the upper control limit

$Q_U = X_n - UL$

When the moving average is less than the lower control limit

$Q_L = LL - X_n$

Where Q_U = Percent of non-conformance at Upper Limit
Q_L = Percent of non-conformance at Lower Limit
UL = Upper Limit
LL = Lower Limit
X_n = Average of four consecutive test values (less than four when production is limited)

If it is decided by the Division that the material is to be allowed to remain in place, then the Sublot shall have its price reduced in accordance with Tables 401.02.29D and/or 401.02.29E, as applicable.

TABLE 401.02.29D
ADJUSTMENT OF CONTRACT PRICE FOR MIX NOT WITHIN TOLERANCE LIMITS OF PERCENT ASPHALT

QU or QL	Percent of Contract Price to be Paid
0.0	100
0.1	98
0.2	96
0.3	92
Greater Than 0.3	*

* The Division will make a special evaluation of the material and determine the appropriate action.

TABLE 401.02.29E
ADJUSTMENT OF CONTRACT PRICE FOR MIX NOT WITHIN TOLERANCE LIMITS OF PERCENT AIR VOIDS

QU or QL	Percent of Contract Price to be Paid
0.0	100
0.1	98
0.2	96
0.3	92
Greater Than 0.3	*

* The Division will make a special evaluation of the material and determine appropriate action.

7.4 Should the moving average of both the test properties for the same Sublot fall outside of the JMF tolerance, thus resulting in a reduced price for each, then the following procedure shall be used. The quantity of material represented by the last Sublot in the moving average will have an adjusted unit price which is the product of the original price times the percent as a result of non-conformance of the first test property times the percentage unit price as a result of non-conformance of the second test expressed in the following formula.

AUP = OUP x PUPAC x PUPAV *

Where:

AUP = Adjusted Unit Price

OUP = Original Unit Price

PUPAC = Percent Unit Price as a result of Asphalt Content Analysis expressed as a decimal

PUPAV = Percent Unit Price as a result of Air Void Analysis expressed as a decimal

* PUPAC and PUPAV are used in the formula as needed as a single non-conforming item or together for both non-conforming items as shown.

7.5 A new moving average shall start with the fourth sample that is taken after production is resumed (less than four when production is limited). If, at any time, the Division determines that a mix cannot be consistently produced within the tolerance limits of the verified design properties, approval of the mix may be revoked, and the contractor will be required to provide a new mix design.

8. SMALL QUANTITY TESTING

8.1 If project activities are such that not more than 75 tons ~~(70 Mg)~~ of a specific mix design are being produced per day during the period of an entire calendar week, then the following small quantity testing requirements shall apply.

8.2 If the plant has a current inspection and approval by District Materials and has successfully verified the mix design being produced~~source rating is A-1, as determined per MP 700.00.52, Guide To Source Rating System Relative To Maintenance Contracts~~, then the minimum quality control sample requirements shall be one sample per week. The sample shall be taken on the first day of use during the week. If the plant has not verified the mix design being produced and quantities do not meet the minimum threshold for verification sampling~~source rating is A-2, as determined per MP 700.00.52~~, then the normal testing requirements of this MP shall apply.

9. DIVISION VERIFICATION SAMPLING AND TESTING

9.1 Verification testing of asphalt mixtures~~HMA~~ is the responsibility of the Division. Quality control tests conducted by the Contractor may be used as a part of the verification process. Verification activities may be accomplished in any of three ways: 1) By conducting sampling and testing completely independent of the quality control activities, 2) by witnessing or reviewing tests performed by the Contractor, or 3) by a combination of both the above. In all cases, those samples and tests taken by the Division completely independent of the Contractor will be taken at a

frequency approximately equal to 10% of the frequency required in the Contractor's approved Quality Control Plan for the applicable item.

9.2 The verification samples taken by the Division will be statistically evaluated for similarity to the Contractors quality control tests in accordance with the guidelines of MP 700.00.54. If the evaluation indicates that the Division's test results are similar to the Contractor's test results, then the material represented by this evaluation will be considered acceptable. Those properties to be evaluated, as referenced in MP 700.00.54, will consist of percent asphalt, percent air voids, and gradation. In addition, the VMA and VFA test results will be evaluated using the guidelines of MP 700.00.54.

9.3 If a dissimilarity is detected, an immediate investigation will be conducted to determine the cause. The intent of the investigation is to define and correct any testing deficiencies that may cause a misrepresentation of the tested material.

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MP 401.02.29 Steward – Asphalt Section
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WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

GUIDE FOR APPROVAL OF COMPONENT AND SHIP LOOSE MATERIALS PERTAINING TO PRECAST AND PRESTRESSED CONCRETE ITEMS

1. PURPOSE

1.1 To set forth the procedures for the approval of component materials used in the fabrication of precast and prestressed concrete items and ship loose materials incidental to precast and prestressed concrete items.

1.2 Ship loose materials are defined as the loose materials that are used in conjunction with various precast or prestressed concrete items. These ship loose materials are normally paid for under the same bid item number as the primary precast or prestressed concrete item.

1.2.1 ~~Examples of ship loose materials include bearing pads and shims that are shipped along with prestressed concrete beams.~~ Materials such as (but not limited to) metal soil reinforcing devices, metal attachment devices, bearing pads, shims, and geotextile fabrics that are used for prestressed concrete beams, and retaining wall systems are ~~also~~ classified as ship loose materials.

2. SCOPE

2.1 This procedure will apply to all precast concrete fabricators and prestressed concrete fabricators that supply material for use on West Virginia Division of Highways projects. It shall also apply to suppliers of any other precast concrete items (such as retaining wall system suppliers), which require the use of ship loose materials.

3. SAMPLING

3.1 Approved Sources

3.1.1 With the exception of coarse and fine aggregate, component materials obtained from a West Virginia Division of Highways approved source and component materials pre-tested at the source in a manner set forth in MP 700.00.01 (or other established procedures) may be used at the precast, or prestressed concrete fabricator without further sampling and testing.

3.1.1.1 Any ship loose materials that are obtained from an approved source will not require any further sampling or testing. However, the approved source laboratory number shall be listed on all shipping documents related to that material.

3.1.2 All component materials that are not obtained from a Division approved source or otherwise pre-approved shall be sampled at the precast or prestressed concrete fabricator and subsequently tested. Ship loose materials that are not obtained from a Division approved source may be sampled at a variety of locations (material fabricator, precast concrete fabricator, material distributor, or whichever location is most convenient), but they must be sampled, tested, and approved prior to shipment to the project. All materials must meet the requirements of the appropriate section of the specifications.

3.1.2.1 Certain ship loose materials may, at the discretion of MCS&T Division, be accepted based on certification rather than sampling and testing.

3.1.3 When AASHTO M 6 is the applicable specification for fine aggregate, natural sand shall meet the requirements of Class A with respect to material finer than the No. 200 (75 µm) sieve. Natural sand shall meet the remainder of the Class B requirements. All other fine aggregate types shall meet all of the requirements of Class B.

3.1.4 Mixing water for precast concrete items shall be tested in accordance with the requirements of section 715.7 of the standard specifications.

3.2 Frequency of Sampling

3.2.1 Aggregates (both coarse and fine) and other component and ship loose materials not obtained from a Division approved source will be sampled by the Division, at the fabricator (or other location as noted in section 3.1.2), as shown in Table 1.

TABLE 1

Material	Sampling Frequency	Sample Size
Cement	Semi-Annually	10 lb (4 kg)
Pozzolanic Additives	Semi-Annually	4 lb (2 kg)
Fine Aggregate	Semi-Annually	25 lb (10 kg)
Coarse Aggregate	Semi-Annually	110 lb (50 kg)
Mixing Water	Semi-Annually	1 quart (1 liter)
Reinforcing Steel		
Epoxy	Annually	5 ft (2 m)
Black Bar	N/A (Accepted on NTPEP Compliance)	NA
Prestressing Steel	Only Sampled at the Source	N/A
Hot-Poured Elastic Type Concrete Joint Sealer	Only Sampled at the Source	N/A
Preformed Expansion Joint Filler	Only Sampled at the Source	N/A
Elastomeric Bearing Pads and Shims	Only Sampled at the Source	N/A
Welded Wire Fabric	Each Lot (if Not NTPEP Compliant)	1 pc. 3 ft x 3 ft (1 m x 1 m)
Bright Wire for Welded Wire Fabric	Reference MP 709.04.40 or in accordance with Q-Cast Certification Requirements	1 pc 5 ft
Concrete Sealant	Only Sampled at the Source	N/A
Steel Inserts & Miscellaneous Steel Hardware	Annually	2 Pieces
Asphalt Plastic Cement	Each Lot or at the Source	N/A
Metal Soil Reinforcing Strips	Each Lot (Either at the Source or At the Point of use Prior to Installation)	N/A (NDT of Random Pieces)
Geotextile Fabric	N/A (Accepted on NTPEP Compliance)	N/A
Steel Diaphragms	N/A (Inspected at the Fabricator)	N/A

3.2.2 The fabricator may not use any component material in the fabrication process until the material has been shown to meet specifications. Until otherwise notified by the Division, the fabricator may continue to use materials that are sampled on a semi-annual basis (and that were approved during the prior sampling period) while these materials are being tested during the current sampling period.

3.2.2.1 An approved laboratory reference number shall be issued to each ship loose material that meets specifications. Approved laboratory reference numbers must be issued to all ship loose materials that are to be paid for under the same bid item number as a precast or prestressed concrete item before an approved laboratory reference number can be issued to that precast, or prestressed concrete item.

3.2.3 At the time of component material sampling, the fabricator shall provide the Division with a current copy of each concrete mix design (and a list of all items that are produced from each mix design) that may be used in production of precast or prestressed concrete items for the Division during the next six months.

3.3 Non-Specification Material

3.3.1 If a material is removed from the Division's approved list, use of that material shall be immediately discontinued, and the material shall be sampled and tested in the same manner as any other material that is not on the approved list (i.e. it shall be sampled and tested at the frequency shown in Table 1) until it regains status on the Division's approved list.

3.3.2 If tests conducted on a component material sample indicate that one or more properties of a material do not meet specification requirements, the Division shall immediately notify the fabricator. Upon receipt of this notification ~~(whether written or verbal)~~, the fabricator shall discontinue the use of the component material in question until further notice by the Division.

3.3.3 If an amount of material finer than the No. 200 (75 µm) sieve, greater than what is allowed by specifications, is present in either the coarse or fine aggregate, then the total amount of material finer than the No. 200 (75 µm) sieve for the entire mix shall be evaluated. The fabricator shall have previously provided a copy of all mix designs as outlined in section 3.2.3, and the total amount of material finer than the No. 200 (75 µm) sieve for the entire mix will be evaluated as outlined in section 3.3.3.1.

3.3.3.1 As long as the total percentage of material finer than the No. 200 (75 µm) sieve present in the entire mix does not exceed the total percent of material finer than the No. 200 (75 µm) that would exist if both aggregate fractions in the mix contained their specified maximum percentage passing the No. 200 (75 µm) sieve, then that combination of aggregates will be considered as meeting specifications.

3.3.4 If it is determined that a ship loose material does not meet specification requirements, use of that ship loose material shall not be permitted.

3.4 Re-Testing of Non-Specification Component Material

3.4.1 When tests of the first sample indicate that one or more properties of a material do not meet specification requirements, the Division shall re-sample the material as soon as possible after the fabricator has taken corrective action, and one of the following two scenarios will occur (3.4.1.1 or 3.4.1.2).

3.4.1.1 If the second sample meets specifications, the Division will immediately notify the fabricator. Upon ~~this~~ notification ~~(whether written or verbal)~~, the fabricator may resume the use of this component material.

3.4.1.2 If the second sample does not meet specifications, the Division will immediately notify the fabricator, but the Division will not re-sample the material in question (from the particular source that did not meet specifications) until the next sampling period specified in Table 1 ~~(and~~ only after corrective action has been taken by the fabricator~~)~~. Until a sample is obtained that meets specifications~~, this non-specification~~ the component material may not be used.

3.4.2 Once a component material in question has been shown to not meet specifications by more than one sample and test, the Division will only re-sample that component material once during the next sampling period (as set forth in Table 1), and one of the following two scenarios will occur (3.4.2.1 or 3.4.2.2).

3.4.2.1 The material is sampled again during the next sampling period, and it meets specifications. The use of this component material may be resumed.

3.4.2.2 The material in question is sampled again during the next sampling period, and again it does not meet specifications. The Division will not re-sample the material in question again until the next sampling period specified in Table 1 (see section 3.4.2). Until a sample is obtained that meets specifications~~, this non-specification~~ the component material may not be used.

3.4.3 For an aggregate in which an excessive amount of material finer than the No. 200 (75 µm) sieve is the only reason for not meeting specifications, there are two possible scenarios. When the first scenario, given in section 3.3.3.1, occurs, that particular combination of fine and coarse aggregate will be considered as meeting specifications. The second scenario is if the total percentage of material finer than the No. 200 (75 µm) sieve present in the entire mix exceeds the total percent of material finer than the No. 200 (75 µm) sieve that would exist if both aggregate fractions in the mix contained their specified maximum percentage passing the No. 200 (75 µm) sieve. In this case, that particular combination of fine and coarse aggregate will be considered as not

meeting specifications. ~~At this point, the~~ ~~Then~~When this second scenario occurs, the Division shall immediately notify the fabricator. ~~Upon~~ ~~u~~Upon receipt of this notification ~~(whether written or verbal)~~, the fabricator shall discontinue the use of this combination of material until further notice by the Division. Situations in which the second scenario occurs will be handled as outlined in section 3.4.4.

Commented [MMA1]: I think that this should be a separate sentence and not combined with the previous sentence.

3.4.4 During any re-sampling of a failing combination of aggregates, both the fine and coarse aggregate shall be re-sampled (so that a current evaluation of the total amount of material finer than the No. 200 (75 µm) sieve present in the entire mix may be performed). The Division will re-sample both the fine and coarse aggregate as soon as possible, and one of the following two scenarios will occur (3.4.4.1 or 3.4.4.2).

3.4.4.1 If the second sample meets specifications, the Division will immediately notify the fabricator. ~~Upon this notification (whether written or verbal),~~ and the fabricator may resume the use of this combination of fine and coarse aggregate.

3.4.4.2 If the second sample does not meet specifications (as outlined in section 3.3.3.1), the Division will immediately notify the fabricator, but the Division will not re-sample that combination of fine and coarse aggregate until the next sampling period specified in Table 1 (see section 3.4.2). Until a sample is obtained that meets specifications, this non-specification combination of fine and coarse aggregate may not be used.

4. ALTERNATE MATERIALS

4.1 The prestressed or precast concrete fabricator may use a different source of material if the current material has been shown to not meet specifications.

4.1.1 This new material shall be sampled as set forth in section 3.0 or 3.2 (whichever is applicable).

4.1.2 In the case of component materials, new concrete mix design (in the case of prestressed items) containing this material shall be approved by the Division prior to the use of this new material. In the case of precast items, a new mix design containing this material shall be provided to the Division at the time of sampling.

4.2 If either a new source of coarse or fine aggregate is used because of an inability of the former combination of material to meet specifications due to an excessive amount of material finer than the No. 200 (75 µm) sieve, both the coarse aggregate and fine

aggregate portions of this new combination shall be re-sampled, and evaluated as set forth in section 3.4.3.

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MP 603.02.10 Steward – Aggregate and Soils Section
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WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

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INSPECTION AND ACCEPTANCE PROCEDURES FOR PRECAST CONCRETE PRODUCTS

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1. PURPOSE

1.1 To set forth procedures for the inspection and acceptance of precast concrete products, including inlets, manholes, box culverts, 3-sided bridge units, retaining wall panels, headwalls, wingwalls, lagging, junction boxes, and any other precast products, and the approval of the plants at which they are fabricated.

2. SCOPE

2.1 This procedure will apply to all precast concrete products supplied for use on West Virginia Division of Highways projects and to all precast concrete product fabricators that supply material for use on West Virginia Division of Highways projects.

2.2 For prestressed concrete members refer to MP 603.10.40 “Inspection and Acceptance Procedure for Prestressed Concrete Bridge Beams.”

3. FABRICATOR APPROVAL

3.1 All precast concrete product fabricators (hereafter referred to as the Fabricator) shall be approved by Materials Control Soils and Testing MCS&T Division prior to the start of any work for the WVDOH. If not listed on the WVDOH Approved List of Precast Concrete Fabricators, a Fabricator shall contact MCS&T Division a minimum of six weeks prior to the planned date on which fabrication is to begin to initiate the approval process.

3.2 In order for a Fabricator to be approved and listed on the WVDOH Approved List of Precast Concrete Fabricators, they must be NPCA (National Precast Concrete Association) certified, QCAST (American Concrete Pipe Association) Certified, or have an equivalent type of certification.

3.3 The process for approving a Fabricator shall include, but not be limited to, an on-site visit to the fabrication plant by a WVDOH representative from MCS&T Division. During this visit, the WVDOH Quality Assurance (QA) personnel shall inspect the fabrication facility, the ~~and~~ Quality Control (QC) lab, and meet with QC and other key personnel from the Fabricator. ~~,~~ Component ~~and sample component~~ materials which will be used in the fabrication of shall be sampled for testing. Batch scales shall be calibrated in accordance with MP 700.00.03 at a minimum once per year..

3.3.1 Sampling and testing of component materials shall be done in accordance with MP 603.02.10. Copies of recent component delivery tickets should be presented on the day of sampling. All component materials must be approved prior to the start of fabrication.

3.3.1.1 Any Fabricator which does not produce for the WVDOH for a period of 2 years shall be removed from the Approved Fabricator list. After removal from the approved list, before a Fabricator can again produce for the WVDOH, they must repeat the approval process. Sampling of component materials will not continue when the plant is not listed on the Approved Fabricator list.

3.3.2 Personnel from the Fabricator required to be present during the initial on-site visit and meeting between WVDOH and Fabricator shall include representatives from Production and Quality Control. Any questions and concerns regarding WVDOH requirements, including applicable Specifications, Materials Procedure (MP's), Standard Details, and QC/QA Inspections shall be addressed at this meeting.

3.3.3 The Fabricator must submit the Quality Control Manual/Plan for review at this meeting.

3.4 All Concrete Mix Designs which will be used on products fabricated for the WVDOH must be submitted for review & approval, prior to the start of fabrication. Any design mix with an aggregate(s) that has a reactivity classes R1, R2, or R3, as shown as in Approved Aggregates Source List, shall be developed in accordance with WVDOH specifications, subsection 601.3.1.1. If an aggregate Source is not listed on the Approved Aggregates Source List, the Division will test the fine and coarse aggregate from the Source, in accordance with AASHTO T 303, to determine the reactivity class of the aggregate prior to its use on any WVDOH project. The Division will inform the Fabricator of the reactivity class of aggregates that they are proposing to use. If a cement Source and/or a SCM Source are not listed on the Approved Source List, the Division will test cement and/or SCM from that Source prior to its use on any WVDOH project.

