MISSISSIPPI DEPARTMENT OF TRANSPORTATION

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For
ASPHALT MIXTURES

MATERIALS DIVISION

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CHAPTER 1
GENERAL

1.1 Purpose - The purpose of this manual is to establish uniform procedures and practices for quality control and quality assurance sampling and testing of asphalt mixtures. This manual provides instructions and procedures for Contractor and MDOT personnel for the design, control and acceptance of asphalt mixtures under MDOT's Quality Management Program (QMP) as required by the specifications. Sampling procedures, sampling frequencies, and testing to be performed by the Contractor for the quality control of asphalt mixtures at the asphalt plant and by MDOT for the quality assurance and acceptability of these mixtures are detailed. When necessary for clarification, examples are provided. For ready reference, the specifications, standard operating procedures, and example forms for documentation of test results are provided in appendices to this manual.

1.2 Terminology

AASHTO - American Association of State Highway and Transportation Officials

ASTM - American Society of Testing Materials

BRCF - Bulk Specific Gravity (G_{mb}) Reheat Calibration Factor

CAT-I - Certified Asphalt Technician-Level I. Contractor or MDOT personnel who have successfully completed the MDOT Asphalt Technician Certification Program for Level I certification. This certification level is required for performance of sampling and testing of asphalt mixtures and component materials.

CAT-II - Certified Asphalt Technician-Level II. Contractor or MDOT personnel who have successfully completed the MDOT Asphalt Technician Certification Program for Level I and Level II. This certification level is required for Contractor personnel who interpret asphalt test results and make necessary plant adjustments such that the asphalt mixture produced conforms to the job mix formula.

CMDT - Certified Mixture Design Technician. Contractor or MDOT personnel who have successfully completed the MDOT Asphalt Technician Certification Program for the design of asphalt mixtures. This certification level is required for designing or approving the design of asphalt mixtures. All personnel at this level must have first completed requirements and obtained CAT-I and CAT-II certification levels.

MMDT – Master Mixture Design Technician. Contractor and MDOT personnel who have successfully completed the CMDT program and subsequently been recertified. For Professional Engineers, one recertification after 5 years is required, and for non-Professional Engineers, recertification after 5 years and after 10 years is required. Personnel holding the MMDT certification will be required to attend 2 MQAC (Mississippi Quality Asphalt Conference) conferences within a 5 year period.

FHWA - Federal Highway Administration

HMA - Hot Mix Asphalt
HT - High Type Asphalt Mixtures
JMF - Job Mix Formula
MDOT - Mississippi Department of Transportation
MRCF - Maximum Specific Gravity (Gmm) Reheat Correction Factor
MT-## - Mississippi Test Methods (e.g., MT-78)
MT - Medium Type Asphalt Mixtures
NCAT - National Center of Asphalt Technology
QA - Quality Assurance
QC - Quality Control
OGFC – Open Graded Friction Course
QMP - Quality Management Program
RAP - Recycled Asphalt Pavement
SMA – Stone Matrix Asphalt
ST - Standard Type Asphalt Mixtures
SUPERPAVE - Superior Performing Asphalt Pavement
TSR - Tensile Strength Ratio
UHMA – Ultra Thin Hot Mix Asphalt
VFA - Voids Filled With Asphalt
VMA - Voids In Mineral Aggregate
WMA - Warm Mix Asphalt
UWMA – Ultra Thin Warm Mix Asphalt

1.3 Definitions

Coarse Aggregate - Material retained on the No. 4 sieve. Check aggregate specific gravity test procedures for sample requirements.

Fine Aggregate - Material passing the No. 4 sieve. Check aggregate specific gravity test procedures for sample requirements.

JMF - The JMF of a mixture is defined as the combined gradation for the blended aggregate, the percentages of the various mixture components, the design asphalt binder content, and the mixture VMA.

Maximum Density Line - The maximum density line is a straight line plot on the FHWA 0.45 power chart which extends from the zero origin point of the chart through the plotted point of the combined aggregate gradation curve on the nominal maximum sieve size.

Nominal Maximum Sieve Size - The nominal maximum sieve size is one sieve size larger than the first sieve to retain more than 10 percent of the aggregate.

Maximum Sieve Size - Maximum sieve size is the smallest sieve at which 100 percent of the aggregate passes

$N_{Initial}$ - The number of revolutions of the Gyratory Compactor representing the compatibility of the mixture received from the asphalt spreader. The required $N_{Initial}$ revolutions for a particular type mixture are specified in the contract specifications.

N_{Design} - The number of revolutions of the Gyratory Compactor required for design characteristics of the job mix formula. The required N_{Design} revolutions for a particular type mixture are specified in the contract specifications.

$N_{Maximum}$ - The number of required revolutions of the Gyratory Compactor representing the density of the pavement layer at the end of design life. The required $N_{Maximum}$ revolutions for a particular type mixture are specified in the contract specifications.

1.4 Referenced Documents

AASHTO Standards

AASHTO M 92	Wire Cloth and Sieves for Testing Purposes
AASHTO M 231	Weighing Devices Used in the Testing of Materials
AASHTO R 18	Establishing and Implementing a Quality System for Construction Materials Testing Laboratories
AASHTO T 2	Sampling of Aggregates
AASHTO T 11	Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
AASHTO T 19	Unit Weight and Voids in Aggregate
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 37	Sieve Analysis of Mineral Filler for Road and Paving Materials
AASHTO T 40	Sampling Bituminous Materials
AASHTO T 84	Specific Gravity and Absorption of Fine Aggregate
AASHTO T 85	Specific Gravity and Absorption of Coarse Aggregate
AASHTO T 88	Particle Size Analysis of Soils
AASHTO T 90	Determining the Plastic Limit and Plasticity Index of Soils
AASHTO T 96	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
AASHTO T 104	Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
AASHTO T 166	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
AASHTO T 209	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
AASHTO T 218	Sampling Hydrated Lime
AASHTO T 269	Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
AASHTO T 275	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
AASHTO T 308	Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

AASHTO Standards (Cont'd.)