3.5 The Fabrication Plant QC Personnel, as a minimum, shall be a certified ACI Grade I Concrete Field Testing Technician and/or a WVDOH PCC Inspector. In addition, if

Self-Consolidating Concrete (SCC) is used, Fabrication Plant QC Personnel shall be a certified ACI SCC Testing Technician.

3.6 All Precast Concrete items shall be accepted by Direct or Master Coverage except when a Fabricator is certified as an Approved Source of concrete lagging as defined in Section 7.0.

4. FABRICATION & INSPECTION OF PRODUCTS FOR DIRECT & MASTER COVERAGE

4.1 Prior to beginning fabrication of any precast concrete products, the Fabricator shall provide written or email notification to MCS&T Division at least one calendar week in advance of the date on which fabrication is to begin.

4.1.1 Depending upon the precast items being fabricated, MCS&T Division may choose to monitor fabrication. Fabrication of structurally significant products such as box culverts and 3-sided bridge units shall be monitored. Other items may be monitored at the discretion of MCS&T.

4.1.2 After fabrication has begun, the Fabricator shall keep MCS&T Division and the Inspector (whether a WVDOH employee or a contract employee representing the WVDOH) informed in advance of the days on which fabrication will take place.

4.2 Shop Drawings must be approved by the West Virginia Division of Highways prior to the start of any work by the Fabricator. The Inspector must have a copy of these approved shop drawings prior to start of any work by the Fabricator.

4.3 Concrete cylinders shall be made for compressive strength testing with 6-inch by 12-inch (150 mm by 300 mm) or 4-inch by 8-inch (100 mm by 200 mm) molds. The cylinders are to be cured in the same area as the products for which they represent (Field Cured as outlined in AASHTO ~~T23~~R100) until tested to create a curing environment similar to the product that they represent. A compressive strength test shall consist of the average result of a set of cylinders, which is at least two cylinders. Form removal for wet cast concrete is not permitted until concrete has reached 50% of the design strength, unless otherwise specified. If forms are stripped from box culverts at 50% of the design strength, another curing method from section 601.12, or ASTM C1577 must be used until 70% of the design strength is obtained. Form removal limitations do not apply to elements fabricated with dry cast concrete. Dry cast concrete is defined as concrete with a slump less than 1-inch.

4.3.1 For both conventional wet cast concrete and SCC mixes, a minimum of one set of compressive strength cylinders shall be fabricated from every 7 yards of concrete, or fraction thereof, with a minimum of one set per day per mix design. Both the form removal strength and the 28-day strength must be confirmed by a set of cylinders. Cylinders shall be the same size as those used in the initial approved mix design. For conventional concrete, slump, temperature, and air content tests shall be conducted on the first batch of concrete each day and every time that cylinders are fabricated. For SCC mixes, spread, temperature, and air content tests shall be conducted on every batch. For all types of concrete, unit weight and yield tests shall be conducted on the

first batch of concrete each day and thereafter as deemed necessary by Quality Control and Quality Assurance Personnel.

4.3.2 For dry cast mixes, the 28-day strength shall be confirmed by a set of compressive strength cylinders. Compressive strength testing for form removal is not required for dry cast mixes. A minimum of one set of compressive strength cylinders shall be fabricated for each item fabricated. The cylinders are to be fabricated in the molds on the vibration table in accordance with ASTM C497. For dry cast mixes, slump testing is not required, and concrete temperature testing shall be performed on the first batch of concrete each day and every time that cylinders are fabricated.

4.4 For precast manholes fabricated with wet cast and SCC mixes, absorption tests are to be conducted in accordance with ASTM C642. Tests should be conducted on a weekly basis for each mix design used, at a minimum; unless otherwise specified.

4.5 For precast products fabricated with dry cast mixes, absorption tests are to be conducted in accordance with ASTM C642, and tests should be conducted on a weekly basis for each mix design used. The maximum allowable absorption shall be 9%.

4.6 Unless otherwise specified, for conventional wet cast and SCC mixes, plastic concrete shall have an air content measured at 7.0 ± 2.0%. For dry cast concrete, the air content test requirement is waived.

4.6.1 Prior to the use of Self-Consolidating Concrete in precast items all mix designs must be submitted to MCS&T for approval and meet the requirements of the following table. Test results from trial batches produced by the laboratory which designed it shall be included in the submittal. The compressive strength of the design mix shall be at least 15% above the specified design strength.

Table 4.6.1 - SCC Mix Design Acceptance

Fresh Property	**Mix Design Batch Acceptance Criteria**
Air Content	7.0± 1.5%
Spread (ASTM C1611)	Target ± 1.5 inches (38 mm) 2 seconds $\leq T_{50} \leq$ 7 seconds Visual Stability Index ≤1.0
Passing Ability (ASTM C1621)	J-Ring Value $\leq$ 1 inch (25 mm)
Segregation Resistance (ASTM C1610)	Segregation ≤ 12%
Unit Weight and Yield	±2% of Theoretical

4.6.2 The following table lists the criteria for SCC production.

Table 4.6.2 - SCC Production Acceptance

Fresh Property	**Production Acceptance Criteria**
Air Content	7.0± 2.0%
Spread (ASTM C1611)	Target ± 2 inches (50 mm) 2 seconds $\leq T_{50} \leq$ 7 seconds Visual Stability Index ≤1.0
Concrete Temperature	<90°F (32°C)
Unit Weight and Yield	±2% of Theoretical

4.6.3 SCC should only be given minimal vibration; and shall not be dropped from a distance greater than 4 feet relative to the top of the form.

1.1.1 Precast products fabricated with dry cast concrete shall be limited to a maximum wall thickness of 12 inches when single sided vibration is used and 18 inches when double sided vibration is used.

5. FINAL INSPECTION

5.1 After fabrication is completed and prior to shipment, the precast items will be stored on dunnage. The Fabricator shall provide MCS&T Division with a written or email request for final inspection a minimum of one calendar week prior to the desired date of inspection. Effective communication from the Fabricator to MCS&T Division and Consultant Inspection Agency is the key to avoiding any scheduling conflicts regarding final inspection.

5.2 At the final inspection, the fabricator shall provide the inspector with documentation of required data pertinent to the product(s) being produced. Attached to this document is a sample inspection sheet to be used as a guide for presenting this information. This documentation is also available on the MCS&T Division Website[1].

5.2.1 For the final inspection, the Inspector may witness compressive strength tests if required, inspect repairs as needed, and conduct a thorough visual examination of each member. A copy of the Inspector's daily reports, a copy of the final inspection report, and all other pertinent information provided to the Inspector by the Fabricator shall be kept on file by MCS&T Division.

5.2.2 For box culverts, trial fitting of adjacent pieces, prior to shipping, will be required as part of the final inspection process. Each adjacent box culvert will be trial fitted in pairs horizontally or vertically; the gaps between each pair will be measured. Dunnage will be placed on a smooth level surface below the bottom of the culvert to prevent damage.

[1] https://transportation.wv.gov/highways/mcst/Pages/WVDOH-Materials-Procedures.aspx

The maximum gap between the adjacent pieces shall not exceed ½ inch (13 mm), unless otherwise stated in the construction plans.

6. ACCEPTANCE & REJECTION

6.1 Upon completion of final inspection, if a precast product meets all specification requirements and does not contain any defects, the Inspector will stamp the precast product as accepted by MCS&T Division and provide a 7-digit Laboratory Reference Number for shipment.

6.2 If, however, the precast product does not meet all specification requirements due to damage, defect, or dimensional tolerance, the product must be further evaluated before potential acceptance by the MCS&T Division or the District for which the product was produced, as discussed further in the next sections.

6.2.1 Minor damage and/or defects may be repaired in accordance with the pre-approved repair procedures which should be incorporated within the Fabricator QC Plan. For cracks 4 mils (0.1 mm) or less a silane treatment may be used. Cracks between 4 mils (0.1 mm) and 16 mils (0.4 mm) shall be repaired by epoxy injection in accordance with Section 603.10.2. Products with cracks exceeding 16 mils (4 mm) shall be rejected by MCS&T. If repairs appear satisfactory and all other specifications are met, the Inspector shall stamp the product as approved for shipment. MCS&T Division will issue a 7-digit Laboratory Reference Number for acceptance.

6.2.2 Major damage and/or defects shall be evaluated on a case-by-case basis. If a product is approved for repair and if repairs appear satisfactory, the Inspector shall stamp the product as approved for shipment.

6.2.3 If a product does not meet specification requirements due to dimensional measurements not within tolerance, the product must be evaluated by the contractor and or District as to its potential acceptance. If the decision is made to accept the product, acceptance shall be provided by the District through a DMIR. If, however, the product will not be accepted, the Inspector will reject the product, and MSC&T Division will apply a Laboratory Reference Number documenting the rejected product.

7. PROCEDURE FOR APPROVED SOURCE OF PRECAST CONCRETE LAGGING

7.1 Precast concrete Fabricators may be classified as an Approved Source of precast concrete lagging if they have met the requirements of Section 3 and are producing lagging which is made in accordance with the relevant WVDOH Standard Details. Once classified as an Approved Source of precast concrete lagging, an Approved Source Lab Number will be assigned to the Fabricator for material tracking.

7.2 MCS&T Division may perform regular quality assurance inspections prior to shipment and/or, monitor fabrication of lagging from a Fabricator that is an Approved Source. The Approved Source Lab Number shall be noted on all shipping documents from the fabricator, and material coverage will be requested under the assigned Approved Source Lab Number. All relevant concrete test data, component material information, QC inspection data, and shipping information shall be kept on file at the Fabricator for

the last three years of fabrication and shall be available upon request by the Division. Failure to produce requested documentation may result in revocation of the Fabricator's Approved Source certification status.

7.3 Approved Sources will be evaluated by the Division by random audits. Audits will be conducted on the material that is available to the Inspector at the time of the audit. All documentation and records for the pieces must be made available to the Inspector on the day of the audit and must be complete, current, and accurate. Failure to produce records shall be a cause for decertification.

7.3.1 All shipping documentation, concrete test data, and component material certifications shall be made available to the Inspector for review. These documents shall include all documents from material that has been shipped to state projects since the last audit. If data indicates that any material did not conform to this MP, the applicable Specifications, or Standard Detail; and was used in a state project, then the Fabricator will be de-certified as an Approved Source of precast concrete lagging.

7.3.2 In addition to documentation, the audit will consist of fabrication monitoring, test observance, and a visual inspection of material that is stocked for shipping on the day of the audit.

7.3.2.1 Each material test monitored during the audit must be performed in accordance with the applicable Standards, and Specifications. Visual inspection of stocked material will include quality checks of surface finish for cracks, spalls, and other surface blemishes after all repairs have been performed and dimensional checks. The material shall be properly stored to avoid handling damage and be accessible to the Inspector. Audits shall be graded on a point system deducted from 100 and weighted based on the Non-Conformance Points found per Table 7.3. A minimum score of 75 shall be considered passing.

TABLE 7.3

Audit Category	**Non-Conformance Points**
Material Test Data Review	10 (per error)
Component Material Certification Review	10 (per error)
Shipping Documentation	10 (per error)
Stocked Material Visual Inspection	15 (per defect)
Dimension Check	20 (per error)
Test Performance Check	15 (per Test)

7.4 When a Fabricator, which is an Approved Source, fails an audit, the Fabricator must submit a written corrective action plan to bring their QC program back into compliance with this MP and corresponding Specifications during a probationary period of one month during which time the fabricator must prove they have fulfilled the corrective actions they submitted before supplying the material again. If the Fabricator fails to

bring their material back into compliance within the probationary period, the Approved Source status will be revoked for a minimum of one year from the date of the end of the probationary period, or until the Fabricator has corrected the nonconformances listed during the failed audit. Two failing audits in a year shall result in revocation of the Fabricator's Approved Source status for one year from the date of the last failed audit. Any evidence of document falsification shall result in immediate loss of Approved Source status, and removal from the Approved List of Concrete Fabricators for a minimum 2 years. Depending on the severity and the legality of the falsified documents the removal may be permanent.

7.5 Non-Conforming material received by WVDOH projects and reported to MCS&T shall result in an immediate failing audit and will require the Fabricator to submit corrective actions. If the Fabricator fails the subsequent audit, it will result in the loss of their Approved Source status.

Ronald L. Stanevich, P.E.
Director
Materials Control, Soils and Testing Division

RLS:Mt
Attachment

PRECAST CONCRETE PRODUCTS
WVDOT DIVISION OF HIGHWAYS MCS&T DIVISION

1. SAMPLE FABRICATION CHECKLIST

1. Preliminary Verifications

NPCA (National Precast Concrete Association) Certification _____

CONCRETE COMPONENTS

Mix Design Lab # (if applicable): _____

Cement Source: _____ **Fly Ash Source:** _____

Coarse Aggregate Source 1: _____ **Coarse Aggregate Source 2:** _____

Cement Type: _____ **Approved/Tested:** _____

Fly Ash Type: _____ **Approved/Tested:** _____

Coarse Aggregate 1: _____ **Approved/Tested:** _____

Coarse Aggregate 2: _____ **Approved/Tested:** _____

Fine Aggregate 1: _____ **Approved/Tested:** _____

Fine Aggregate 2: _____ **Approved/Tested:** _____

Batch Water Source: _____ **Approved/Tested:** _____

Admixtures: _____

STEEL COMPONENTS

Reinforcement: Supplier(s): _____

Description: _____ **Lab Number:** _____

Description: _____ **Lab Number:** _____

Description: _____ **Lab Number:** _____

Inserts: **Supplier(s):** _____

Description: _____ **Lab Number:** _____

_____

_____

SHIPLOOSE MATERIAL

Grates: **Fabricator:** _____

Mill Certs.: _____ **Galvanize Cert.:** _____ **Lab Number:** _____

Mastic: **Fabricator:** _____

Inspected at: _____ **Lab Number:** _____

SHOP DRAWING REVIEW

Approval Date: _____ **Approved By:** _____

PRECAST CONCRETE PRODUCTS
WVDOT DIVISION OF HIGHWAYS MCS&T DIVISION
SAMPLE FABRICATION CHECKLIST

Preliminary Verifications

POST POUR WORK

Repairs: **Approved Repair Procedures: ____**

Approved by: _____ **Approval Date: _____**

Repair Witnessed: _____

Comments: _____

Sample Form Inspection (Pre-Placement of Concrete)

Product Type (s)				
Criteria	**Design Dimension**	**Tolerance (±)**	**Actual Measurement**	**Within Tolerance**
Fill in Form Information (if applicable)				
Height of Product (ft-inch)				
Depth of form (ft-inch)				
Inside Width of form (inch)				
Outside Width of form (inch)				
Inside Length of form (inch)				
Outside Length of form (inch)				
Wall Thickness (inch)				
Forms Square and Level (√)				
Skew dimensions [if applicable (ft-inch)]				
Locations of inserts, sleeves, block outs, etc. (√)				

Product Type(s)		**Form Properly sealed at joints & edges (√)**	
Framework Constructed of metal on concrete foundation (√)		**Form Clean & Free of debris (√)**	
Form dimensionally correct (√)		**Release Agent applied (√)**	
Other Information:			

Reinforcing Steel	
Reinforcing Steel (Condition)	
Fill in steel information (if applicable)	
Size & Grade	
Location & Lapping Length (√)	
Spacing and Clearances (√)	
Chairs, Spacers properly used	

Sample Concrete Placement & Curing

Quality Control Concrete Testing			
Concrete Truck Arrival Time		**Concrete Truck Departure Time**	
Concrete Temp		**Ambient Temp, Weather Conditions**	
Slump/Spread (inch)		**Air Content (%)**	
QC Tests performed per Specifications & Passing		**Number & diameter (inch) of Cylinders**	
Comments:			

Placement of Concrete			
Lift	**Start Time**	**Completion Time**	**Vibrated (External/Internal/Both)**
1st			
2nd			
3rd			
4th			
Placement of Concrete Completion Time			
Comments:			

Curing/Finishing of Concrete	
Top Surface Finished Per Specification	
Lifting loops/inserts accessible	
Product Curing Location (Inside/Outside)	
Product Covered & Heat Applied (Time Start & Time Finished)	
Heat Sensors Installed (√)	
Compressive Strength Cylinders Stored with Product under Curing/Normal Environment (√)	
Compressive Strength Test Conducted when curing was discontinued (√)	
Comments:	

Sample Concrete Post Pour Product Inspection

Product	
Visual Inspection for Damage (√)	
Notes (Size & Location of cracks, spalls, honeycomb, etc.)	
Products in Need of Repair (√)	
Repair Method Approved (√)	
Comments:	

Product Type (s)				
Criteria	**Design Dimension**	**Tolerance (±)**	**Actual Measurement**	**Within Tolerance**
Fill in Form Information (if applicable)				
Height of Product (ft-inch)				
Inside Width of product (inch)				
Outside Width of product (inch)				
Inside Length of product (inch)				
Outside Length of product (inch)				
Wall Thickness (inch)				
Product Square and Level (√)				
Skew dimensions [if applicable (ft-inch)]				
Locations of inserts, sleeves, block outs, etc. (√)				

Product	
Dimensional Tolerances Met? (yes or no)	
Heights (yes or no)	
Widths (yes or no)	

Depths (yes or no)	
Wall Thickness(es) (yes or no)	
Inserts, sleeves, lifting points, etc. (yes or no)	
All Concrete Finishes per specification (yes or no)	
Product properly transported (yes or no)	
Product stored on proper dunnage (yes or no)	
Design Shipping Strength met (yes or no)	
Repairs Satisfactory (yes or no)	
Product Stamped for Final Inspection (yes or no)	
Comments:	

Sample Inspection Sheet

Inspection Date_____ QC Personnel_____ QC Signature_____

Fabricator_____ Location_____

Project Name_____ WV State Project #_____ Federal Project #_____

Authorization # _____ Inspection done by_____

Steel Reinforcement

Reinforcement Supplier _____

Description_____ Approved Lab #_____

Description_____ Approved Lab #_____

Description_____ Approved Lab #_____

Product Description	Quantity	Date Cast	Slump/ Spread (inch)	Air Content (%)	Design Strength (psi)	Cylinder Breaks (psi)	Date Of Break	Absorption (%)
Type "D" inlet								
Type "G" inlet								
36-inch Manhole (base, riser, top)								
48-inch Manhole (base, riser, top)								
10'0"x 12'0" Box Culvert								NA
Lagging 8"x24"x54"								NA
Type A Reinforced Panel								NA
6'0" Coping								NA
24-inch								

Wing wall								

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

QUALITY ASSURANCE OF REINFORCED CONCRETE CULVERT, STORM DRAIN, AND SEWER PIPE

1. PURPOSE

1.1 To set forth the procedures which govern the Quality Assurance of Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.

1.2 To set forth manufacturers Quality Control requirements.

1.3 To set forth acceptance inspection procedures.

1.4 To set forth documentation and shipping procedures.

2. SCOPE

2.1 This procedure will apply to all manufacturers of Reinforced Concrete Culvert, storm pipe, and sewer pipe for use in West Virginia projects.

2.2 This procedure will establish the basis for acceptance of reinforced concrete pipe.

3. APPLICABLE SPECIFICATIONS

3.1 All standard types of reinforced concrete pipe are to be manufactured and tested in accordance with Section 714.2 of the WVDOH Specifications for Roads and Bridges.

3.2 Each LOT of reinforced concrete pipe having a wall thickness of 4.5 inches (115 mm) or less, which is manufactured in accordance with the applicable specifications is treated in the following manner to determine acceptability.

3.2.1 The three-edge bearing test (AASHTO T 280) shall be used to determine the force required to produce the 0.01 inch (0.25 mm) crack and the minimum specified ultimate load.

1.1.1.1 50% of the LOTs of Class III and Class IV concrete pipe 24 inches (610 mm) in diameter and less, and conforming to WVDOT Specifications, will be accepted based on the Fabricator's certification, provided they are QCast Certified by the American Concrete Pipe Association (ACPA). Testing of Class III and Class IV concrete pipe greater than 24 inches (610 mm) in diameter shall be witnessed by the Division.

1.1.1.2 50% of the LOTs of Class V Concrete Pipe with a diameter less than 24 inches, and conforming to WVDOT Specifications, will be accepted based on the Fabricator's certification, provided they are QCast Certified by the ACPA. Testing of Class V Concrete Pipe, with a diameter greater than or equal to 24 inches, shall be witnessed by the Division.

3.2.2 The absorption test (AASHTO T 280) shall be conducted on samples selected from the wall of the pipe.

3.2.3 A plant inspection of the finished product is conducted to determine dimensional conformance and freedom from defects.

1.1.1.3 For LOTs of concrete pipe accepted on the Fabricator's certification, the inspection, including the three-edge-bearing test, will be performed and recorded by the Fabricator's Quality Control person. These LOTs shall be as defined in Table 1, but the sizes shall be based on the criteria in the QCast Certification program.

3.3 Each LOT of reinforced concrete pipe fabricated with dry cast concrete having a wall thickness greater than 4.5 inches (115 mm), which is manufactured in accordance with the applicable specifications, is treated in the following manner to determine acceptability.

3.3.1 The compressive strength of the concrete will be determined by testing cores taken from the wall of the pipe. The manufacturer may choose to test this pipe as specified in Section 3.2.1, in which event the requirements for the 0.01 inch (0.25 mm) crack and the minimum specified ultimate load shall be met. This choice shall not be applied to a LOT (refer to Table 1) of pipe, which has been previously cored and found unacceptable.

1.1.2 The absorption test (AASHTO T 280) shall be conducted on samples selected from the wall of the pipe.

1.1.3 A plant inspection of the finished product will be conducted by the Division to determine dimensional conformance, and freedom from defects.

1.2 Each LOT of reinforced concrete pipe fabricated with wet cast concrete can be accepted on the basis of compressive strength from cylinder breaks (cylinders made per AASHTO ~~T 23~~R 100 and tested per AASHTO T 22) reaching the required 28-day compressive strength or by the three-edge bearing test (AASHTO T 280) as detailed in Section 3.2.1.

1.2.1 The absorption test (AASHTO T 280) for wet cast pipe shall be conducted on samples cored from the wall of the pipe or by making cylinders (4-inch x 8-inch minimum in accordance with AASHTO ~~T 23~~R 100).

1.3 Flared end sections will be accepted by either the inspection method or Fabricator certification method, with the same size criteria as outlined in Section 3.2.

1.3.1 Acceptance by the inspection method of precast concrete flared end sections is to be based on verification of compressive strength of concrete as determined from cylinders or cores. Flared end sections must also meet the dimensional requirements listed on the standard detail and on appearance. The testing frequency for compressive strength cores and steel verification coring is 1 out of every 40 pieces, but cylinders shall be fabricated and tested for each piece, if cylinders are used for strength acceptance instead of cores.

1.3.2 In order to accept flared end sections by the Fabricator certification method, the Fabricator must be QCast Certified by the ACPA. The fabricator will take

photos/videos showing correct steel placement and cover for one piece in each LOT. All flared end sections must be fabricated within the dimensions listed on the standard detail and have an acceptable finish free of bug holes, spalls, cracks and other surface defects.

TABLE 1

SAMPLING AND TESTING FREQUENCY FOR REINFORCED CONCRETE PIPE

A production "LOT" is defined as follows:

It is a pipe of the same size and class that is manufactured using the same process and similar materials during continuous days of production. The production LOT shall not exceed the specified value of 1% of the LOT and the minimum number tested per LOT is as follows:

Number of Pipe Sections in the LOT	Number of Pipe Sections to be Tested
0 to 300	1
301 to 800	2
801 to 1500	3
over 1500	3 plus 1 section per each 600 pieces or fraction thereof over 1500 pc.

When the tests indicate that a production LOT is acceptable for WVDOH use, the LOT should be inspected by the Division's representative.

4. QUALITY CONTROL REQUIREMENTS

4.1 Quality Control is the responsibility of the manufacturer and shall include the following:

4.1.1 Ensure all component materials used in the fabrication of the pipe have been sampled, tested, and approved (MP 603.02.10).

4.1.2 Ensure quality workmanship as well as a quality product throughout the production.

4.1.3 To scribe into each piece of pipe the following:

(a) Cast Date
(b) Class and Wall Type
(c) Manufacturer's Trademark

4.1.4 Notify the Division's representative upon the completion of casting of a LOT (Refer to Table 1) of pipe so the Division may select a representative sample and witness the testing.

4.1.5 To conduct the three-edge bearing test or to secure cores to ensure strength requirements are met (Section 3.2 and 3.3).

4.1.6 To conduct the absorption test (AASHTO T 280) on samples selected from the wall of the pipe.

4.1.7 Any LOT of pipe or portion of a LOT of pipe failing to meet the specification requirements will be stored separately from acceptable pipe.

4.1.8 Accurate inventory records containing the information required in Section 6.1.2 will be kept and maintained by the manufacturer.

5. ACCEPTANCE CRITERIA

The Division will:

5.1 Sample and test the component materials to be used in the manufacturer of the reinforced concrete pipe in accordance with MP 603.02.10.

5.2 Select representative samples of the LOT to be tested and:

(a) Witness the three-edge bearing test and/or the coring procedure
(b) Verify dimensional conformance
(c) Verify actual steel placement
(d) Determine the steel area

5.3 Ensure each piece comprising the LOT is scribed as stated in 4.1.3.

5.4 Make a visual inspection of the LOT and designate unacceptable units to be removed or set apart from the approved pipe in the LOT.

6. SHIPPING REQUIREMENTS

6.1 The approved LOT of pipe or portion of the LOT can be shipped by the manufacturer providing the following provisions have been met:

6.1.1 The manufacturer will notify the Division's representative prior to each shipment so that the Division may maintain a current inventory with the manufacturing plant.

6.1.2 The manufacturer will supply one copy of the shipping invoice to Materials Control, Soils and Testing Division and one copy to the Division's representative at the project site. The invoice shall contain the following information.

(a) Cast date of the approved LOT
(b) Master laboratory reference number
(c) Size, class, and wall type
(d) Project number
(e) Number of pieces

7. ACCEPTANCE PRACTICE

7.1 Ensure the information on the shipping invoice, as required in Section 6.1.2, agrees with the shipment it accompanies. (Number of pieces, class, size, and type, etc.).

7.2 Check each piece of pipe for the proper identification markings (Section 5.3) and make a visual inspection of each piece to ensure there is no evidence of damage during shipment.

8. COVERAGE REQUEST FROM PROJECT SITE

8.1 Request for coverage shall include the information as referenced on the shipping invoice, Section 6.1.2

Ronald L. Stanevich, P.E.
Director
Materials Control, Soils and Testing Division

RLS:Mg

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION MATERIALS

PROCEDURE

STANDARD METHOD OF TEST FOR DETERMINING THE QUALITY OF WATER USED WITH HYDRAULIC CEMENT

1. PURPOSE

1.1 To establish a standard method of test and acceptance criteria to be used in determining the quality of water used with hydraulic cement.

2. PURPOSE

2.1 This procedure is applicable to untreated water sources used in combination with mixtures containing hydraulic cement. An untreated water source may be defined as a source other than a treated public water system.

2.2 Treated water systems may be used without testing.

3. APPLICABLE DOCUMENTS

3.1 *MP 642.40.20*

3.2 *AASHTO T 106*

3.3 *AASHTO T 154*

3.4 *AASHTO T 162*

4. PROCEDURE

4.1 Untreated water shall be tested at the source for pH. When the pH of the water is between 4.5 and 8.5 no further testing is necessary.

4.2 If the pH is less than 4.5 or more than 8.5, all tests listed in this procedure will be conducted. A water source whose pH is determined to be within the limits defined ~~above~~ in section 4.1 ~~,may~~but appears to be contaminated with foreign material which could have an adverse effect on the ~~p~~Portland cement concrete shall have a sample forwarded to the Materials Division and all tests listed in this procedure will be conducted. ~~If the sampler has reason to believe that this may be the case, a sample shall be forwarded to the Materials Division for further tests as defined below.~~ The sample shall be accompanied with the required documentation indicating the sampler's reasons for requesting testing. These tests shall be conducted before first use and thereafter once every 6 months, or more often when there is reason to believe that a change has occurred in the characteristics of the water source.

5. TEST METHODS

5.1 Total Solids Content, Chloride as Cl^-, Sulfate as SO_4, and Alkalies as (Na2O + 0.658 K2O)

5.1.1.1 Tests shall be conducted in accordance with MP 642.40.20.

Commented [MMA1]: Where in MP 642.40.20 are these tests currently referenced, or is that one of the updates that will need to be made to MP 642.40.20? It doesn't look like T263 & T264 are current AASHTO standards any longer.

Commented [PMD2]: Mike,

This one of the updates that will have to be made in MP642.40.20. ASTM C1602 has the test methods that will have to be added. Testing for Total Solids Content, Chloride as Cl-, Sulfate as SO4, and Alkalies as (Na2O + 0.658 K2O) .

5.2 Compressive Strength

5.2.1 The water under test shall be compared, in mortar, with distilled water. The proportions of dry materials in the mortar shall be 500 grams of Type III Cement, 1500 grams of graded OTTAWA sand and the amount of water sufficient to produce a flow of 110 ± 5 in 25 drops in accordance with AASHTO T 106 using the sample under test and compared to three specimens made using distilled water.

5.3 Time of Setting by ~~Gillmore Needle~~ Vicat Needle

5.3.1 Time of set will be prepared with the test sample and Type III Cement in accordance with ~~AASHTO T 154.~~ ASTM C191. A control specimen will be made with distilled water for basis comparison.

6. ACCEPTANCE CRITERIA FOR UNTREATED WATER SOURCES

~~Total Solids Content 2000 ppm* Compressive Strength (Min% Control at 1 day) 90~~
~~Time of Set, (deviation from control) -60 to +90 Minutes~~

Performance Requirements for Untreated Water Source	
Requirements for Mixing Water	Limit
Compressive Strength (Min% Control at 1 day)	90
Time of Set, (deviation from control)	-60 to +90 minutes

	Chemical and Physical Limits for Untreated Water Source	
	Maximum Concentration in Combined Mixing Water, ppm	Limit
A	Chloride as Cl^-, ppm	
	In prestressed concrete or bridge decks	500
	Other reinforced concrete in moist environments or containing aluminum embedments or dissimilar metals or with stay-in-place galvanized metal forms	1,000
B	Sulfate as SO4, ppm	3,000
C	Alkalies as (Na2O + 0.658 K2O), ppm	600
D	Total solids by mass, ppm	50,000

~~*Water containing more than 2000 ppm of total solids may be determined acceptable if compressive strength and time of set tests indicate that the solids will not adversely affect the concrete.~~

Ronald L. Stanevich, P.E.
Director
Materials Control, Soils and Testing Division

MP 715.07.20 Steward – Cement and Concrete Section
RLS:T

Commented [MMA3]: We no longer use the Gillmore needle. Can we specify the Vicat test instead in this MP?

Commented [PMD4]: Yes, I went ahead and made the change.

Commented [MMA5]: This test method would need changed if we require Vicat instead.

Commented [MMA6]: Is this number a typo? The * footnote below notes a 2,000 ppm limit, above which would be acceptable based on compressive strength results. The table is allowing 50,000 ppm.

Commented [PMD7]: Mike,

This requirement was from the previous version of this MP and should be removed now that I read it again. The previous MP did not have a limit of total solids of ppm that could be used. I like the list ASTM C1602 has limiting it at 50,000. All of these new requirements are directly from ASTM C1602.

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

PROCEDURAL GUIDELINES FOR MAINTAINING CONTROLCHARTS FOR AGGREGATE GRADATIONS

1. PURPOSE

1.1 To provide a standard method for developing and maintaining control charts to evaluate the grading characteristics of mineral aggregates.

2. SCOPE

2.1 Control charts shall be maintained where specified for sized aggregates, for bases and sub-bases, aggregates for Portland c~~C~~ement and hot-mix asphalt, etc.

3. INTENT

3.1 It is the intent to have the procedure outlined hereinafter used in instances in which it can be reasonably and logically applied. The applicability of the procedure ~~will~~ shall normally depend on circumstances such as the number of samples, the continuity of delivery, etc. The moving average may not necessarily be continuous for the entire project. A new moving average series may be started after periods of inactivity, changes in materials or processes, change in job mix formula, resuming operations after correcting deficiencies, etc.

4. GENERAL

4.1 Paper Charts

4.1.1 Control charts ~~should~~shall be prepared on 10 x 10 cross section paper approximately 25 inches wide. A chart length of approximately 30 inches ~~should~~shall be displayed at all times. When standard cross section sheets are used, the most recent sheet must be displayed, and all the previous sheets placed chronologically in a holder.

4.1.2 The item number and/or description of the material ~~should~~shall be noted on the top of the chart and visible at all times.

4.1.3 Control charts ~~will~~ shall be maintained at the project office or at the testing site where applicable.

4.1.4 Scale – The control chart ~~should~~shall have a vertical scale of one division equal to one percentage point (or one inch equal to 10 percent), except in the following cases: (a) a vertical scale of two divisions equal to one percentage point (or one inch equals five percent) ~~should~~shall be used for any sieve which has a specification tolerance range less than ten percent, and (b) in the case of coarse aggregates used in

Portland cCement concrete, a vertical scale of one division equal to 0.1 percentage point (or one inch equal to one percent) ~~should~~shall be used for the #200 sieve.

4.1.5 On the horizontal scale the test values ~~will~~ shall be plotted on the heavy, vertical lines (one inch apart), progressing from the left to the right.

4.1.6 General Arrangement- Control charts are to be arranged on the cross section paper in the manner described below; an example of the arrangement is shown on Attachment 1. [Note on the attachment the 10 X 10 squares are "stretched" vertically to allow the graph to fit the 8 1/2 by 11 paper.]

4.1.7 The largest sieve size ~~will~~ shall be located toward the top of the chart and the smallest sieve size toward the bottom of the chart. The spacing between the lower limit of one sieve and the upper limit of the adjacent sieve ~~should~~shall be a minimum of one inch.

4.1.8 The vertical scale for each sieve ~~will~~ shall be arranged so that the heavy lines ~~will~~ shall have a value of zero or a value which is a multiple of five. For instance, zero, five, ten, fifteen, etc.

4.1.9 Lines corresponding to the upper and lower limits of the specification ~~will~~ shall be drawn in red (pen or pencil) across the graph. At the beginning and end of each sheet (or length of the displayed portion) a vertical red line ~~will~~ shall be drawn between the specification limits of each sieve, an arrow ~~will~~ shall be placed at the end of each vertical line. The specification limits ~~will~~ shall be indicated above and below the arrows, and the sieve size and scale ~~will~~ shall be indicated between the limits on the outside of the displayed portion of the chart.

4.1.10 Inside the solid red lines, that define the specification limits, two green dashed lines ~~will~~ shall be drawn. (Note exception in Section 4.1.11). These lines ~~will~~ shall be located parallel to the specification lines and at a distance from each specification line equal to approximately twenty (20) percent of the specification range. The band (area) between the green dashed lines and the specification line ~~will~~ shall be known as the caution band. This band may be shaded a light yellow or amber to symbolize the caution which the contractor ~~should~~shall exercise to prevent the quality of his/her work from going outside the specification limits.

4.1.11 For screens specifying only 100 percent passing, plotting of caution band is not applicable. Also, when the lower specification limit is zero, plotting of the lower caution band is not necessary.

4.1.12 Plotting of Test Data – Individual test values ~~will~~ shall be plotted with a blue color pen, or pencil, using the symbol O. [For paper charts the circle ~~should~~shall be approximately 1/10 (0.1) inch in diameter.]

4.1.13 Averages of consecutive test values ~~will~~ shall be plotted with a red color pen, or pencil, using the symbol □. [For paper charts the square ~~should~~shall be approximately 1/10 (0.1) inch on either side.]

4.2 Computer Generated Charts

4.2.1 Standard variable control computer generated charts allowing hand plotting or computer plotting of individual data may be used under the following constraints: The chart sequence shall display the applicable sieve sizes ~~Computer generated charts using any standard variable control charting program may be used that allow hand plotting or computer plotting of the individual data and in a sequence that displays the applicable sieve sizes~~ vertically in descending order from top to bottom ~~from largest sieve size at the top of the display to smallest sieve size toward the bottom~~ of the display in the least number of pages as practical when printed. The screen display ~~should~~shall show horizontally on any given sieve at least eight potential data areas.

4.2.2 The item number and/or description of the material ~~should~~shall be noted on the top of the chart and visible at all times.