AASHTO T 312	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
AASHTO T 315	Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)
AASHTO T 316	Viscosity Determination of Asphalt Binder Using Rotational Viscometer
AASHTO T 331	Bulk Specific Gravity (Gmb) and Density of Compacted Hot Mix Asphalt (HMA) Using Automatic Vacuum Sealing Method

ASTM Standards

ASTM C 604	Test Method for True Specific Gravity of Refractory Materials by Gas-Comparison Pycnometer
ASTM C 1252	Test Method for Uncompacted Void Content of Fine Aggregate (as Influenced by Particle Shape, Surface Texture, and Grading)
ASTM D 3289	Standard Test Method for Density of Semi-Solid and Solid Bituminous Materials (Nickel Crucible Method)
ASTM D 3665	Standard Practice for Random Sampling of Construction Materials
ASTM D 4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 5821	Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D 7227	Standard Practice for Rapid Drying of Compacted Asphalt Specimens Using Vacuum Drying Apparatus

Mississippi Test Methods

MT-6	Nuclear Determination of Bitumen Content of Bituminous Paving Mixtures
MT-16	Nuclear Method for Field In-Place Density Determination
MT-24	Determination of the Specific Gravity of Fine Aggregate Using the Le Chatelier Flask
MT-31	Quantitative Analysis of Hot Bituminous Mixtures
MT-59	Determination of Loss of Coating of HMA (Boiling Water Test)
MT-63	Resistance of Bituminous Paving Mixtures To Stripping (Vacuum Saturation Method)
MT-76	Microwave Method for Determining the Moisture Content of Hot Bituminous Mixtures

Mississippi Test Methods (cont'd)

MT-78	Volumetric Design of Hot Bituminous Paving Mixtures Using The Superpave Gyratory Compactor
MT-80	Volumetric Mix Design Procedure for Stone Matrix Asphalt
MT-81	Preparation and Testing of Stone Matrix Asphalt Mortars
MT-82	Drain down Testing of Stone Matrix Asphalt Mixtures
MT-83	Mix Design of Open Graded Friction Course Hot Mix Asphalt
MT-84	Permeability of Open Graded Friction Course Asphalt Mixtures
MT-85	Abrasion Testing of Open Graded Friction Course Asphalt Mixtures

Standard Operating Procedures

CSD-50-70-54-000 Random Sampling

Forms

TMD-004	Asphalt Paving Inspector's Daily Report
TMD-005	QA Mixture Report
TMD-006	Summary Report of QC Mixture Properties
TMD-008	Summary Report of QC Gradation Properties
TMD-020	HMA Daily Plant Samples Random Numbers
TMD-042	Bituminous Mix Design
	QMP Inspector's Checklist
	Asphalt Roadway Inspection Checklist
	Asphalt Plant Inspection Checklist

CHAPTER 2
PERSONNEL REQUIREMENTS

2.1 General. MDOT's QMP program for asphalt requires the performance of quality control and quality assurance sampling, testing, and design by trained and knowledgeable personnel. Contractor personnel and MDOT personnel directly involved in QC and QA sampling and testing of asphalt mixtures must have successfully completed the MDOT Asphalt Technician Certification Program (*Materials Division Inspection, Testing, and Certification Manual Section 1.3.3*) to obtain certification at the level commensurate with their duties.

2.2 Contractor Quality Control Personnel Requirements.

2.2.1 CAT-I Technician. The Contractor must provide at least one CAT-I Technician full time at each plant site during production and testing of asphalt. Sampling of asphalt and component materials must be conducted by the CAT-I Technician or by plant personnel under the direct observation of the CAT-I Technician. All testing, data analysis and data posting must be performed by the CAT-I Technician or by an assistant under the full time direct supervision of the CAT-I Technician.

2.2.2 CAT-II Technician. The Contractor must have a CAT-II Technician available to make necessary process adjustments.

2.2.3 CMDT or MMDT Technician. All job mix formulas submitted by the Contractor for approval must be developed by and signed by a CMDT or MMDT Technician.

2.3 MDOT Quality Assurance Personnel Requirements.

2.3.1 CAT-I Technician. All sampling, testing and data analysis for quality assurance must be performed by a MDOT CAT-I Technician or by an assistant under the direct full time supervision of the MDOT CAT-I Technician.

2.3.2 CMDT or MMDT Technician. An MDOT CMDT or MMDT Technician must approve all proposed changes to the Contractor's job mix formula.

CHAPTER 3
QC AND QA LABORATORIES

3.1 General. All laboratories involved in the design, design verification, quality control, and quality assurance testing of asphalt mixtures and component materials must be fully equipped to perform the required tests. All such equipment must meet the requirements of MDOT's specified test methods.

3.2 QC Laboratory. Post an organization chart, including names, telephone numbers and current certification (CAT-I, CAT-II, CMDT and MMDT), of all personnel responsible for the quality control program on the project. Post the chart in a readily visible location.

Post all required quality control charts in a readily visible location, and maintain in an up-to-date status. Charts may be maintained on a computer. However, updated computer charts shall be printed and displayed at a minimum of once each production day.

The laboratory shall be setup and calibrated prior to production. Calibration shall be according to the procedures and frequencies given in AASHTO R 18. Inspect and calibrate the laboratory equipment as follows:

Check calibration of Gyratory compactor according to the requirements in the manufacturer's manual (at a minimum, verify the angle of gyration and the load on the specimen during compaction).

Check balances for accuracy, precision and readability in accordance with AASHTO M 231.

Check the water baths used for specific gravity testing for constant water level, temperature, and make sure the specimen basket does not touch the walls of the tank each time testing is performed. Make sure a non-corrosive metal wire or a non-absorptive cord is used to hang the basket from the bottom of the balance.

Check calibration of maximum specific gravity flask and fine aggregate angularity cylinder.

Check vacuum pumps to confirm that the required pressure is being applied to the flask or pycnometer.

Check accuracy of all thermometers.

Check temperature of ovens and water baths.

Check sieves for conformance to AASHTO M 92. As a daily routine during use, visually check sieves for holes, wear and separated or broken mesh.

Ensure inside diameter of gyratory molds meets tolerances specified in Section 4.2 of AASHTO T 312. Molds found to be outside the tolerance should be discarded.

Maintain a written record of all calibration data in the laboratory files.

3.3 QA Laboratory. Post a chart in the QC Laboratory and in the QA Laboratory giving the names, telephone numbers and current certification (CAT-I, CAT-II, CMDT and MMDT) for all personnel responsible for the quality assurance program on the project(s).

Calibrate all laboratory equipment according to the requirements for the QC laboratory in Section 3.2 of this manual.

At the beginning of production, and randomly thereafter, inspect measuring and testing devices in the QC Laboratory to confirm both calibration and condition. Document all inspections made. Promptly notify the Contractor, both verbally and in writing, of any deficiencies found. Refer any questions on proper equipment or calibration to the Materials Division for resolution.

CHAPTER 4
JOB-MIX FORMULA

4.1 General. The Contractor is responsible for the design of each job mix formula used on the project and for any necessary adjustments during production. A job mix formula may be a new design, or one being transferred from a previous project for which it was developed and under the conditions set out in the specifications. The Contractor shall not place any mixture prior to receiving a "tentative" approval for the job mix formula and a MDOT design number from the Central Laboratory.

MDOT is responsible for the verification of each job mix formula submitted by the Contractor for use on the project.

4.2 Contractor Responsibilities.

4.2.1 Original Design of Job Mix Formula. Design the job mix formula in accordance with the applicable MS Test Method. At least 10 working days prior to the proposed use of each mixture, submit in writing to the Engineer (with a copy to the District Materials Laboratory) the proposed job mix formula signed by a CMDT or MMDT Technician. Prepare samples of the materials representative of the job mix formula for submission to MDOT's Central Laboratory in accordance with the applicable MS Test Method.

4.2.2 Job Mix Formula Transfers. A verified job mix formula may be transferred from one project to another under the following conditions:

If the mixture is currently being produced on the project from which it is being transferred, check the quality control test results and the quality assurance test results to verify consistent performance to the job mix tolerances. If the test results show satisfactory performance, the job mix formula may be transferred. A summary of the results on MDOT Forms TMD-006 and TMD-008 shall be provided along with information on which projects the job mix formula had previously been used.

If the mixture is not currently being produced on an active project or has not been produced within the past six months, run the bulk specific gravity test on each aggregate component. If the specific gravity of each individual aggregate component is within a tolerance of 0.025 from the original job mix formula, the combined bulk specific gravity of the aggregate blend is within a tolerance of 0.015 from the original job mix formula, and the mixture properties meet the design requirements when calculated with the new aggregate specific gravity results, the job mix formula may be transferred.

At least 10 working days prior to the proposed use of each mixture, submit in writing to the Engineer (with a copy to the District Materials Laboratory) a request for transfer of the verified job mix formula signed by the Contractor's CMDT or MMDT Technician. The written request must certify that the source

and characteristics of the materials have not changed since the original job mix formula was issued. Include all required supporting documentation with the request.

Original Job Mix Formulas that have been revised in the field during production as set out below in Subsection 4.2.3 of this manual shall not be transferred to another project. Only the revised JMF will be considered for transfer.

4.2.3 Adjustments To Job Mix Formula. When necessary, minor adjustments may be made to a job mix formula under the conditions set out in Subsection 401.02.5.7 of the contract specifications and as follows:

Each job mix formula proposed and verified from laboratory tests is considered tentative until a sufficient quantity of mixture has been processed through the plant, placed on the roadway, compacted to required density, and tested to determine if any corrections or adjustments are needed.

Determine what adjustments, if any, are necessary from the quality control test results and the quality assurance test results for density, VMA, air voids, asphalt content, aggregate gradation, and other required design characteristics.

Check the specifications to determine the amount of RAP allowed in the mixture is not exceeded. This amount may be a function of mixture type and location in the structure (i.e. top lift).

Check the aggregate blend for the proposed JMF to make sure that the Sand Ratio is less than or equal to 60 percent. Calculate the Sand Ratio by using the following formula:

$$Sand_Ratio = \frac{B - D}{C - D} \times 100 \leq 60\%$$

Where: B = % of JMF passing the No. 30 sieve.
C = % of JMF passing the No. 8 sieve.
D = % of JMF passing the No. 200 sieve.

Example:

Sieve Size	Percent Passing
1/2”	100.0
3/8”	96.5
No. 4	70.1
No. 8	42.4
No. 16	27.2
No. 30	19.8
No. 50	12.4
No. 100	8.3
No. 200	6.3

$$Sand_Ratio = \frac{19.8 - 6.3}{42.4 - 6.3} \times 100 = 37.4$$

For surface course mixtures, check that the combined aggregate blend meets the specification limits for the amount of limestone used in the mixture (maximum of 50 percent of the total aggregate blend).

For 9.5 mm mixtures, and all MT and HT mixtures designed above the maximum density line, check the fine aggregate angularity in accordance with ASTM C 1252, Method A.