4.2.3 Control charts ~~will~~ shall be maintained at the project office or at the testing site where applicable. These charts must be kept current, printed daily when applicable, and prominently displayed vertically in the specified sieve sequence (from largest sieve to smallest sieve). When printed, the most recent sheet(s) ~~should~~shall be displayed, and the previous sheets shall be placed chronologically in a holder

4.2.4 Scale – To the extent possible, the control chart ~~should~~ shall have a vertical scale which visualizes the differences in tolerances limits between the specified sieves.

4.2.5 On the horizontal scale the test values ~~should~~shall ~~–~~be plotted on heavy, vertical lines, progressing from the left to the right.

4.2.6 General Arrangement – Control charts ~~are to~~shall be arranged on the computer screen (and when printed and displayed) in the manner described hereinafter.

4.2.7 The largest sieve size ~~will~~ shall be located toward the top of the chart and the smallest sieve size toward the bottom of the chart. The spacing between the lower limit of one sieve and the upper limit of the bordering sieve ~~should~~shall ~~–~~ be such that a clear demarcation between sieves is provided.

4.2.8 The vertical scale for each sieve ~~will~~ shall be arranged so that the heavy lines ~~will~~ shall have a value of zero or a value which is a multiple of five. For instance, zero, five, ten, fifteen, etc.

4.2.9 General construction of the control chart ~~should~~shall be the same as described in Sections 4.1.9 through 4.1.13 as applicable.

5. PLOTTING TEST DATA

5.1 Symbols and Color Code

5.1.1 Individual test values ~~will~~ shall be plotted in a blue color using the symbol described in Section 4.1.12

5.1.2 Averages of consecutive test values ~~will~~ shall be plotted with a red color using the symbol described in Section 4.1.13.

5.2 Individual Test Values and Moving Average.

5.2.1 Test values ~~will~~ shall be rounded to the nearest whole percentage point and plotted, except the No. 200 sieve ~~will~~ shall be rounded to the nearest one tenth (0.1) percentage point then plotted.

5.2.2 The average at the start of the job begins with the second sample result. This average ~~will~~ shall be plotted on the appropriate line on the control chart. Likewise, the average is continued for the third through fourth result, averaging all previous results and plotting each of these averages on the appropriate line on the control chart. The moving average ~~will~~ shall be considered to be the average of five consecutive test values and is determined by starting with the fifth test value and averaging it with the four preceding test values. Thereafter only the last consecutive five sample result ~~will~~ shall be averaged, i.e., second test value through sixth test value, third test value through seventh test value, and so forth. All averages ~~will~~ shall be plotted on the control chart in the manner described in Section 4.1.13 and rounded in the manner described in Section 5.2.1.

5.2.3 As successive symbols are plotted across the control chart, from left to right, the blue symbol O (individual value) ~~will~~ shall be connected with a dashed blue line as depicted in Attachment 1, and the red symbols ~~will~~ shall be connected with a solid red line as depicted in Attachment 1.

5.2.4 All additional samples, if taken, ~~will~~ shall be plotted on successive heavy vertical lines and treated in the same manner as above.

5.2.5 At the bottom of the cross-section paper, or below the last (smallest) represented sieve size printed from the computer, and immediately left of the vertical line on which test data is plotted, the following information ~~will~~ shall be written:

1. The laboratory number assigned to the test.
2. The initials of the person plotting the test data.
3. The date the sample was taken.

6. INDIVIDUAL OR MOVING AVERAGE TEST VALUES OUTSIDE THE SPECIFICATIONS

6.1 Individual Test Values

6.1.1 When the individual test value on a sieve is outside the specification limits, or differs markedly from those preceding it, the Project Engineer/Supervisor and the contractor ~~will~~ shall be promptly advised. The contractor ~~will~~ shall immediately take any steps that may be necessary to bring the production under control.

6.2 Moving Average

6.2.1 When an average value of consecutive tests falls in the caution zone the contractor ~~will~~ shall be advised that the material is, or is becoming, borderline, and the following notation ~~will~~ shall be made in the plant or project diary:

"Contractor advised that _____ material is borderline". (Write item number for base course or aggregate size and item number for other material in the blank space).

6.3 Material Outside Specification Limits

6.3.1 When three consecutive individual test values are outside the specification limits or when an average of consecutive tests falls outside the specification limits the contractor ~~will~~ shall be promptly advised that the material is non-conforming, and the contractor ~~will~~ shall immediately take any necessary steps to correct the deficiencies. When an average falls outside of the specification limits and the two immediately following individual test values are also outside the specification limits, operations ~~will~~ shall be discontinued until the contractor gives reasonable assurance that the deficiency has been corrected. After the contractor has taken significant steps to correct the deficiency the next individual sample that meets the specifications after production is resumed ~~will~~ shall be used to start a new average.

_____
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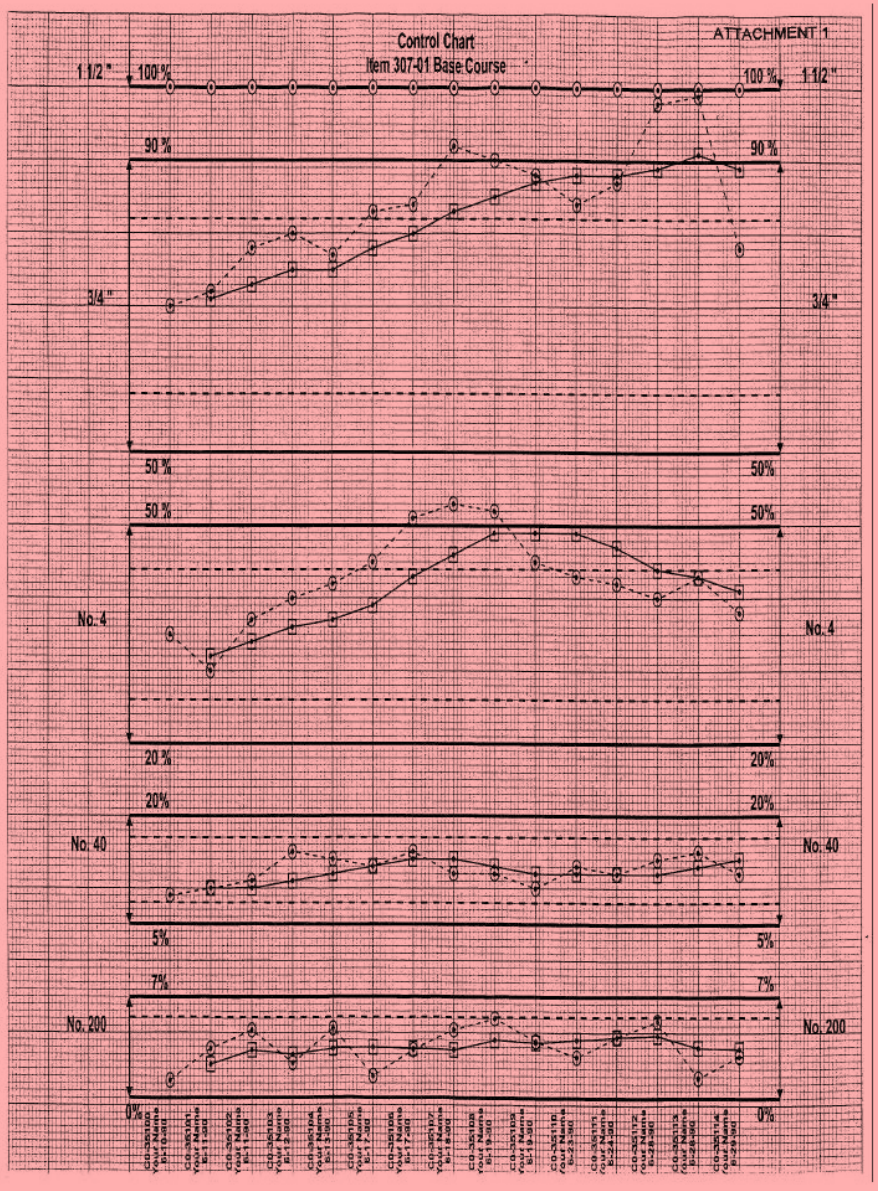
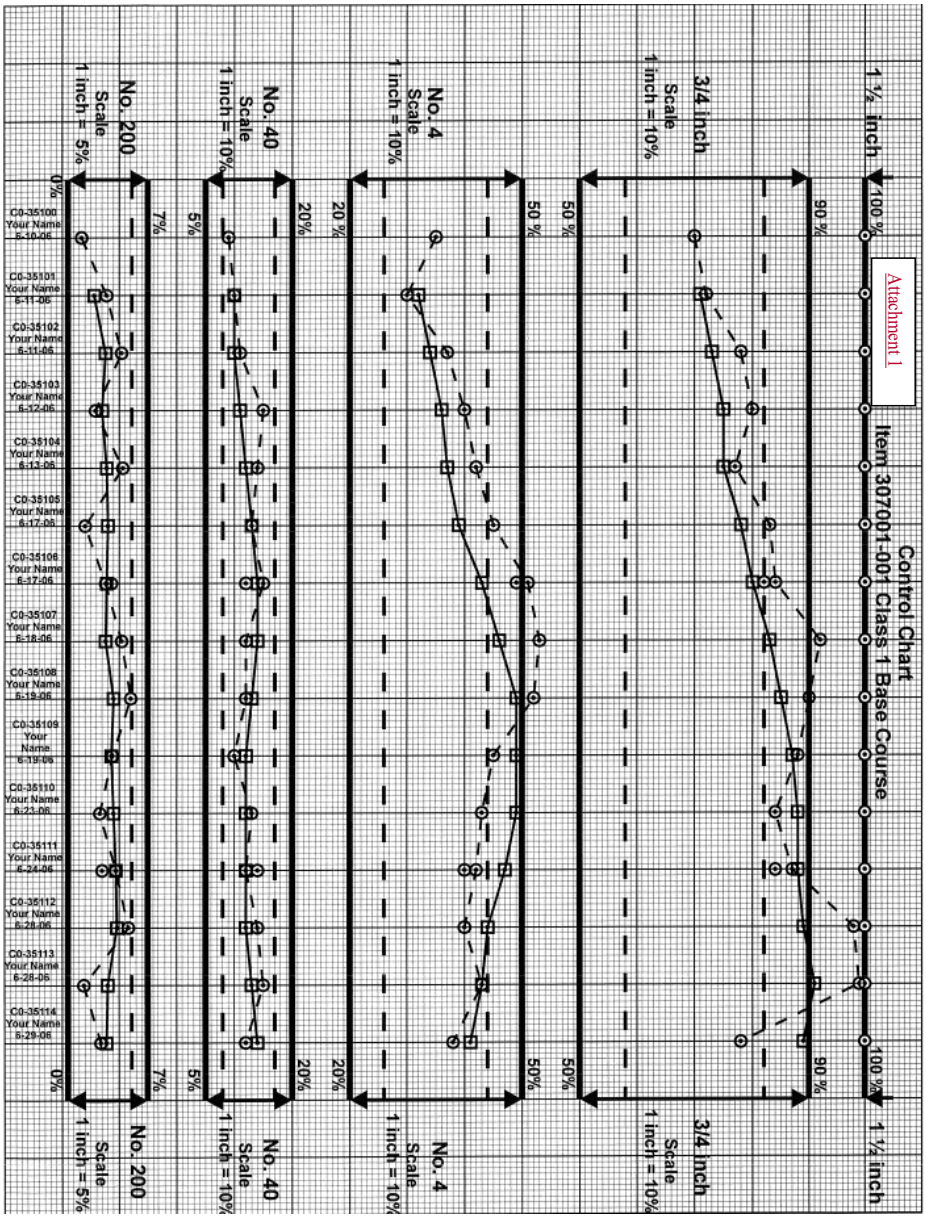
Materials Control, Soils & Testing Division

MP 300.00.51 Steward – Aggregate & Soils Section
RLS:M
ATTACHMENT

Commented [JCT1]: Replacing Attachment 1 with a clearer, identical image.




Control Chart
Item 307001-001 Class 1 Base Course
Attachment 1
1 ½ inch
3/4 inch
No. 4
No. 40
No. 200
Scale
1 inch = 10%
1 inch = 5%
100 %
90 %
50 %
20 %
5%
7%
0%
C0-35100 Your Name 6-10-06
C0-35101 Your Name 6-11-06
C0-35102 Your Name 6-11-06
C0-35103 Your Name 6-12-06
C0-35104 Your Name 6-13-06
C0-35105 Your Name 6-17-06
C0-35106 Your Name 6-17-06
C0-35107 Your Name 6-18-06
C0-35108 Your Name 6-19-06
C0-35109 Your Name 6-19-06
C0-35110 Your Name 6-23-06
C0-35111 Your Name 6-24-06
C0-35112 Your Name 6-28-06
C0-35113 Your Name 6-28-06
C0-35114 Your Name 6-29-06

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

STANDARD METHOD OF TEST FOR DETERMINING THE PERCENTAGE OF COAL AND LIGHTWEIGHT PARTICLES IN AGGREGATE

1. PURPOSE

1.1 To provide a standard method of testing for coal and lightweight particles in aggregates by means of a sink-float separation in a heavy liquid with a designated specific gravity.

2. SCOPE

2.1 This procedure is applicable to fine and coarse aggregates.

3. APPLICABLE DOCUMENTS

3.1 ASTM C 123 OR AASHTO T 113

3.2 ASTM E 11

3.3 ASTM E 100

3.4 ASTM C 702 OR AASHTO T 248

3.5 MATERIALS PROCEDURE (MP) 700.00.06

3.6 ASTM C 127 OR AASHTO T 85

3.7 ASTM C 128 OR AASHTO T 84

4. APPARATUS

4.1 *Sieves*—The following sieve sizes conforming to AASHTO M-92; 4.75 mm (No. 4) and 300 µm (No. 50).

4.2 *Balance*—The balance shall have sufficient capacity, be readable to 0.1 percent of the sample mass, or better, and conform to the requirements of M 231.

Commented [SRL1]: Simplified and made uniform with previously edited MP's.

4.3 *Oven*—An oven capable of maintaining a temperature of 110°C ± 5°C (230°F ± 9°F).

4.4 *Containers*—Large vat/tank for storage of heavy liquid with compatible mesh bucket for immersion of coarse aggregate into heavy liquid, buckets for soaking test portion,

Pans for surface drying the aggregates, 600 ml Pyrex beakers for containing fine aggregate test portions.

4.5 *Skimmers*—Made of 300 µm (No. 50) sieve cloth conforming to ASTM E 11. Fitting one with a handle for scooping floating particles from heavy liquid. The other must be capable of fitting over 600 ml Pyrex beakers.

4.6 *Stirring Rods*—A glass rod for stirring fine aggregates, a large metal rod for stirring coarse aggregates.

4.7 *Heavy Liquid*—Consisting of a mixture of zinc bromide and water in such proportions so that a designated specific gravity of 2.00 ± 0.01 can be maintained at all times during the test.

4.8 *Hydrometer*—Conforming to the requirements of ASTM E 100 and capable of measuring the liquid specific gravity to within ± 0.01.

4.9 *Safety Equipment*—Industrial type rubber gloves, face shield or goggles.

Note: Although there is no particular hazard from the fumes of zinc bromide solution, precautions shall be taken to avoid inhalation of fumes and contact with eyes and skin. Goggles and gloves shall be worn, and the solution should only be used in a laboratory exhaust hood.

~~A No. 4 (4.75 mm) and No. 50 (300 µm) U.S. Standard 8-inch (203 mm) diameter sieve conforming to ASTM E 11 Specifications.~~

~~Balance or scale having a capacity of 500 grams and a sensitivity of at least 0.1 gram for weighing fine aggregates; and a capacity of 10,000 grams with a sensitivity of 1 gram for weighing coarse aggregates.~~

~~Oven capable of being maintained at 230 ± 9°F (110 ± 5°C).~~

~~Containers: Large Nalgene vat (or comparable material) for storage of heavy liquid and compatible mesh bucket for immersion of coarse aggregate into heavy liquid.~~

~~Buckets for soaking and pans for surface drying the aggregates. 600 ml Pyrex beakers for fine aggregates.~~

~~Skimmers: Made of No. 50 sieve cloth conforming to ASTM E 11. Fitting one with a handle for scooping floating particles from heavy liquid. The other must be capable of fitting over 600 ml Pyrex beakers.~~

~~Stirring Rods: A glass rod for use with fine aggregates and a large metal rod for coarse aggregates.~~

~~Heavy Liquid: Consisting of a mixture of zinc bromide and water in such proportions so that a designated specific gravity of 2.00 ± 0.01 can be maintained at all times during the test.~~

~~Hydrometer: Conforming to the requirements of ASTM E 100 and capable of measuring the liquid specific gravity to within ± 0.01.~~

~~Safety Equipment: Industrial type rubber gloves, face shield or goggles.~~

~~NOTE: Although there is no particular hazard from the fumes of zinc bromide solution, precautions shall be taken to avoid inhalation of fumes and contact with eyes and skin. Goggles and gloves shall be worn and the solution should only be used in a laboratory exha~~

5. SAMPLE PREPARATION

5.1 Secure a field sample of the aggregate in accordance with MP 700.00.06. Samples shall be representative of the sources from which they are obtained and shall be reduced to an appropriate size by use of a sample splitter or by quartering in accordance with ASTM C 702 or AASHTO T 248.

5.2 The samples shall be dried in an oven to a constant mass at a temperature of 110 ± 5°C (230±9°F) ~~(110 ± 5°C)~~.

5.2.1 In the following minimum test portions, the oven-dried sample shall be weighed to the nearest one gram and that weight recorded.

Nominal Maximum Size of Aggregate (Sieve Openings)	Minimum Weight of Test Sample (Grams)
No. 4 (4.75 mm)	200 grams
¾ in (19.0 mm)	3,000 grams
1 ½ in (37.5 mm)	5,000 grams
3 in (75.0 mm)	10,000 grams

5.3 The fine aggregate oven dry sample shall be cooled to room temperature and sieved over a 300 µm (No. 50) ~~(300 µm)~~ sieve until less than one percent of the retained material passes through the sieve in one minute of continuous sieving. Discard the minus 300 µm (No. 50) ~~(300 µm)~~ sieve material.

5.3.1 Bring the plus 300 µm (No. 50) ~~(300 µm)~~ test portion to a saturated-surface-dry condition as specified in ASTM C 128 or AASHTO T 84. (See Note 1 and Note 2).

Note 1 ~~–~~ If material undergoes degradation in water, the material does not have to be brought to an SSD condition.

Note 2 ~~–~~ Pit derived silica sand commonly contains soft and easily degradable aggregations of sub-bituminous coal. Because of this possible degrading constituent, pit sand ~~will~~shall not be subjected to SSD condition under this procedure.

5.4 Coarse aggregates shall be sieved over a 4.75 mm (No. 4) ~~(4.75 mm)~~ sieve. The plus 4.75 mm (No. 4) ~~(4.75 mm)~~ material shall be thoroughly washed and oven dried to a constant mass at a temperature of 110°C ± 5°C (230 ± 9°F) ~~(110 ± 5°C)~~.

5.4.1 Allow oven dry sample to cool to room temperature and weigh a test portion to a minimum test size, to the nearest 1 gram and record weight.

5.4.2 Bring sample to a saturated-surface-dry condition as specified in ASTM C 128 or AASHTO T 84. (See Note 1 and Note 2).

6. PROCEDURE

6.1 Under a ventilation hood or in adequately ventilated area, check the heavy liquid (zinc bromide) for correct specific gravity (2.00 ± 0.01).

6.2 Fine Aggregate - weigh a test portion to a minimum of 200 grams to the nearest 0.1 gram and record weight. This test portion shall be placed in a 600 ml beaker and a volume of heavy liquid poured into the beaker until the liquid level is at least 1 in (25 mm) above the sample level.

6.2.1 Agitate the test portion by means of a glass-stirring rod allowing the lightweight particles to float to the surface.

6.2.2 Pour the liquid and floating lightweight particles into a second beaker, passing through a 300 µm (No. 50) ~~(300 µm)~~ skimmer, making sure that only the floating particles are poured off with the liquid.

6.2.3 Repeat procedure in 6.2.2 until test portion is free from floating particles, then drain heavy liquid from test portion back into vat. Rinse test portion with water to remove heavy liquid from sample and discard.

6.2.4 Wash the decanted particles retained on the 300 µm (No. 50) ~~(300 µm)~~ skimmer with water until all the zinc bromide is removed.

6.2.5 Dry decanted particles to a constant weight and weigh to the nearest 0.1 gram.

6.3 Coarse Aggregate - Place sample into mesh bucket and place into vat of zinc bromide solution.

6.3.1 NOTE: If test portion is sufficiently large, two or more runs may be necessary to complete testing.

6.3.2 Agitate test portion by means of a large metal stirring rod allowing the lightweight particles to float to the surface.

6.3.3 Remove floating pieces from heavy liquid by scooping with a 300 µm (No. 50) ~~(300 µm)~~ skimmer. Repeat process until test portion is free of floating particles.

6.3.4 Raise mesh bucket to drain heavy liquid from test portion into vat. Rinse test portion with water to remove heavy liquid from sample and discard.

6.3.5 Wash lightweight particles with water until all the zinc bromide is removed.

6.3.6 Dry lightweight particles to a constant weight and weigh to the nearest 1.0 gram.

6.4 Slag: Due to the manufacturing process, there is entrapped air in the aggregate. The procedure for slag is the same for any other coarse aggregate; however, a greater number of pieces will come to the surface than with other types of aggregates. The floating particles must be friable before they are considered as deleterious.

7. CALCULATION

7.1 Calculate the percentage of lightweight particles as follows:

7.1 Fine Aggregates

~~L = W1 x 100~~ $L = \frac{W_1}{W_2} \times 100$ ~~W2~~

~~Coarse Aggregates L =~~

~~W1 x 100~~

~~W3~~

~~Where:~~

L = Percentage of lightweight particles
$W1_1$ = Oven dry mass of lightweight particles~~Dry weight of lightweight particles~~
$W2_2$ = ~~Dry weight of fine aggregate test portion~~Oven dry mass of test portion
~~W3 = Dry weight of coarse aggregate test portion~~

7.2 Report results to nearest 0.1 percent.

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MP 702.01.20 Steward – Aggregate & Soils Section
RLS:M

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

METHOD OF PREPARATION AND EVALUATION OF AGGREGATE FOR SOAK TEST

1. PURPOSE

1.1 Various rock types may react differently to the presence of interstitial water. Material that is above the phreatic zone in the crust may undergo physical changes when subjected to a saturated environment and, if used in ~~portland~~Portland cement concrete, these changes might be injurious to the strength of the concrete. This test is strictly qualitative, in that only physical and megascopic changes are noted. Since test results are descriptive, no decision on the acceptability of the material can be made without corroborating qualitative test results. This test gives an indication of what happens to the aggregate in a saturated environment and what may happen to the aggregate when mixed in ~~portland~~Portland cement concrete.

~~*NOTE*~~*Note*: Portland cement concrete does not represent a saturated environment but since water is used in the mixing process, the external surface may become saturated and physical changes may take place. Such changes as increased friability may occur and, subsequently, this could change the percent of fines in the mix and the gradation of the aggregate, both of which could affect the strength of the concrete.

2. SCOPE

2.1 This method of preparation and evaluation is applicable to all material to be used for coarse aggregate in ~~portland~~Portland cement concrete. The test is usually performed on limestone and sandstone samples since these types are usually above the phreatic zone when quarried or mined. River gravel is excluded because it is usually foundina saturated environment; (either in a river, (as in dredging operations) or very near a river~~ a river,~~ (as in a pit operation)). The test is applied when required by the governing specifications and is a standard quarry investigation test.

3. EQUIPMENT

3.1 Containers - Pans or buckets large enough to accommodate the aggregate, which will be filled with water

4. SAMPLES

4.1 Washed and oven dried samples are received from the Preparation Laboratory when the soak test is required for crusher run aggregate. For quarry investigations, samples of ledge rock (rock barrow) taken at the quarry site at the time of the investigation are used.

4.2 There is no definite sample weight to be used, but a sample of 3000-5000 grams will be sufficient for a representative sample.

5. PROCEDURE

5.1 Make a lithologic description of the material including such things as color, hardness, toughness, friability, presence of fracture and bedding planes, presence of inclusion or clastic material, etc. After the description, place the material in the bucket and fill with water until the water level is about 50mm (2 inches) above the aggregate. Set aside and let soak for 24 hours.

Commented [JCT1]: Adding metric conversion, similar to other MP's

5.2 After the soaking period is finished, drain the water and note any changes in the physical character of the material as described in Section 5.1

6. EVALUATION

6.1 Results of the test are to be reported on the appropriate Division form. No conclusion about the applicability or non-applicability should be made. For a quarry investigation the test results should be put in a quarry investigation file for later incorporation into the final report. This result, along with other quality test results will be used in making recommendations for the applicability of the material for highway use.

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MP 703.00.30 Steward – Aggregate & Soils Section
RLS:M

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

FIELD CALIBRATION AND OPERATION OF ROLLING 3m STRAIGHT EDGE ON BRIDGE DECKS

1. PURPOSE

1.1 To establish a field calibration procedure for the 10 ft ~~3 m~~ rolling straight edge.

1.2 To establish a procedure for documenting out of tolerance bridge deck sections.

2. FIELD CALIBRATION

~~The marking of high and low sections on the deck is best accomplished by the use of red and green clothes dye. One small package should be mixed with 1.89 L of water. It is suggested the dye be mixed in gallon jugs and poured into the appropriate tank on the machine. Drain the tanks and flush when it is anticipated the machine will not be used for a week or more.~~

~~Before using, ensure the tank valves on the bottom of the tank are open. Use the red dye solution for high areas and green dye solution for low areas. Do not leave fluid in tanks in freezing weather.~~

2.1 Under each set of wheels place a piece of steel or other suitable solid material, with dimensions approximately ~~76 mm x 305 mm x 13 mm~~ 3" x 12" x 0.5". Stretch a piece of string between the front and rear wheels, across the top of each of the pieces, and adjust the center riding wheel so that it just touches the string.

2.2 When straight edging a deck with a vertical curve, the riding wheel should be adjusted as above and then a final adjustment up or down should be made according to the vertical differences of the curve in a ~~3 m~~10 ft. length.

2.3 When the center wheel is in proper alignment, the dial on the straight edge should read zero. If adjustment is needed, lengthen or shorten the linkage to this center wheel as per the instructions of the manufacturer of the straight edge. ~~This adjustment may be made by removing the top from the control box and loosening the Allen-bolt on the straight gear ram~~. ~~Move the ram up or down to get the zero adjusted, then tighten the Allen-bolt.~~

~~The adjustment for the high and low valves to open on 3 mm, 6.3 mm or any other designated tolerance is accomplished in the following manner.Fill the tanks with premixed red dye and green dye.Set the dial to read the designated high tolerance.Loosen the two Allen-bolts at the lower front face of the dial marker high side.~~

~~Turn on the electric switch at the side of the control box (on is up), and raise or lower the slide held by the Allen-bolts until the solenoid valve opens. Then secure by tightening the Allen-bolts.Repeat the above procedures for the low side.~~

3. OPERATION

3.1 Preparation

Obtain a bridge deck floor plan from the project plans and place this plan sheet on a hard surface. Cover the deck floor plan with graph paper. Align the graph paper so that the lines are parallel to the centerline of the deck. Draw a centerline and parallel lines, set to scale at 2 ft.~~0.6 m~~ intervals, the length of the deck.

As an alternate method, the bridge floor plan may be printed on graph paper with one set of lines parallel to the centerline or a sketch may be drawn on graph paper.

If the bridge includes a horizontal curve, mark locations on the scale drawing that are 25 feet~~7.6 m~~ to 50 feet~~15.2 m~~, apart along the centerline. Lay off lines at these locations, perpendicular to the centerline. Mark locations that represent 2 ft.~~0.6 m~~ intervals along these lines. Connect these locations to produce lines parallel to the centerline.

3.2 Procedure

~~3.2.1~~ Mark the centerline of the bridge with suitable~~with a suitable~~ chalk. If stations are available on the bridge, draw a transverse perpendicular line every 25 feet~~7.6 m~~ to 50 feet.~~15.2 m~~. Continue to mark off longitudinal lines parallel to the centerline at 2 ft.~~0.6 m~~ centers. Transfer the location of the transverse perpendicular lines to the bridge deck plans or overlay.

~~3.2.2~~ Pull the rolling straight edge down the bridge centerline with the center wheel running over the chalk line. When the pass is completed, move the straight edge to the next 2 ft.~~0.6 m~~ line and push it back across the bridge. Repeat this operation until all lines have been straight edged. The direction the straight edge is oriented should not be changed.

~~3.2.3~~ Transfer the location of any high or low readings~~dye markings~~ (measure to the nearest 1 inch.~~30 mm~~) from the deck to the overlay paper or other graph paper. Mark red and green (red for high, green for low) lines and tie them together as per the attachment. The lines should be extended and joined approximately 2 ft.~~0.3 m~~ into the next two segments of the bridge deck area. The areas may then be computed by use of a planimeter.

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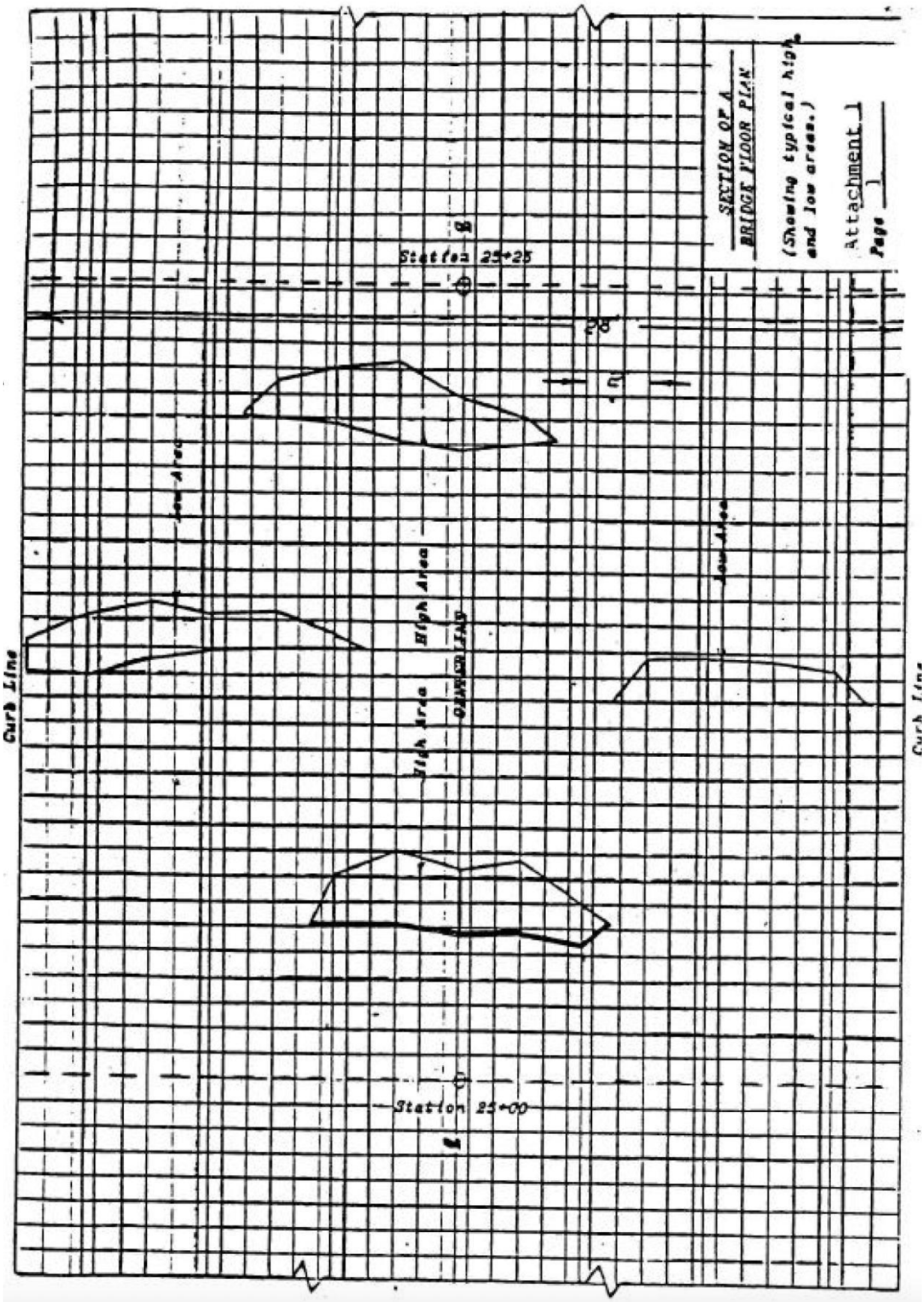
MP 601.11.20 Steward – Pavement Analysis and Evaluation Section
RLS:A
ATTACHMENT


SECTION OF A
BRIDGE FLOOR PLAN
(Showing typical high and low areas.)
Attachment 1
Page 1
Station 25+25
Station 25+00
Curb Line
Curb Line
Low Area
High Area
High Area
Low Area
CROWN

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

SAMPLING COMPACTED ASPHALTIC MIXTURES FROM THE ROADWAY

1. PURPOSE

1.1 This procedure has been written to provide a means for sampling compacted roadway asphalt~~ic~~ mixtures.

2. SCOPE

2.1 This method covers the procedure for sampling of asphaltic paving mixtures taken from the finished pavement for determination of the characteristics of the compacted mixture. ~~Alternative methods of sampling may be found in AASHTO T-230.~~

2.2 Samples obtained using this method will be collected for several reasons including but not limited to the following:

2.2.1 Visual examination.

2.2.2 Measurement for layer thickness.

2.2.3 Determination of bulk specific gravity, air voids, and other volumetric properties.

2.2.4 Determination of bond strength between constructed layers.

3. REFERENCED DOCUMENTS

3.1 *WVDOH Standard Specifications – Current Edition*

a) Section 410: Asphalt and Wearing Courses, Percent Within Limits (PWL)

3.2 *Materials Procedures*

a) MP 401.02.31, Quality Control and Acceptance of Asphalt Mixtures
b) MP 401.07.20, Sampling Loose Asphaltic Mixtures
c) MP 401.07.22, Measurement for Thickness of Asphalt Pavement Using Drilled Cores
d) MP 401.07.23, Interface Bond Shear Strength of Multi-layered Asphalt Pavement Specimens
e) MP 401.13.50, Determination of Percent Within Limits

3.3 *AASHTO Procedures*

a) AASHTO T331, Bulk Specific Gravity and Density of Compacted ~~Hot Mix~~ Asphalt Mixtures~~(HMA)~~ Using Automatic Vacuum Sealing Method

4. EQUIPMENT AND TOOLS

4.1 Powered core drill, water cooled, equipped to core cylindrical samples.

4.2 Diamond drill bit of six (6) inch *inside diameter* size.

4.3 Incidental materials and equipment.

4.4 Hand-held core sample extraction tool capable of grasping and removing a drilled cylindrical pavement core sample from the pavement without damage to the core sample.

Note: Worn drill bits of the same size as those used for coring have been successfully used by cutting slots vertically along the side of the casing to allow for expansion.

4.5 An ice cooler large enough to hold the sample without distortion after it is removed from the pavement.

Note: Large ice coolers (approximately 150 quart) have been used successfully to store and transport multiple pavement cores.

4.6 Small plastic bags for core specimens

4.7 Masking tape

4.8 A marking pencil, paint pen, lumber crayon, or other means suitable for labeling cores.

4.9 Markers for labeling the plastic bags.

5. MAT DENSITY, BOND STRENGTH, AND THICKNESS CORE SAMPLES

5.1 Density acceptance of the asphalt~~ic~~ mixture from the roadway shall be determined on the basis of test results from core samples for each Lot. One sample shall be taken from each Sublot. Samples are to be selected by means of a random sampling plan.

5.1.1 Random numbers used shall be generated from a calculator, software capable of generating random numbers, or from the Random Number Table attached to this MP. All random numbers shall be recorded and maintained in order to verify the means of sample locations.

5.2 At the Pre-Paving Meeting, WVDOH and Contractor personnel shall confer and agree on the sequence and widths of the paving operation in order for a sampling plan to be developed by the Division. The plan shall begin at the intended starting point and progress continuously until the end of the paving operation. Lots for mainline travel lanes should not be extended onto outside shoulders. As paving progresses onto the outside shoulders, new lots shall be established along the shoulders. Ramps, turning lanes, and truck lanes are traveled lanes and shall be considered as mainline pavements.