Check that the limits on the amount of natural sand in the mixture are not exceeded. In the event adjustments are necessary, the change in aggregate gradation and asphalt content must be within the tolerances specified for the job mix formula (JMF limits) in Subsection 401.02.5.5 of the specifications when compared to the original JMF for the project. Regardless of such tolerances, any adjusted job mix formula gradation must be within the design master range in Subsection 401.02.1.2.3 of the specifications for the mixture specified. The job mix formula asphalt content may only be reduced if the production VMA meets or exceeds the minimum design VMA in Subsection 401.02.3.1.1 of the specifications for the mixture being produced.

When a job mix formula adjustment is necessary, submit a written request to the Engineer (with a copy to the District Materials Laboratory) signed by a CAT-II Technician, setting out what adjustments are needed. Attach sufficient test data to justify the change (current stockpile gradations, production results, aggregate specific gravities, and TSR data if necessary). The request must include the sample test number that indicates when the change is to become effective. The requested change, if approved, may become effective at a test point up to four individual tests prior to the test when the request was formally made. Written documentation in the form of a letter, FAX, or e-mail must exist indicating that the QC/QA team had discussed a possible change for the adjustment to be allowed at a point prior to the test number at the time of the formal request.

Further adjustments after the approval of a JMF change will not be allowed until at

least six additional tests (at normal sampling frequency) have been conducted.

4.2.4 Redesign of Job Mix Formula. A job mix formula must be redesigned when any of the following events occur: (1) a change in sources of material(s) is made, (2) when unsatisfactory results or changed conditions make it necessary (such as segregation, bleeding, shoving, rutting, raveling, cracking, or other pavement distress), or (3) if the viscosity at 275ºF of the asphalt binder shipped changes by 50 percent or more in either direction from that used in the mix design, as evidenced by a comparison of the temperature-viscosity curves.

4.3 MDOT Responsibilities. MDOT is responsible for verification of Contractor's job mix formulas in accordance with the following requirements:

4.3.1 Original Designs.

4.3.1.1 Project Engineer. Check the Contractor's request to insure conformance to the bid items in the contract. If the request does not conform to the mixture type set out in the bid items, reject the request and return to the Contractor by cover letter explaining the reason for rejection. If the Contractor's request is in conformance with the bid items, forward the request to the District Materials Engineer.

4.3.1.2 District Materials Engineer. Check the source for each coarse aggregate component and determine if it is from a MDOT approved source. If not, for each unapproved aggregate component obtain a 45 kg sample from the Contractor's stockpile or cold feed bin in accordance with AASHTO T 2 and submit to the Central Laboratory for soundness and abrasion tests. Verification of the contractor's job mix formula cannot be made until the aggregate sources are approved.

Check the source of asphalt binder for listing on MDOT's Approved List of Suppliers. Asphalt binder from unapproved suppliers cannot be used.

Check the Contractor's proposed job mix formula for accuracy, completeness and conformance to the required design characteristics of the specifications.

If in agreement, submit a written request to the State Materials Engineer for verification of the Contractor's job mix formula. Attach a copy of the Contractor's request, proposed job mix formula, and supporting data. Send a copy of your request with attachments to the Construction Division.

Deliver or have the Contractor deliver the samples required for the applicable MS Test Method to the Central Laboratory.

4.3.1.3 Central Laboratory. Check the Contractor's job mix formula for accuracy and conformance to design characteristics required in the specifications for the required asphalt mixture.

Check to see if each coarse aggregate component is from an approved source. If not,

check for sample(s) from the District Materials Laboratory for source approval. Test the sample(s) in accordance with AASHTO T 19, T 96 and T 104, and determine conformance to Section 703 of the Standard Specifications.

Test Contractor samples submitted with the job mix formula, in accordance with current MDOT policy.

If all test results are found to be in conformance with the specification requirements, issue the verified job-mix formula on Form TMD-042 by cover letter. If the mixture is found not to be in conformance with the specification requirements, reject the job mix formula with an explanation of the reasons for the rejection in writing.

4.3.2 Job Mix Formula Transfers.

4.3.2.1 Project Engineer. Determine if the original job mix formula complies with the bid items in the contract for which the transfer is to be made. If the request does not conform to the mixture type set out in the bid items, reject the request and return to the Contractor by cover letter explaining the reason for rejection. If the Contractor's request is in conformance with the bid items, forward the request to the District Materials Engineer.

4.3.2.2 District Materials Laboratory.

Verification of the Contractor's request for transfer of a job mix formula from one project to another will be based on the Contractor's documentation, and such additional testing and investigation that may be necessary. Verify that the source and characteristics of the materials have not changed since the original job mix formula was issued. Perform any additional testing and investigation that may be necessary for verification.

If it is determined that there has been a change in the source of any component material(s) or there has been a change in any characteristics of the material(s) or mixture, reject the Contractor's request in writing giving the reasons for rejection.

When the investigation confirms that the source and characteristics of materials has not changed, the requested transfer may be made. The District Materials Engineer must submit a written request for the transfer to the State Materials Engineer. This request must certify to the conditions set out in Subsection 4.2.2 of this manual for verification of job mix formula transfers.

4.3.2.3 Central Laboratory. Upon receipt of the District Materials Engineer's request, check all documentation for conformance to specified requirements for verification of job mix formulas as set out in Subsection 4.2.2 of this manual. If the request meets the specified criteria, issue the verified job mix formula on Form TMD-042 and make distribution by cover letter. **NOTE:** All JMF transfers are once again tentative until production and compaction requirements for the new project are met.

4.3.3 Adjustments To Job mix Formula.

4.3.3.1 Project Office and District Materials Laboratory. Upon receipt of the Contractor's request and documentation for adjusting the job mix formula, check to see if sufficient quantity of material has been processed through the plant, placed on the roadway, compacted, and tested in order to determine if adjustments are necessary (minimum of four QC production tests).

From the Contractor's documentation, determine if density, VMA, air voids, asphalt content, and other required design characteristics have been established by quality control test results and quality assurance test results.

Determine if current production values meet the mixture design requirements.