5.3 All lots shall be calculated and laid out based on converting 2500 tons to square yardage using the project plan lift thickness and a project theoretical yield. The theoretical yield

shall be based on 94% of the design maximum theoretical density from the approved JMF (Form T400) for asphaltic mixture designs. The lots shall be laid out using the full width of placement for each pull. However, no samples shall be taken from the inside shoulder adjacent to the median (generally four feet in width), or the outside 12 inches (one foot) of the unsupported or supported edge of a paving mat. The remaining dimension of width shall be considered testable and used to determine the random location of each sample. Partial lots shall be laid out and either considered separate lots or combined with the previous lots as per Table 410.7.1 of the WVDOH Standard Specifications.

5.3.1 Sample locations determined using random numbers shall be rounded to the nearest 1ft for both length and offset. If it is determined that the offset is zero or the maximum dimension in the testable width, the samples should be taken within either the first or last one foot respectively of material at each side of the testable width. Additionally, samples determined to fall at the same location as a sample removed from an underlying paving lift should be recalculated using a new random number for either width or length.

NOTE: *It is likely that some lots will be laid out in the field beginning with a mat that is a different dimension than that where the lot ends. Such would be the case for a lot that starts within a mat being pulled along the median where the fast lane and inside shoulder are being pulled simultaneously (approximately 16'), but ends along the outside or slow lane (approximately 12') on the other side of the median. In such a case, it will be necessary to calculate the area on the side of the median where the lot is started, then use the remaining area for the lot to determine the length of the remaining portion of the lot on the other side of the median.*

5.4 Refer to the Illustrative Example included in this MP for examples of how to select samples using a random sampling plan for pavement courses. Density acceptance samples and bond strength samples should be cross-referenced to a corresponding mixture acceptance sample as per MP 401.07.20.

5.4.1 For purposes of identification, the sampling ID shall be consistent for projects. Along with the pertinent project identification data (as indicated in Section 410 of the Standard Specifications) that is needed for processing test results, it will be necessary to discern all samples on the project by lot, sublot, and type of sample. For mat density and bond strength samples obtained from the mat, and for joint density samples obtained from the longitudinal joint, they should follow the convention shown below. Please note that mat density and bond strength samples shall also be measured for thickness.

Layer/Lot Designation	Lot #	Sub Lot #	Type of Sample	Example Sample ID
B – Base I – Intermediate S – Surface/Wearing J – Joint Density Core	2	5	M – Mat B – Bond Core D – Density Core	B2-5M J2-5

5.5 Samples for mat density shall be used to determine the percent compaction of the finished mat by first determining the bulk specific gravity of each specimen as per AASHTO T331,

and then by dividing by the corresponding daily theoretical maximum density of the paving mixture.

6. LONGITUDINAL JOINT DENSITY CORE SAMPLES

6.1 Samples shall be taken on the basis of a random sampling plan established for each lot. Lots shall be established as specified in Standard Specifications 410.7 - Acceptance Testing and will consist of 10,000' of constructed longitudinal joint. Each lot will be further divided into sublots consisting of 2,000'. Partial lots shall be addressed as described within Section 410.7 of the Standard Specifications. Lots along constructed joints between travel lanes shall not extend onto the constructed joint adjacent to the outside shoulders. New lots shall begin with the constructed joint adjacent to the outside shoulders.

6.2 One sample shall be taken from each sublot. Refer to Figure 3 for an example of how to select samples using a random sampling plan.

6.3 A core sample taken from a longitudinal vertical joint shall be centered on the line where the joint between the two adjacent lifts abut at the surface as illustrated in Figure 1 below. The center of all vertical joint cores shall be within one (1) inch of this joint line.

6.4 When the two lanes forming the longitudinal joint have daily theoretical maximum specific gravity values differing by more than 0.050, particular attention should be paid to these core locations. Examine each longitudinal joint core sample to ensure that approximately one-half of the longitudinal joint core sample is from each lane. If the materials in the longitudinal joint core are unbalanced, take a replacement sample at a location within twelve (12) inches longitudinally of the original sample location and adjust the location of the core drill relative to the joint line to ensure approximately equal material on each side of the joint will be obtained in the core sample.

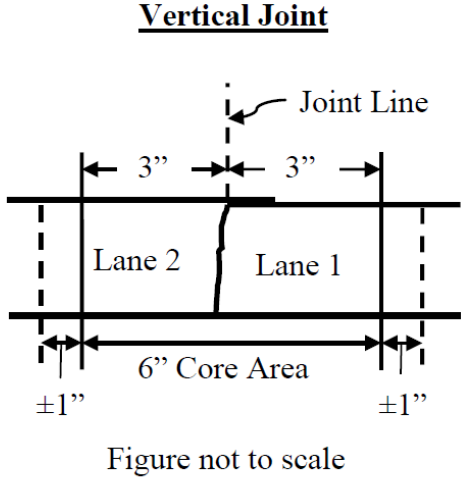


Figure 1 – Cross-sectional View, Position of Core Along Longitudinal Joint

6.5 Samples for joint density shall be used to determine the percent compaction of the finished mat by first determining the bulk specific gravity of each specimen as per AASHTO T331,

and then by dividing by the corresponding daily theoretical maximum densities of the paving mixture.

7. GENERAL CORING AND SAMPLING PROCEDURE

7.1 In the presence of the Engineer's representative, the contractor shall core and identify the density acceptance samples as specified in Section 410.7 of the Standard Specifications.

7.2 Efforts should be taken to cool the pavement with ice or other suitable means prior to coring. Using the powered core drill, drill core samples to the specified diameter (6.0 ±0.125 inches) and to a depth sufficiently below the depth of the pavement course to be sampled. Ensure sufficient water is dispersed through the core bit during drilling to keep the drill bit and core sample cool enough in order to allow cutting through the pavement without damaging the sample and the core bit. Carefully and slowly lower the drill bit to the surface of the pavement course at the start of drilling to prevent the drill bit from moving and to obtain a smooth clean initial drill cut at the surface of the core sample. After drilling to a sufficient depth, carefully raise the core drill bit to prevent any damage to the core sample.

7.2.1 Additional care should be taken when laying out and drilling samples for bond strength testing. Prior to drilling the sample, mark the pavement within the area to be cored using a lumber crayon or other suitable means to indicate the direction of traffic. Efforts shall~~need to~~ be taken to ensure ~~that~~ the core location has cooled sufficiently, and the drill bit is plumb so the~~that a~~ sample is not skewed after removal. Skewed samples will likely not be suitable for testing in the shear testing apparatus. Drilling depth shall be such that the core is cut completely through the material immediately underlying the surface lift to prevent the core from pulling apart at the bonded surface during the removal process.

7.3 Carefully dislodge or break the core sample away from the underlying pavement layer. Do not distort, bend, crack, damage or physically change the physical condition of the core sample during this operation.

7.4 Using a hand-held core sample extraction tool, carefully grasp and remove the core sample from the pavement. Do not distort, bend, crack, damage or physically change the physical condition of the core sample during removal from the pavement.

7.5 Immediately after removing the core sample from the pavement, wash off the core sample with water to remove the fine material generated from the drilling operation. Air dry or towel dry the core sample sufficiently to allow identification of the Lot and sublot number on each core sample by using a paint pen, or other suitable means.

7.6 If a core sample includes materials other than the material or pavement course to be tested, clearly show and mark with a paint pen the section(s) of each core sample to be discarded. Core samples suspected of including more than one material and not clearly showing the section to test, and the section(s) to discard, will be considered non-conforming samples and will not be tested until the section to test is identified.

7.7 Once the core sample has been obtained and identified, the Division will take immediate possession of the core sample and store it in a proper environment. Overheating or impact can damage core samples and prevent accurate test results.

7.8 Samples should be placed in separate small plastic bags and stored out of direct sunlight and/or placed in a cooler with enough ice to prevent them from warming up. The sample bags can be marked ahead of time to further help identify individual samples once transported to the lab. Core samples should then be laid in the cooler with the top surface (flat) down on the bottom of the cooler to prevent movement.

7.9 During the same work shift for placement of the sampled asphalt concrete mix, each core hole location ~~should~~ shall be backfilled with compacted mixture of the same material being used for paving, or other preapproved method. Efforts ~~should~~ shall be taken to clean the hole of loose debris and any standing water shall~~should~~ be removed. If asphalt mixture is used for backfilling, the material shall be placed in lifts, as necessary, and substantial compactive effort shall be applied to each lift using a device comprised of a suitable handle with an attached tamping foot of a size slightly smaller than the core hole. Fuel or solvent based release agents are strictly prohibited during this process. Each core location shall be sealed with an approved crack/joint sealant prior to contract completion.

7.10 After the Lot is completed or has been terminated, or at the end of each day~~s~~ of placement, the Division personnel will transport the core samples from each day~~'s~~ of production to the District Materials Laboratory or Materials Control, Soils & Testing Division for additional processing and evaluation.

Illustrative Example – Project and Lot Layout

An exactly four-mile-long project is to commence paving within the next couple of weeks along an interstate roadway. The division has contacted the contractor to determine the paving sequence and widths and has confirmed that the approved JMF maximum theoretical density is 2501 kg/m3. For theoretical yield on the project, 94% of 2501 kg/m3 is 2351 kg/m3. Dividing by 1000 and then multiplying by 62.4 PCF, the corresponding density in English units is 146.7 PCF. Using this value, and selecting the proper conversion factor from Table 1 below, the corresponding application rate per square yard at 1.5 inches thick is determined as follows:

Table 1 - Conversion of Design Bulk Density to In-Situ Application Rate

Project Design Thickness (inches)	Conversion for Application Rate (psy)
1.00	0.750
1.25	0.938
1.50	1.125
1.75	1.313
2.00	1.500
2.25	1.688
2.50	1.875
2.75	2.063
3.00	2.250

(Use English units) 146.7 pcf x 1.125 cf/SY = 165 psy *(nearest pound)*

The corresponding lot area for placement of the material in square yards is then calculated as follows:

(2500 tons x 2000 pounds per ton)/165 psy = 30,303 sy *(nearest sy)*

Work will begin on the inside fast lane next to the median. The first pull will be 16’ wide. The length of the lot, length per sublot, and total area per sublot is calculated as follows:

30,303 SY x 9 = 272,727 sf

272,727 sf/16 = 17,045’ Total lot length *(nearest linear foot)*

17,045/5 = 3409’ length per sublot

30,303/5 = 6,061 sy per sublot *(nearest sy)*

These values will be used to lay out the station for the beginning of each sublot, and to keep track of the breakdown of a sublot that begins on one side of median and then continues on the other side in an opposite direction. The area for each sublot is used when the situation above occurs and there is a change within the sublot to a pull of a different width.

The beginning and ending stations for each lot and sublot shall then be calculated and plotted in continuous fashion. Figure 2 shows a clean project layout using the widths for each pull, beginning and ending stations and how each lot/sublot progress for a complete project. Daily stops can also be approximated and then actual stops shown on a diagram to help keep track of the entire project. Partial mat and joint lots were addressed along the main travel lanes and new lots were started along the shoulder.

Project Layout By Area - With Estimated Daily Paving Stops

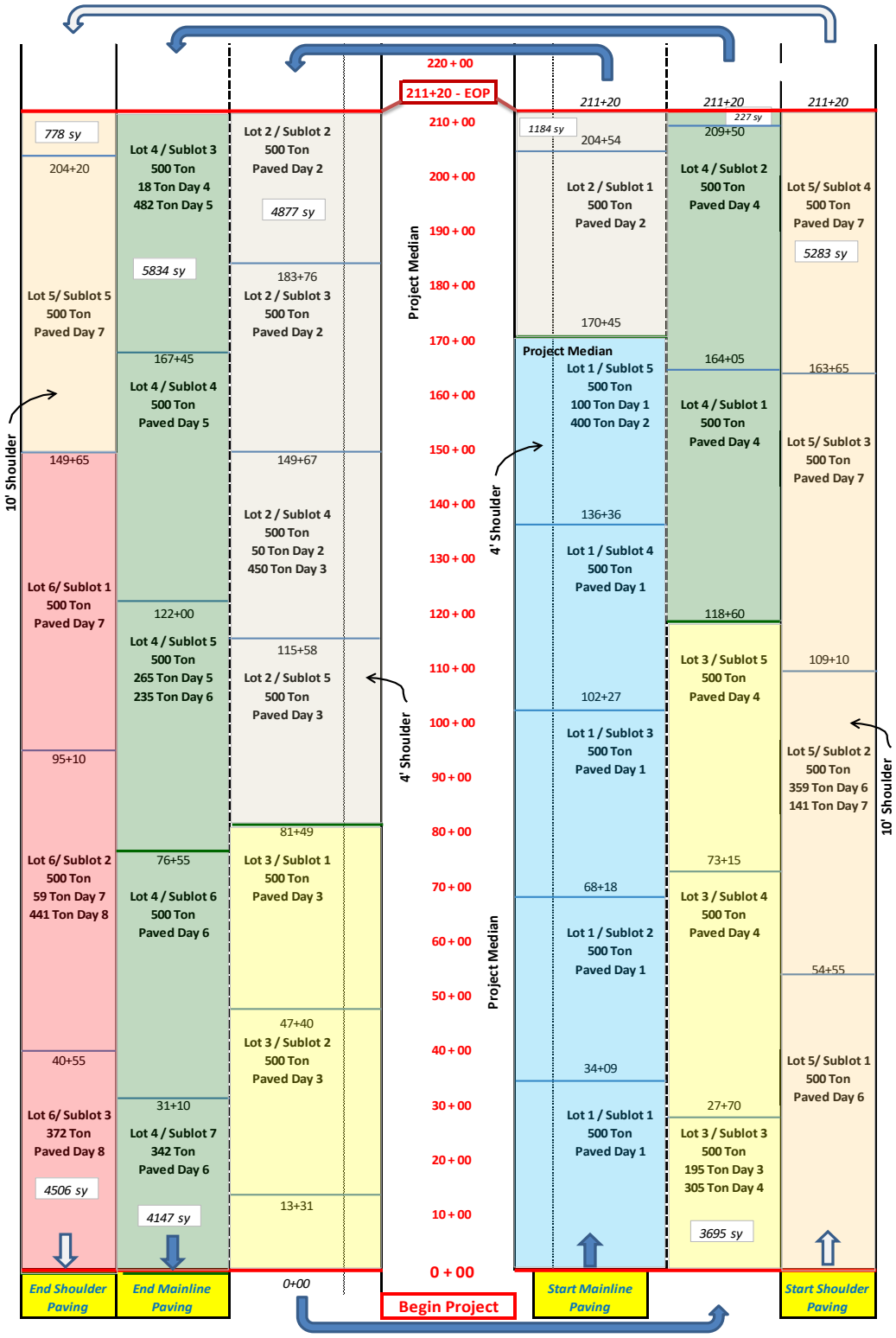


Figure 2

Using Lot 1 from Figure 2, the random sample locations are determined as shown below:

Lot #1-Density Cores

Sublot	Random Numbers		Length	Width
	X (length)	Y (width)		
1	0.632	0.287	0.632 (3409') = 2,155'	0.287 (11') = 3'
2	0.534	0.264	0.534 (3409') = 1,820'	0.264 (11') = 3'
3	0.871	0.159	0.871 (3409') = 2,969'	0.159 (11') = 2'
4	0.753	0.177	0.753 (3409') = 2,567'	0.177 (11') = 2'
5	0.277	0.530	0.277 (3409') = 944'	0.530 (11') = 6'

Lot #1- Bond Strength Cores

Sublot	Random Numbers		Length	Width
	X (length)	Y (width)		
1	0.149	0.155	0.149 (3409') = 508'	0.155 (11') = 2'
2	0.239	0.992	0.239 (3409') = 815'	0.992 (11') = 11'*
3	0.295	0.480	0.295 (3409') = 1,006'	0.480 (11') = 5'
4	0.517	0.473	0.517 (3409') = 1,762'	0.473 (11') = 5'
5	0.805	0.741	0.805 (3409') = 2,744	0.741 (11') = 8'

* *Sample should be taken between 10'-11' offset*

Using the offsets and lengths within each sublot, the stations and offsets for Mat Density and Bond Strength Core samples are determined as shown below.

Lot #1 - Corresponding Sample Stations for Mat Density –

Sublot	Beginning Station	Length	Sample Station
1	0+00	2,155	21+55, 3' offset
2	34+09	1,820'	52+29', 3 offset
3	68+18	2,969'	97+87, 2' offset
4	102+27	2,567'	127+94, 2' offset
5	136+36	944'	145+80, 6' offset

Lot #1 - Corresponding Sample Stations for Bond Strength

Sublot	Beginning Station	Length	Sample Station
1	0+00	508’	5+08, 2’ offset
2	34+09	815’	42+24, 10’ offset
3	68+18	1,006’	78+24, 5’ offset
4	102+27	1,762’	119+89, 5’ offset
5	136+36	2,744’	163+80, 8’ offset

For purposes of illustration, all locations for loose samples, mat density cores, and bond strength cores are shown in Figure 3 below. Refer to MP 401.07.20 for more information on obtaining loose samples of asphaltic mixture for determination of asphalt content and gradation.

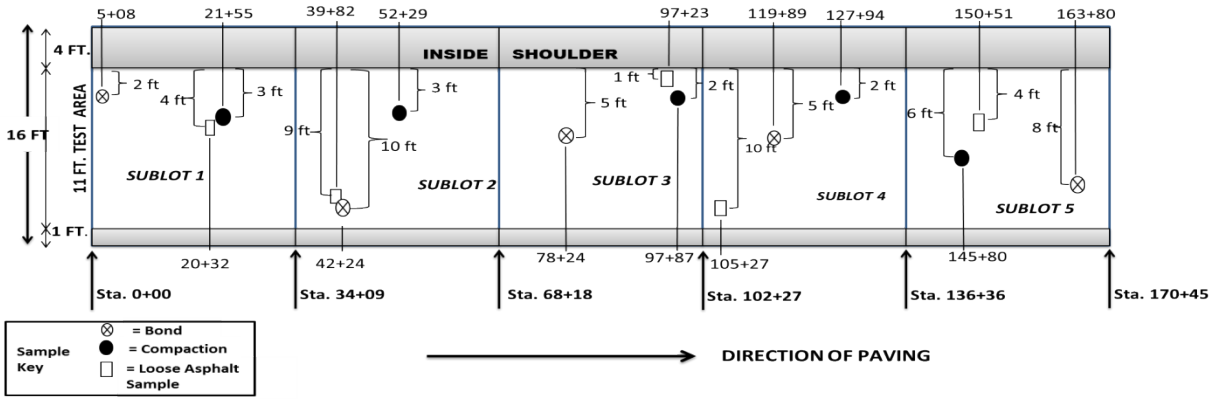


Figure 3

Using the same methodology and following the continuous lots in correspondence to paving sequence, the entire project layout for sampling can be completed as shown in Figure 4. Longitudinal joint lots begin at Station 0+00 between the fast and slow lanes and Joint Lot 1 ends at 10+00. Joint Lot 3 begins at Sta. 20+00 and continues to the other side of the median and extends the amount of the lot remaining.

After Figure 4, a summary is shown to help quantify the daily and total sampling efforts for the project.

Project Layout with Sampling Plan - Density and Bond Cores, Loose Mix Samples

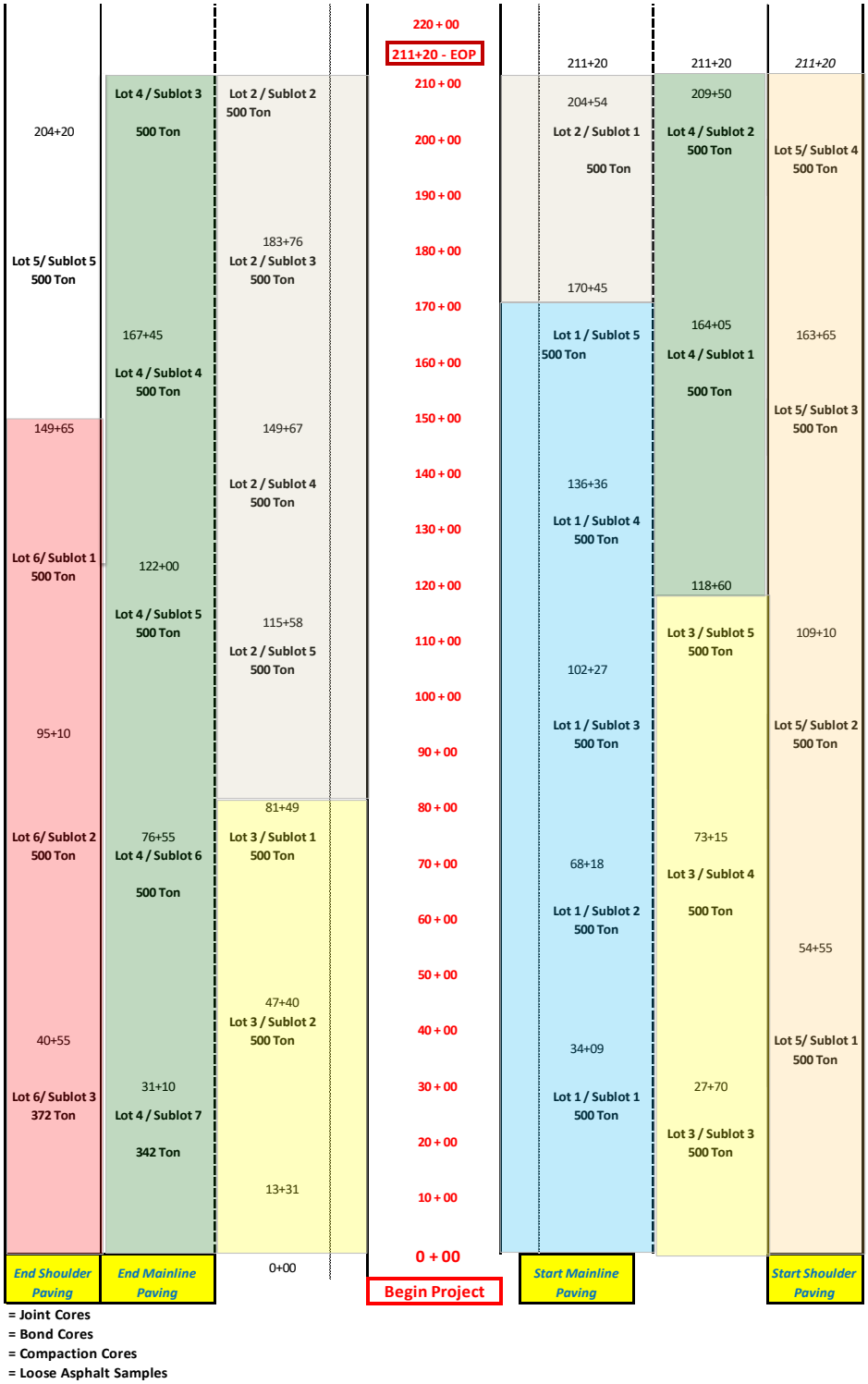


Figure 4

Table 2 – Testing Summaries from Daily and Total Production

	Loose Sample	Density Core *	Bond Core *	Joint Cores
Day 1	4	4	4	0
2100 Ton	4 --> Lot 1	4 --> Lot 1	4 --> Lot 1	
Day 2	4	5	4	0
1950 Ton	1 --> Lot 1	1 --> Lot 1	1 --> Lot 1	
	3 --> Lot 2	4 --> Lot 2	3 --> Lot 2	
Day 3	4	3	5	0
2145 Ton	2 --> Lot 2	1 --> Lot 2	2 --> Lot 2	
	2 --> Lot 3	2 --> Lot 3	3 --> Lot 3	
Day 4	5	5	4	11
2323 Ton	3 --> Lot 3	3 --> Lot 3	2 --> Lot 3	5 --> Lot 1
	2 --> Lot 4	2 --> Lot 4	2 --> Lot 4	5 --> Lot 2
				1 --> Lot 3
Day 5	2	2	3	5
1265 Ton	2 --> Lot 4	2 --> Lot 4	3 --> Lot 4	4 --> Lot 3
				1 --> Lot 4
Day 6	5	4	3	9
1918 Ton	3 --> Lot 4	3 --> Lot 4	2 --> Lot 4	5 --> Lot 4
	2 --> Lot 5	1 --> Lot 5	1 --> Lot 5	4 --> Lot 5
Day 7	3	5	4	13
2200 Ton	1 --> Lot 5	2 --> Lot 5	2 --> Lot 5	1 --> Lot 5
	2 --> Lot 6	3 --> Lot 6	2 --> Lot 6	5 --> Lot 6
				5 --> Lot 7
				2 --> Lot 8
Day 8	3	2	3	4
812 Ton	3 --> Lot 6	2 --> Lot 6	3 --> Lot 6	4 --> Lot 8
		* *Measured for Thickness*		
Totals :	**30**	**30**	**30**	**42**
	6 Lots	**6 Lots**	**6 Lots**	**8 Lots**
	60 Cores Measured for Thickness			

Table 3 - Random Numbers

.858	.082	.886	.125	.263	.176	.551	.711	.355	.698
.576	.417	.242	.316	.960	.819	.444	.323	.331	.179
.687	.288	.835	.636	.596	.174	.866	.685	.066	.170
.068	.391	.739	.002	.159	.423	.629	.631	.979	.399
.140	.324	.215	.358	.663	.193	.215	.667	.627	.595
.574	.601	.623	.855	.339	.486	.065	.627	.458	.137
.966	.529	.757	.308	.025	.836	.200	.055	.510	.656
.608	.910	.944	.281	.539	.371	.217	.882	.324	.284
.215	.355	.645	.460	.719	.057	.237	.146	.135	.903
.761	.883	.771	.388	.928	.654	.815	.570	.539	.600
.869	.222	.115	.447	.658	.989	.921	.924	.560	.447
.562	.036	.302	.673	.911	.512	.972	.576	.838	.014
.481	.791	.454	.731	.770	.500	.980	.183	.385	.012
.599	.966	.356	.183	.797	.503	.180	.657	.077	.165
.464	.747	.299	.530	.675	.646	.385	.109	.780	.699
.675	.654	.221	.777	.172	.738	.324	.669	.079	.587
.279	.707	.372	.486	.340	.680	.928	.397	.337	.564
.338	.917	.942	.985	.838	.805	.278	.898	.906	.939
.316	.935	.403	.629	.130	.575	.195	.887	.142	.488
.011	.283	.762	.988	.102	.068	.902	.850	.569	.977
.683	.441	.572	.486	.732	.721	.275	.023	.088	.402
.493	.155	.530	.125	.841	.171	.794	.850	.797	.367
.059	.502	.963	.055	.128	.655	.043	.293	.792	.739
.996	.729	.370	.139	.306	.858	.183	.464	.457	.863
.240	.972	.495	.696	.350	.642	.188	.135	.470	.765

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WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION
MATERIALS PROCEDURE

GUIDE TO DETERMINING INTERFACE BOND SHEAR STRENGTH OF MULTI-LAYERED ASPHALT PAVEMENT SPECIMENS

1. PURPOSE

1.1 To establish an approved method for determining the interface bond shear strength between layers of asphalt concrete pavement in cored samples taken from the roadway.

2. SCOPE

2.1 This test method covers the determination of the interface bond shear strength between layers of asphalt concrete pavement in cored samples of both Marshall and Superpave mixes.

2.2 This test method is applicable for cores obtained from both newly constructed and previously existing asphalt concrete pavements. It could also be used to determine the interface bond strength between asphalt concrete and Portland cement concrete.

2.3 This test is applicable on six-inch diameter cores that are not less than two inches thick.

3. REFERENCED DOCUMENTS

3.1 *AASHTO Standards:*

~~a) T-168, Standard Practice for Sampling Hot-Mix Asphalt Paving Mixtures~~

~~b)~~a) T245, Standard Method of Test for Resistance to Plastic Flow of Asphalt~~Bituminous~~ Mixtures Using Marshall Apparatus

3.2 ASTM Standards

a) D5581, Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (6 in. Diameter Specimen)

4. APPARATUS

4.1 Bond Test Device – The device used for the bond shear test shall be designed to accommodate six-inch diameter test specimens. The specimen shall have a nominal diameter of 6.0 ± 0.125 inch. The device shall have a cylindrical metal specimen holder (reaction frame) and a movable specimen holder (shearing frame). The reaction frame shall have the capabilities to tightly hold samples slightly smaller than

six-inches. The shearing frame shall move freely through the use of friction reducing bearings. The shearing frame shall have a spherical loading head. The gap between the reaction frame and the shearing frame shall be ¼ inch ± 1/32 inch.

4.2 Loading Machine – The loading machine shall produce a uniform vertical movement of two inches per minute. The Marshall Stability test apparatus or other mechanical or hydraulic testing machine may be used provided the rate of movement is maintained at two inches per minute while the load is being applied.

4.3 Wet masonry saw.

4.4 White or silver paint (See 6.3)

4.5 Infrared temperature gun (capable of measuring to 0.1 °F)

4.6 Supply of MP 401.07.23 data sheets available on the MCS&T Toolbox Webpage[1]

5. ROUNDING OF DATA

5.1 Test data and calculations are rounded to the following nearest significant digit.

Station Number	1ft (not on data sheet)
Diameter	0.05 in
Thickness of Overlay	0.05 in
Thickness of Existing HMA	0.05 in
Max Load Applied	1 lb
Cross Section Area	1 in^2
Bond Shear Strength	1 psi
Average Bond Shear Strength	1 psi
Standard Deviation	0.1 psi
Internal Temperature	0.1 °F

6. PREPARATION OF TEST SPECIMENS

~~6.1 Number of Test Specimens – a single test procedure shall consist of at least three specimens.~~

~~6.2~~6.1 Each roadway core specimen shall be six inches in diameter with the entire surface of the perimeter perpendicular to the top surface of the core within ¼ inch. If the height of the core above or below the interface being tested is greater than three inches, it shall be trimmed with a wet masonry saw to a height of approximately three inches.

~~6.3~~6.2 Identify the location of the interface layer with white or silver paint with three equally spaced marks approximately one inch long around the perimeter of each core.

[1] https://transportation.wv.gov/highways/mcst/Pages/tbox.aspx

7. PROCEDURE

7.1 Specimen dimensions – measure the diameter of the core and the thickness of the overlay and existing HMA layer to the nearest 0.05 inch. Measure the diameter in at least three locations and average the readings. For more details, see MP 401.07.22.

7.2 Specimen conditioning – allow the specimens to stabilize at the test temperature of 75±5°F (24±2°C) in a water bath or oven; this stabilizing process should take a minimum of 120 minutes.

7.3 Specimen positioning – orient the core in the bond strength device so that the direction of traffic marked on the core is vertically pointing downward and the marked interface is centered between the edge of the reaction frame and the edge of the shearing frame.

7.3.1 Align the loading head adjacent to the bonded interface. The loading head shall rest parallel to the bonded interface on the asphalt overlay portion of the specimen. Sample positioning and loading is shown in Figure 1.

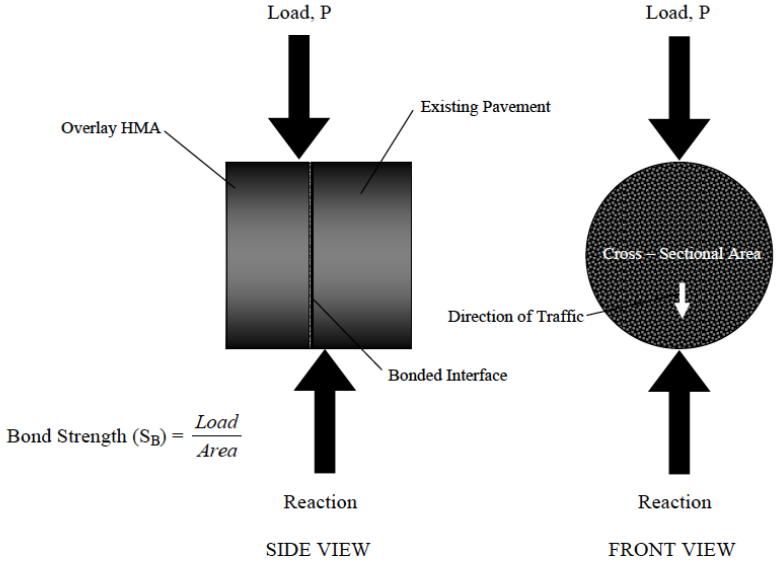

Figure 1. Loading Scheme Used for the Bond Strength Test

Note: Thinner layer of the sample should be placed in the loading side of the frame.

7.4 Rate of displacement - Apply the displacement continuously and without shock at a constant strain rate of two inches per minute until failure occurs. Record the maximum load in pounds, P_{MAX}, carried by the specimen during the test.

7.5 Immediately following the shearing of the sample, measure and record the temperature of the sample at the interface using the infrared temperature gun.

8. CALCULATION

Calculate the bond shear strength, S_B, as follows:

$$S_B = P_{MAX} / A$$

Where:

S_B = bond shear strength, pounds per square inch (psi)
P_{MAX} = maximum load applied to the specimen, pounds-force (lbf)
A = cross sectional area of test specimen, square inches (in^2)

And:

$$A = \pi D^2/4$$

Where:

A = cross-sectional area of test specimen, square inches (in^2)
D = average diameter of test specimen, inches (in)

9. REPORT

9.1 Record each core number or identification, sampling date, and test date.

9.2 Failure surface. Identify if failures occurred at the interface, in the existing layer, or in the overlay of each core. If a failure occurs in the existing layer, below the bond interface, and does not meet the minimum requirement of 100 PSI, the core (sublot) shall be eliminated from the lot PWL calculation. If at least 3 sublots remain after core elimination, the lot shall be calculated using the remaining sample results. The bond PWL calculation shall not be performed if two or fewer sublots remain. An investigation shall be conducted by District Materials to determine the cause of the failures and the results reported to Materials Division.

9.3 Note the appearance of the interface including any contaminants, milling striations, stripping, tack coat streaks, or other observations.

9.4 Record the test results for each core.

9.4.1 Specimen dimensions – including thickness of the overlay asphalt, thickness of the existing layer, the average diameter as specified in Section 7.1, and the cross-sectional area.

9.4.2 Maximum load applied.

9.4.3 Temperature of the sample interface, recorded to the nearest 0.1 °F.

9.4.4 Bond shear strength, rounded to the nearest psi.

9.5 Calculate and record the mean and standard deviation of the bond strength for each lot~~the set~~ of cores.

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WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

NUCLEAR DENSITY TEST BY THE ROLLER PASS METHOD

1. PURPOSE

1.1 The purpose of this procedure is to determine the density of construction materials by the roller pass method. The procedure consists of two parts, with Part I to determine the required maximum density and Part II to compare field densities to the required maximum density.

2. SCOPE

2.1 This test method or method of testing is applicable to aggregate base courses, select material for backfilling, crushed aggregate backfills, granular material, subgrade, and random material having 40% or more of +3/4 inch ~~(+19 mm)~~ material as specified in MP 717.04.21.

3. REFERENCES

3.1 MP 712.21.26

3.2 MP 717.04.21

4. EQUIPMENT

4.1 One complete nuclear density gauge unit meeting the requirements specified in MP 717.04.21. This would include the manufacturer's printout of standard counts.

4.2 One measuring tape, approximately 50 feet ~~(15 m)~~

4.3 Lime, chalk, lumber crayon, or other suitable material to mark test sites

4.4 Dry silica sand

4.5 Supply of data sheets

4.6 One vehicle meeting the safety and security requirements of the Nuclear Regulatory Commission for transporting nuclear density gauges

5. PERSONNEL TRAINING

5.1 All personnel performing the testing must meet the minimum training requirements specified in MP 717.04.21.

5.2 All personnel must know and follow the requirements of the Nuclear Regulatory Commission.

6. ROUNDING OF DATA

6.1 Test values and calculations are to be rounded according to the following procedure:

6.1.1 If the figure following the last significant number to be retained is ~~larger than~~ five or larger, increase the last significant number to be retained by one.

~~6.1.2 If the figure following the last significant number to be retained is five and there are no figures beyond five except zeros, the last significant number to be retained is increased by one if odd or left unchanged if even.~~

~~6.1.3 If the figure following the last significant number to be retained is five and there are figures following the five, the last significant number to be retained is increased by one.~~

~~6.1.4~~6.1.2 If the figure following the last significant number to be retained is less than five, the last significant number is left unchanged.