Determine if the requested adjustments to aggregate gradation and/or asphalt binder content are within the specified tolerances. (Note- The asphalt binder content can only be reduced if the production VMA meets or exceeds the minimum design VMA requirements for the mixture being produced.)

If in agreement with the Contractor's request, the District Materials Engineer shall submit a written request to the State Materials Engineer for a revised job mix formula with the Contractor's request and all documentation attached. If not in agreement, reject the request and provide reasons for rejection in writing.

4.3.3.2 Central Laboratory. Review the request, and if warranted by the documentation, issue a revised job mix formula on Form TMD-042. Make distribution of the revised job mix formula by cover letter.

CHAPTER 5
CONTRACTOR'S QUALITY MANAGEMENT PROGRAM

5.1 General. The Contractor is responsible for quality management and maintenance of a quality control system that furnishes reasonable assurance that the mixtures and all component materials incorporated in the work conform to contract requirements. The Contractor is responsible for the initial determination and all subsequent adjustments in proportioning materials used to produce the specified mixture. Adjustments to plant operation, spreading, and compaction procedures must be made immediately by the Contractor when results indicate that they are necessary.

5.2 Sampling.

5.2.1 Aggregate and RAP Stockpiles.

5.2.1.1 Sampling Location. Obtain samples from the stockpiles or cold feed bins in accordance with AASHTO T 2.

5.2.1.2 Sampling and Testing Frequency. Take the first sample of each stockpile after the stockpiles have been established at the plant and prior to the first day of mixture production. Thereafter, sample once every eight production samples with a minimum of one from each stockpile per production week. Stockpile testing of the aggregate and RAP piles during production will be waived provided that gradation tests were conducted during the building of the stockpiles (see Subsection 401.02.5.3 of the contract specifications).

5.2.1.3 Testing. Determine the washed gradation of each aggregate stockpile sample in accordance with AASHTO T 11 and T 27.

Determine the gradation of RAP stockpile samples in accordance with MT-31. Determine the asphalt content of the RAP stockpile, when necessary, by using the same procedures used in the MS Test Procedure for the design of the particular mixture.

For all 9.5 mm mixtures, and all MT and HT mixtures designed above the maximum density line, determine the fine aggregate angularity of the aggregate blend in accordance with ASTM C 1252, Method A. Conduct the tests in an area of the laboratory not subjected to vibration. This test may be conducted off site.

5.2.2 Asphalt Binder Material. Asphalt binder is accepted in accordance with the procedures set out in the *Materials Division Inspection, Testing, and Certification Manual Section 2.1.2.*.

Asphalt binder from the asphalt working tank shall be sampled by the Engineer in accordance with AASHTO T 40 and ASTM D 3665. Samples will be obtained on a random basis at the minimum frequency of one sample per 200,000 gallons. The Contractor shall make available to the Engineer the samples, which shall be placed in a sealed one-quart metal container, for submission to the Central Laboratory for AASHTO T 315 testing.

Immediately upon notification by MDOT that a sample of asphalt binder failed to conform to specification requirements, suspend operations. Notify the supplier and jointly determine the cause of the failure and take appropriate action to correct the problem. When it is determined that the asphalt binder is back in compliance, operations may resume. Any mixture placed containing non-complying asphalt binder will be accepted, removed, or replaced as appropriate in accordance with Subsection 105.03 of the Mississippi Standard Specifications for Road and Bridge Construction.

5.2.3 Asphalt Mixture.

5.2.3.1 Testing Requirements. As a minimum, the Contractor's Quality Management Program (QMP) must include the following:

5.2.3.1.1 Mixture Gradation. Conduct extraction tests for gradation deter-mination on the mixture. Sample according to the frequency set out in Subsection 401.02.5.3(i) of the contract specifications and test in accordance with MT-31. The minimum sample sizes for the mixtures are as follows:

Mixture Type	Minimum Sample Size - gm
25 mm	3,000
19 mm	2,000
12.5 mm	1,500
9.5 mm	1,000

5.2.3.1.2 Air Voids and VMA. Determine air voids and VMA, at N_{Design}, from the average results of two bulk specific gravity tests on laboratory compacted specimens and two maximum specific gravity tests on the mixture. Sample according to the sample frequency set out in Subsection 401.02.5.3(i) of the contract specifications and test according to Sections 5.4 through 5.10 of this manual.

5.2.3.1.3 Asphalt Content. Determine the asphalt content in accordance with MT-6 (nuclear gauge) or by using the incinerator oven in accordance with AASHTO T 308. Sample according to the sampling frequency set out in Subsection 401.02.5.3(i) of the contract specifications.

5.2.3.1.4 Fractured Face Count. Determine fractured face count of aggregates retained on the No. 4 sieve in accordance with ASTM D 5821, at a minimum of one test per day of production. A face will be considered a "fractured face" only if it has a projected area of at least as large as one quarter of the maximum cross-sectional area of the aggregate particle, and the face has sharp and well-defined edges. This area will be visually determined. A piece of aggregate with a small chipped area will not be considered as having a fractured face.

5.2.3.1.5 Stripping Tests. At least one stripping test (TSR) must be performed according to MT-63 at the beginning of each job mix production and thereafter, one test per each two weeks of production. One stripping test (boiling water test) per day of production must be performed in accordance with MT-59.

5.2.3.1.6 Density Tests. Conduct density tests as necessary to control and maintain required compaction according to MT-16, Method C (nuclear gauge), AASHTO T 166, AASHTO T 275, or AASHTO T 331. (**NOTE:** The nuclear gauge may be correlated, at the Contractor's option, with the average of a minimum of four pavement sample densities.)

5.2.3.1.7 Quality Control Charts. Plot the individual test data, the average of the last four tests, the warning limits and the JMF limits for the following characteristics as a minimum.

Mixture Gradation (Percent Passing) Sieves:
1/2-in, 3/8-in, No. 8, No. 30, No. 16 (for 4.75 mm mixtures), and No. 200.
Asphalt Content, Percent - P_b
Maximum Specific Gravity - G_{mm} Air voids @ N_{Design}, Percent - P_a VMA @ N_{Design}, Percent

Keep charts up-to-date and posted in a readily observable location. Note any process changes or adjustments on the Air Voids chart. Charts may be maintained on a computer. However, updated computer charts shall be printed and displayed at a minimum of once each production day.

5.2.3.2 Determining Sampling Increment Size. At the beginning of each day, the Contractor shall specify the anticipated tonnage to be produced. The frequency of sampling is then determined from Section 401.02.5.3(i) of the contract specifications. The anticipated tonnage shall be split into appropriate testing increments and a sample obtained randomly from each increment. Complete MDOT Form TMD-020 for each production day.

EXAMPLE

Anticipated Tonnage For The Day (Estimate) ..... 1800 Tons
Number of Samples Required..... 3
Testing Increment Size (1800 ÷ 3) 600
Increment for Sample 1 ..... From 1 to 600 Tons
Increment for Sample 2 ..... From 601 to 1200 Tons
Increment for Sample 3 ..... From 1201 to 1800 Tons
Increment for Sample 4 ..... From 1801 to 2400 Tons

5.2.3.3 Determining Sample Location. The approximate location of each sample within the increments shall be determined by selecting random numbers according to S.O.P. CSD-50-70-54-000, or from Table 1 of ASTM D 3665 according to the procedures in Sections 5.2 through 5.6. At the start of the first day, select four (4) random numbers from a randomly selected starting point on one of the charts. For subsequent days, select four new random numbers by continuing from the ending number of the previous day in the same direction established when the initial numbers were chosen. Keep a copy of the chart in the project files. The calculations of sampling tonnage are completed for all four random numbers even though the Contractor predicted that only three tests would be required. This is done just in case the Contractor's production exceeds the original prediction. The random numbers selected shall be multiplied by the tonnage increments selected for the day. This number shall then be added to the total tonnage of all previous increments to yield the approximate tonnage when the sample is to be taken.

If this procedure calls for the first sample to be taken at less than 50 tons production, take the first sample at 50 tons production.

EXAMPLE
(Increment Size From Example In Subsection 5.2.3.2)

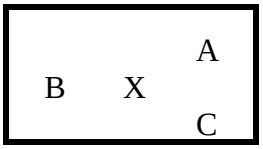
Sample	Tonnage Range	Random Number	Increments x Random No.	+ Total Tons Prev. Increm.	Sample Tonnage
1	1 - 600	0.570	342	+ 0	342
2	601 - 1200	0.351	211	+ 600	811
3	1201 - 1800	0.656	394	+ 1200	1594
4	1801 -	0.200	120	+ 1800	1920

This procedure is to be used for any number of samples per day.

The plant operator shall not be advised ahead of time when any of the samples are to be taken.

5.2.3.4 Mixture Sampling Point. Sample all mixture samples from the truck box. Truck box sampling presents some safety hazards because it may be necessary to climb on top of the truck box and stand on the hot mixture while sampling in order to obtain a representative sample. After the last batch has been dumped into the truck box, establish a reference point on the surface of the load, either at the high point, if some semblance of a conical shape exists, or near the middle of the truck box if the surface shows no such conical shape. Then establish at least three incremental sample points about midway between the previously established point and the sides to the truck and equally spaced around the load (see sketch). At these sampling points, remove the upper 2 to 3 inches of mixture, insert the sampling shovel or other device into the mixture to extract the sample increments and place increments in a sample container.

The total sample shall have a mass of at least 40 kg.



X - Reference Point

A - Sample Point
B - Sample Point
C - Sample Point

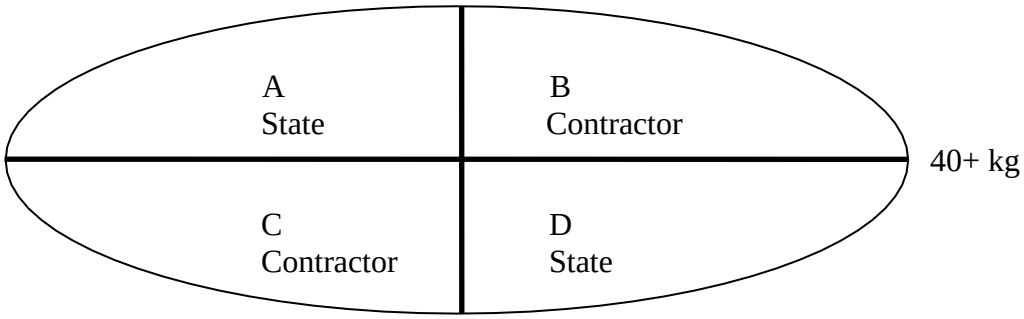
5.2.3.5 Sample Identification. Bag/Box and label the retained portion of all samples. The label shall include:

State or Contractors sample.
Project ID.
Date sample was taken.
Sample No.
Sample tonnage point.
Percent AC being metered into the mixture at time the sample was taken.
Mixture Type Designation being produced.
Pavement layer being placed.
Percent RAP setting at the time sample was taken, when applicable.

5.3 Reduction of Mixture Samples to Testing Size

5.3.1 General. The entire sample shall be mixed and quartered on a clean, smooth, metal surfaced table, with a minimum surface of 48 inches x 48 inches (it is recommended that this table be heated).