6.2 Test values and calculations shall be rounded to the following nearest significant digit:

6.2.1 Form T-313 (Ttest Section)

Lift thickness compacted	0.1 in. ~~(10 mm)~~
Depth below grade Length of test section Width of test section Station number	1 ft ~~(0.1 m)~~
Offset	1 ft ~~(1 m)~~
Dry density (DA) Average density (DB) Maximum density (DC)	1 ft ~~(0.1 m)~~
	1 ft ~~(0.1 m)~~
	1 ft ~~(0.1 m)~~
	1 PCF ~~(1 kg/m^3)~~
	1 PCF ~~(1 kg/m^3)~~
	1 PCF ~~(1 kg/m3)~~

6.2.2 Form T-317 (Quality Control Tests)

Station number	1 ft ~~(0.1 m)~~
Offset	1 ft ~~(0.1 m)~~
Depth below grade	1 ft ~~(0.1 m)~~
Lift thickness compacted	0.1 in. ~~(10 mm)~~
Maximum density (DC)	1 PCF ~~(1 kg/m^3)~~
Dry density (DE)	1 PCF ~~(1 kg/m^3)~~
Relative density (DF)	1%
Average DF *(X)*	0.1%
Target (f)	1%
Quality index (QL)	0.01
Within tolerance (DG)	1%
Minimum percent for 100% Pay (DH)	1%

7. PREPARATION FOR TESTING

7.1 Standardization of the Nuclear Gauge

7.1.1 Warm up the gauge according to the manufacturer's recommendations.

7.1.2 Standardization of the gauge must be performed away from metal and other objects.

7.1.3 Clean the top of the standard block and the bottom of the gauge with a cloth.

7.1.4 Standardize according to manufacturer's recommendations.

7.1.5 Compare the standard counts to the manufacturer's standard counts using tolerances acceptable to the Division. For the Troxler 34003~~0~~ series gauge, the standard counts must be within ± 2% for density and ± 4% for moisture from the manufacturer's standards.

7.1.6 If the gauge is not within the specified tolerances for either moisture or density, repeat section 7.1.4 -7.1.5. If the gauge will not standardize for either moisture or density after 4 attempts, ~~there is probably something wrong with the gauge~~a different gauge shall be used. The gauge which failed to standardize may be used again in the future if the procedure referenced in Section 5.2.10 of ~~There may be electronics problems, the gauge needs calibrated or a stability check needs to be performed. Refer to~~ MP 717.04.21 is followed and the gauge is found to be stable. ~~for a more detailed explanation. In any case, do not use a gauge for testing that will not standardize.~~

7.1.7 G~~A g~~auges shall~~must~~ be standardized before testing and at least every four hours during testing.

7.1.8 When a gauge is to be used for testing pipe or structure backfill in a trench, first check the standardization of the gauge according to sections 7.1 - 7.1.5. If the gauge is functioning properly, standardize the gauge in the trench. The standard counts in the trench shall~~would~~ be used for testing in the trench only and the tolerances would not be applied to the standard counts taken in the trench. When the gauge is moved to a non-trench condition for testing, new standard counts shall~~would~~ be required.

8. PART I PROCEDURE FOR DETERMINING THE MAXIMUM DENSITY

8.1 All data and calculations for Part I of this procedure will be recorded on form T-313 (copy attached). Record the Contract ID, project number, lab number etc. before starting the test.

8.2 The test is to be performed at the beginning of placement of an item. However, any problems with the material, placement, or compaction equipment shall be corrected prior to performing the test.

8.3 The test section will be 100 feet ~~(30 m)~~ long by the width being placed in one operation, except in restricted areas.

8.3.1 In restricted areas, where the 100-foot ~~(30 m)~~ length cannot be obtained, check the project's records to determine if a maximum density for the material has been determined on the project. If the material, lift thickness, and compaction equipment remain unchanged, ~~T~~the existing maximum density shall be used for Part II of this procedure, if available. A maximum density determined in a restricted area shall not be used in a non-restricted area. If a maximum density is not available for the material, obtain the~~as~~ largest ~~a~~ test section ~~as~~ possible. For pipe backfill, a lift on both sides of the pipe can be used.

8.4 Divide the test section into 5 equal subsections and number the subsections. Randomly locate a test site within each of the subsections according to MP 712.21.26.

8.5 Water shall be added to untreated aggregates, if necessary, in a quantity satisfactory to the Engineer. The aggregate must visually appear wet ~~in order~~ to properly compact.

8.6 Once the material had been placed in the test section, the material shall be rolled with compaction equipment meeting the following requirements:

8.6.1 All compaction equipment must be in good working condition.

8.6.2 The materials shall be compacted with rollers providing a minimum applied force of 10 tons ~~(9 Mg)~~.

8.6.3 In restricted areas, inaccessible to conventional rollers, the compaction equipment must be satisfactory to the Engineer to provide the desired compactive effort. The Division may request verification that the above compaction equipment meets the specified requirements.

8.7 The test section shall be rolled with 12 roller passes. A roller pass is one complete coverage over the material. In restricted areas, where conventional rollers cannot be used, the material shall be compacted until it appears well densified or to the satisfaction of the Engineer.

8.8 If the material shears or breaks down during rolling, the number of roller passes may need to be reduced. The designated number of roller passes must not be changed without the approval of the Engineer.

8.9 Once the material has been rolled, testing will be performed on test sites ~~numbers~~ 1 and 2.

8.10 Smooth and level the test site. ~~and~~ F~~f~~ill any voids with fines scraped from the surface, but no more than 1/8 inch ~~(3 mm)~~.

8.10.1 Place the guide plate on the test site. Next place the drive rod in the guide plate and while standing on the plate, drive the rod at least two inches ~~(50 mm)~~ deeper than the location where the end of the gauge source rod will be when testing. The gauge source rod can be extended in two-inch (50 mm) increments. The source rod must be as deep as possible within the lift but must not extend beyond the lift. For example, a five-inch ~~(125 mm)~~ lift would be tested with the source rod in the four-inch ~~(100 mm)~~ position and the hole would be six ~~(150 mm)~~ inches deep. Carefully remove the drive rod to prevent material from falling into the hole.

8.10.2 Place the gauge over the test site and insert the source rod to the desired depth. Pull the gauge tight against the side of the hole toward the scaler. Make sure the gauge is sitting flush on the material. Mark the outline of the gauge with lime or other suitable material so the test sites can be relocated.

8.10.3 Take a one-minute density reading.

8.10.3.1 Record the dry density (DA) in Section A of form T-313. Perform the same testing on site 2.

8.11 Average the two dry densities (DA) obtained in 8.10.3.1.

8.12 Roll the material in the test section two additional roller passes. In restricted areas, the compaction equipment would pass over the material the above indicated number of passes.

8.13 After the material has been rolled the additional number of passes, perform tests again on sites 1 and 2 according to 8.10 through 8.10.3 and record the values in section B.

8.14 Average the two densities according to 8.11.

8.15 Compare the value in 8.14 to the value obtained in 8.11. If the increase in density is 1 PCF ~~lb/ft^3 (16 kg/m^3)~~ or less, the material is considered to have achieved its maximum density. If the increase in density is greater than 1 PCF ~~lb/ft^3 (16 kg/m)~~, roll the material two additional passes according to 8.12 and repeat the testing on sites 1 and 2. Continue the rolling and testing sequence until the increase in density between two consecutive rolling sequences is 1 PCF ~~lb/ft3 (16 kg/m^3)~~ or less. The Division may direct~~request~~ the contractor to cease rolling even though the increase is more than 1 PCF ~~lb/ft3 (16 kg/m^3)~~ if the material is breaking down.

8.16 Once the increase in density is 1 PCF ~~lb/ft3 (16 kg/m^3)~~ or less, move the last two density readings to the maximum density determination section on form T-313. T~~hen t~~ake density measurements on sites 3, 4, and 5.

8.17 The average of the five density readings is the maximum density (DC) for thi~~s~~e material.

8.17.1 The maximum density will be used to control the material for Part II of this procedure.

8.17.2 Division personnel may request that Part I be repeated if the test was not performed properly or the maximum density obtained does not appear to be realistic.

9. PART II QUALITY CONTROL TESTING

9.1 All test data and calculations for Part II of this procedure will be recorded on form T-317 (copy attached). Record the Contract ID, project number, item number, etc. on the form before starting the testing.

9.2 The lot number would have a prefix letter based on the following designations for the use of the material being tested:

Embankment :	F
Subgrade:	S
Base:	B
Pipe/Structure Backfill:	p

9.3 Transfer the maximum density (DC) and the lab number from form T-313 to form T-317. Record the lab number in the section for reference lab number.

9.4 Randomly locate the test site according to MP 712.21.26.

9.5 Determine the dry density (DE) with the nuclear gauge according to the procedure described in sections 8.10 through 8.10.3. The test sites do not have to be marked on the roadway.

9.6 Calculate the percent relative density (DF) by using the equation on form T-317.

9.7 Perform the remaining four tests in the lot. Five tests are always required to evaluate a lot.

9.8 Calculate the average relative density (*X*) for the five tests in the lot.

9.9 Obtain the target percentage of dry density (T) from the project's governing specifications.

9.10 Determine the range (R) of the relative densities (DF) by subtracting the smallest value from the largest.

9.11 Calculate the quality index (QL) by using the equation on form T-317.

9.12 Use the Table for Estimating the Percent of a Lot Within Tolerance (copy attached) and determine the percent within tolerance (DG) that corresponds to the QL value calculated in 9.11 above.

9.13 Obtain the minimum percent for 100% pay (DH) from the project's governing specifications.

9.14 ~~In order f~~For a lot to meet specifications, the percent within tolerance (DG) must be equal to or greater than the minimum percent for 100% pay (DH).

10. GENERAL

10.1 Independent tests for similarity checks can be recorded on form T-317. Use only the applicable sections of the form.

10.2 If the material changes or the material is supplied from a new source, repeat Part I to obtain new control data.

10.3 If the percent relative densities are consistently above 105 percent or below 95 percent, and there is no apparent cause for the high or low values, repeat Part I to obtain new control data.

10.4 Test data for several lots can be recorded on form T-317.

Ronald L. Stanevich, PE
Director
Materials Control, Soils & Testing Division

MP 700.00.24 Steward – Asphalt Section
RLS:J

ATTACHMENTS: QL Table
Form T-313
Form T-317

TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE

Quality Index (QL) Positive Values	Percent Within Tolerance
.66	99
.65	98
.62	97
.60	96
.58	95
.57	94
.55	93
.53	92
.51	91
.50	90
.48	89
.46	88
.45	87
.44	86
.42	85
.41	84
.40	83
.38	82
.37	81
.36	80
.34	79
.33	78
.32	77
.30	76
.29	75
.28	74
.27	73
.25	72
.24	71
.23	70
.22	69
.21	68
.19	67
.18	66
.17	65
.16	64
.15	63
.14	62
.13	61
.11	60
.10	59
.09	58
.08	57
.07	56
.06	55
.05	54
.04	53
.02	52
.01	51
.00	50

Quality Index (QL) Negative Values	Percent Within Tolerance
.00	50
.01	49
.02	48
.04	47
.05	46
.06	45
.07	44
.08	43
.09	42
.10	41
.11	40
.13	39
.14	38
.15	37
.16	36
.17	35
.18	34
.19	33
.21	32
.22	31
.23	30
.24	29
.25	28
.27	27
.28	26
.29	25
.30	24
.32	23
.33	22
.34	21
.36	20
.37	19
.38	18
.40	17
.41	16
.42	15
.44	14
.45	13
.46	12
.48	11
.50	10
.51	9
.53	8
.55	7
.57	6
.58	5
.60	4
.62	3
.63	2
.66	1

West Virginia Division of Highways
Materials Control Soil and Testing Division

FORM T-313
MP 700.00.24
REV. 09-22

Lab Number _____
Auth. Number _____
Project Number _____
District Number _____
Item Number _____
Date _____ Contract ID _____

Source of Material:			Length of Test Section:		
Roller Type:			Width of Test Section:		
Roller Weight	Static:	Working:	Gauge Number		
Lift Thickness Compacted:			Manufacturer's Standards		
Depth Below Grade:			Density:	Moisture:	
Depth of Gauge Source:			Standard Counts		
Observed	Yes	No	Density:	Moisture:	

Test Site Number	1	2	3	4	5
Station Number					
Offset					

A	Number of Passes		
	Test Site	DA	Dry Density
	1		
	2		
DB	Average		

B	Number of Passes		
	Test Site	DA	Dry Density
	1		
	2		
DB	Average		

C	Number of Passes		
	Test Site	DA	Dry Density
	1		
	2		
DB	Average		

D	Number of Passes		
	Test Site	DA	Dry Density
	1		
	2		
DB	Average		

DB = ∑ DA / 2

DC = ∑ DA / 5

Maximum Density Determination		
Test Site	DA	Dry Density
1		
2		
3		
4		
5		
DC	Max. Density	

Inspector's Name: _____
Inspector's Signature: _____
Project's Evaluation
Checked By: _____
Date: _____

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS & TESTING DIVISION

LAB NUMBER _____
AUTH NUMBER _____
PROJECT NUMBER _____
DISTRICT _____
ITEM NUMBER _____
CONTRACT ID _____

FORM T-317
MP 700.00.24
REV. 09-22

GAUGE #	DATE						
MANUFACTURER'S DENSITY STANDARD	LOT NUMBER						
	BEGINNING STATION						
	ENDING STATION						
MANUFACTURER'S MOISTURE STANDARD	OFFSET						
	DEPTH BELOW GRADE						
	DEPTH OF GAUGE SOURCE						
	LIFT THICKNESS COMPACTED						
DC FROM TEST SECTION	DENSITY STANDARD						
	MOISTURE STANDARD						

$$DF = \frac{DE\ (100)}{DC}$$

$$\bar{X} = \frac{\sum DF}{5}$$

$$QL = \frac{\bar{X} - T}{R}$$

DC	MAXIMUM DENSITY						
	REFRENCE LAB NUMBER						
TEST NUMBER 1	**DE**	DRY DENSITY					
	DF	% RELATIVE DENSITY					
TEST NUMBER 2	**DE**	DRY DENSITY					
	DF	% RELATIVE DENSITY					
TEST NUMBER 3	**DE**	DRY DENSITY					
	DF	% RELATIVE DENSITY					
TEST NUMBER 4	**DE**	DRY DENSITY					
	DF	% RELATIVE DENSITY					
TEST NUMBER 5	**DE**	DRY DENSITY					
	DF	% RELATIVE DENSITY					
LOT EVALUATION	$\bar{X}$	AVERAGE **DF**					
	T	TARGET	95%	95%	95%	95%	95%
	QL	QUALITY INDEX					
	DG	% WITHIN TOLERANCE					
	DH	MIN. FOR 100% PAY	80%	80%	80%	80%	80%
	DI	PASS / FAIL					

INSPECTOR'S NAME: _____
INSPECTOR'S SIGNATURE: _____

PROJECT'S EVALUATION

CHECKED BY: _____ DATE: _____

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

NON-DESTRUCTIVE THICKNESS DETERMINATION OF PAVEMENTS USING MAGNETIC IMAGING TOMOGRAPHY TECHNOLOGY

1. SCOPE

1.1 Determine thickness of pavements through non-destructive means.

1.2 This procedure is applicable for any items of pavements requiring thickness testing.

2. PURPOSE

2.1 Determine pavement thickness.

3. EQUIPMENT

3.1 MIT Scan T2 scanner, MIT Scan T3 scanner, or equivalent.

3.2 Round metal targets of type and diameter according to Table 1.

Table 1

Pavement Type	Name	Material	Disc Diameter	Disc Thickness	Minimum New Pavement Thickness	Maximum New Pavement Thickness
Asphalt	AL RO 07	Aluminum	7.0 cm (2.75 in)	1.0 mm (0.39 in)	5/8 in	4 ¾ in
	AL RO 12	Aluminum	12 cm (4.72 in)	1.0 mm (0.39 in)	1 5/8 in	7 in
	AL RO 30	Aluminum	30 cm (11.81 in)	0.5 mm (0.20 in)	4 ¾ in	13 ¾ in
Concrete	ST RO 30	Steel	30 cm (11.81 in)	0.65 mm (0.26 in)	4 ¾ in	13 ¾ in

4. PROCEDURES

4.1 Placement

4.1.1 Place discs after milling, sweeping, subgrade/base preparation, or any other procedures prior to paving. Place discs on level, stable base free of rocks or other debris at randomly selected locations according to sampling plans in the appropriate specifications.

4.1.2 For Concrete paving, place reflector discs at least 3 feet from dowel bars, tie bars, steel reinforcement, or other metallic objects. When an Automatic Dowel Bar Inserter is used, place an additional disc 7 feet ahead of the specified disc in order to avoid dowel bars.

4.1.3 If necessary, secure reflector discs to the base. Use an appropriate amount of PK nail(s), typically no more than 4, to ensure the disc remains in place and does not lift, tilt, or bend during paving operations.

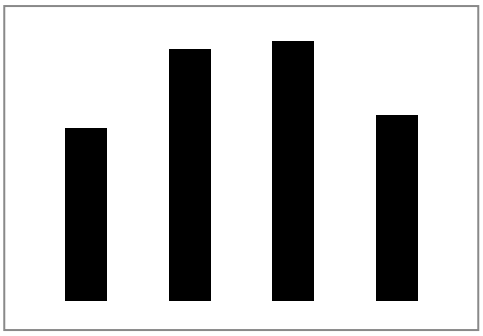
4.2 Measurement

4.2.1 Follow the manufacturer's instructions for operating the scanner.

4.2.2 Select the appropriate reflector type in the scanner settings based on the disc placed at the site during construction.

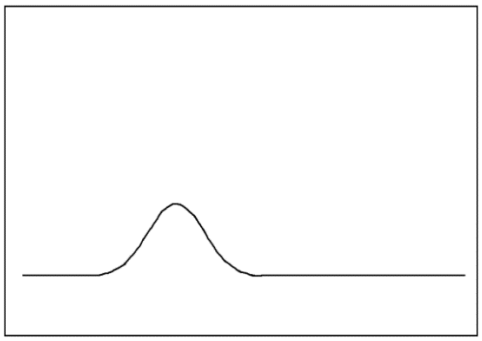
4.2.3 Locate the reflector disc by using the scanner's applicable search function.. When the disc is located, the screen will show an output similar to Figure 1 below.

Figure 1



4.2.4 Place the scanner about 1-2 feet before the location of the edge of the reflector disc and start measurements. At a slow walking pace, roll the sensor unit in a straight line over the location of the disc at a steady rate until the scanner reading is complete. The screen will show an output similar to Figure 2 below.

Figure 2



4.2.5 To avoid incorrect readings, it is important to avoid testing close to any steel, including vehicles, equipment, steel toed shoes, and manhole covers.

4.2.6 Take three readings at each location. The readings should all be within 0 to 2 mm of each other. If the difference between any of the readings is more than 2 mm, take 3 additional readings. If any of the 3 readings are again different by more than 2 mm, the engineer may require drilling a core to determine the thickness.

4.3 Reporting

4.3.1 Data collection can be performed by data transfer from the scanner to a computer, or by using Form 701.10.01. When reporting readings on paper, report numbers as accurate as they are shown on the scanner's screen.

_____
Ronald L. Stanevich, P.E.
Director
Materials Control, Soils and Testing Division

RLS:Fwa