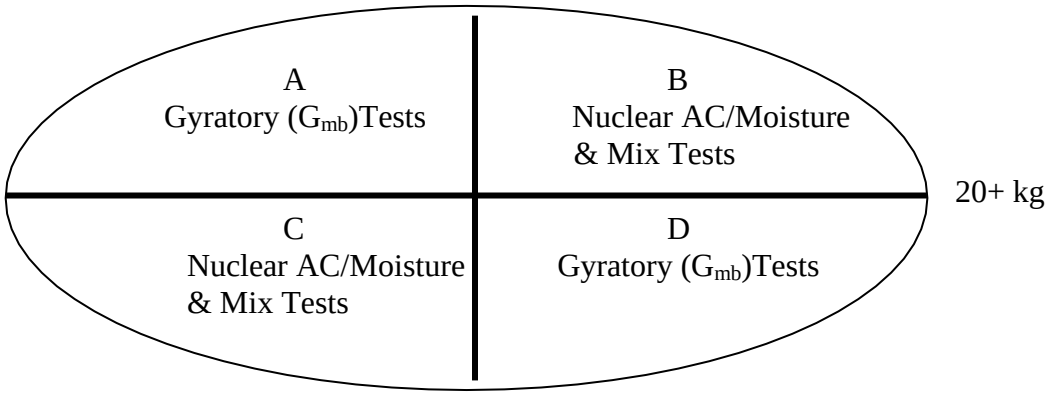
5.3.2 Initial Sample. Quarter the sample into State and Contractor samples. Start with the total minimum 40 kg of mix. Place entire sample on table, quickly mix and quarter to minimize temperature loss. Quarter sample as shown in the following sketch:



Combine diagonal quarters as indicated on the sketch to form the State sample (A & D) and the Contractor sample (B & C) for further quartering. Continue quartering process until test samples are in the oven. Place in a closed container and label the retained sample with the required information in Subsection 5.2.3.5 of this manual. Store samples in a safe place until no longer needed for sample verification.

Retain the State sample (A&D) (minimum of 20+ kg) in a dry and protected location at the laboratory site. Retain these samples until picked up by MDOT for the dispute resolution process (if needed) or 14 calendar days, whichever occurs first. At the completion of the project, the remaining samples may be discarded with the approval of the Engineer.

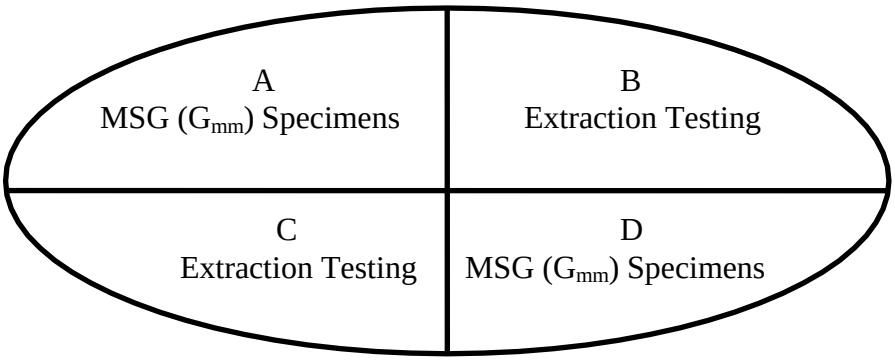
5.3.3 Nuclear AC / Moisture / Gyratory Reduction. Reduce the 20+ kg of mix from Subsection 5.3.2 of this manual into a Gyratory sample and a Nuclear AC / Moisture sample or retained sample according to the following sketch:



Combine quarters B & C and place the unconsolidated material in the oven in a metal container at 10º to 20ºF above AC content gauge calibration temperature. If this sample is going to also be used for the maximum specific gravity test (G_{mm}), age for a period of time as required in Subsection 5.4.2. After oven aging, remove a portion of the combined quarters B&C for moisture test. Prepare a Nuclear AC test pan from remainder. After completion of AC content testing, quarter the sample as recommended in Subsection 5.3.4. For 19 mm and 25 mm mixtures, it will be necessary to save that part of segments B & C not used for the AC content gauge sample for recombining with the AC content gauge sample after the test to provide sufficient sample size for the Maximum Specific Gravity tests.

Carefully reduce quartered A & D independently to the required specimen weight to produce 115 mm high gyratory specimens. Place in separate containers and age in the oven as required in Subsection 5.4.2.

5.3.4 MSG (G_{mm}) / Extraction Reduction. After completion of the Nuclear AC test, remove the mixture from the pan and quarter for further testing according to the following sketch:



For 19 mm and 25 mm mixtures, it will be necessary to save that part of the split in Subsection 5.3.3 not used for the AC content gauge sample for recombining with the AC content gauge sample after the test to provide sufficient sample size for the Maximum Specific Gravity tests. Combine quarters B&C for the extraction test. Careful handling of the materials is required to prevent possible segregation which may have a significant effect on the gradation results. Use quarters A & D independently for the Maximum Specific Gravity samples. Use the appropriate sample size as required in Subsections 5.2.3.1.1 and 5.6.1.1.

5.3.5 Modifications. Modifications to the above quartering process may be made depending on the testing options selected. Make the proposed changes to the process prior to the start of the project and with the approval of the Engineer. In no case will scooping from the bucket or a pile on the table be acceptable.

5.4 Compaction of SHRP Gyratory Specimens

5.4.1 Equipment

5.4.1.1 Compactor. The compactor shall conform to the SHRP Superpave Gyratory Compactor requirements in AASHTO T 312. The compactor shall be located in an indoor controlled temperature environment. The angle of gyration shall be set at 1.25 ± 0.02° using the manufacturer's calibration kit furnished with the compactor. The compactor shall be set to apply a constant vertical load of 600 ± 18 kPa. Set dwell at the appropriate number of gyrations or dwell time (this is typically 5 gyrations for most Troxler compactors, or 5 seconds for most Pine compactors). Other manufacturers are similar, but check with the MDOT Central Laboratory if uncertain.

5.4.2 Procedures. At least 30 minutes to one hour before compacting Gyratory specimens, place two specimen mold assemblies in the aging oven to heat up. The mold assembly consists of the specimen mold and puck.

From the two samples of material obtained as described in Subsection 5.3.3 weigh approximately 4500g (adjust weight to provide a compacted specimen approximately 115 mm (±5 mm) in height) into a metal container, cover and place in a convection aging oven set at 10 to 20 °F above the compaction temperature. The compaction temperature shall be the temperature to which the asphalt binder must be heated to produce a kinematic viscosity of 280 ± 30 mm^2/s. The temperature will be determined from a current temperature-viscosity curve for the particular asphalt binder being used. (**NOTE:** For polymer modified asphalt binder, use the manufacturer's recommended compaction temperature.)

Mixture Aging (to allow for asphalt absorption and control compaction temperature): Heat the two covered containers of mixture for a minimum of 30 minutes not to exceed two (2) hours. These times may be increased for projects with extended storage or haul times.

Place a paper disc in the bottom of the heated specimen mold assembly.

Remove one container of mixture from the oven, pour the mixture into the mold using a funnel with one continuous operation, scrape the container and level the mixture in the mold. Measure temperature of the mixture in the mold. If within the compaction temperature range, place a paper disc on top of the mixture and compact immediately. If too hot, allow sufficient time to cool to the required temperature range. Do not allow the thermometer to touch the mold.

Seat the mold assembly in the compactor and apply the number of gyrations required for N_{Design} according to mixture design requirements in Subsection 401.02.3.2 of the specifications for the mixture being produced.

After compaction is complete, remove the mold assembly from the compactor, remove the paper disc from the top of specimen, cool for 5 to 10 minutes in front of

a fan before extruding the specimen.

After cooling, extrude the specimen by using the hydraulic jack and holder furnished with the compactor.

Smooth rough edges with spatula, place flat side down on a smooth and level surface, properly identify, and cool with a fan to room temperature.

Repeat the above procedure for compaction of one additional specimen.

5.5 Compacted Specimen Bulk Specific Gravity, G_{mb}

5.5.1 One of the following appropriate test methods should be used to determine G_{mb}: AASHTO T 166, AASHTO T 275, or AASHTO T 331. AASHTO T 166 Method A is the preferred method to determine GmbMeasured, and is further explained in Section 5.5.2. If specimen water absorption exceeds 2 percent, then AASHTO T 275 or AASHTO T 331 should be utilized. AASHTO T 331 should be used for all OGFC mixtures. (**NOTE**: The same method to determine $Gmb_{Measured}$ should be used throughout the entire project.)

5.5.2 Weigh the specimens in air, designate this mass as A. Immerse the specimens in 77 ± 2°F water bath for 3 to 5 minutes and then weigh in water, designating this mass as C. Surface dry the specimens by blotting quickly with a damp towel and then weigh in air (include any water that may drain from voids in specimens), designating this mass as B. (**NOTE:** ASTM D 7227 may be used to dry back specimens, if needed). Calculate the G_{mb} to three decimal places using the following formula:

$$Gmb_{Measured}\,(atN_{Design}) = \frac{A}{B - C}$$

Example:

Dry mass of specimen (A) = 4750.0 g SSD mass of specimen (B) = 4768.4 g Mass of specimen in water (C) = 2732.8 g

$$Gmb_{Measured}\,(atN_{Design}) = \frac{4{,}750.0}{4{,}768.4 - 2{,}732.8} = 2.334$$

5.5.3 If the bulk specific gravity $Gmb_{Measured}$ of the two specimens deviates by more than 0.015, the results are considered suspect and a new set of specimens must be made from the remaining QA samples.

5.5.4 Average the $Gmb_{Measured}$ (at N_{Design}) values for the two test specimens and use the results for the computation of air voids and VMA for the sample.

5.5.5 On the first day of production of a mix design, the Engineer may designate one of the retained samples for the Contractor to cool to ambient air temperature overnight, heat in a 230ºF convection oven for two hours, and to quarter for testing. The Contractor shall then compact and test Gyratory specimens in accordance with Sections 5.4 and 5.5 of this manual, and develop a Bulk Specific Gravity Reheat Calibration Factor (BRCF).

Determine the BRCF by the second day of production if the QA tests are being conducted on reheated samples to compare the average G_{mb} of an unreheated compacted sample to the average G_{mb} of a reheated compacted sample. The BRCF will be considered accurate for the entire production of a particular mix design, but may be repeated at the discretion of the Contractor or the Engineer. This factor is only used to correct reheated results to agree with the original results when tests are performed on reheated samples. Calculate the BRCF to four decimal places according to the following formula:

$$BRCF = \frac{G_{mb}(Unreheated)}{G_{mb}(\text{Re}\,heated)}$$

If the comparison of the reheated G_{mb} to the original G_{mb} shows a difference of 0.005 or less, then a BRCF shall not be used.

5.5.6 Determine the corrected G_{mb} for reheated samples according to the following formula:

$$\text{Corrected } G_{mb} = G_{mb} \text{ (Reheated) x BRCF}$$

5.6 Maximum Specific Gravity, G_{mm}

5.6.1 Procedure. Determine two G_{mm} values for the sample according to the procedures of AASHTO T 209 as modified below. Average the two test values for calculations. If the values for the individual tests differ by more than 0.011, conduct additional tests to determine the correct value for G_{mm}.

5.6.1.1 Use the appropriate sample from Subsection 5.3.4 of this manual. The minimum specimen size shall be 2000 grams for 19 mm and 25 mm mixtures and 1500 grams for 9.5 mm and 12.5 mm mixtures.

5.6.1.2 Age the sample under the same conditions as the Gyratory specimens (Subsection 5.4.2).

5.6.1.3 Thoroughly break up the mixture and cool to ambient temperature, using care not to fracture the mineral particles, so that the particles of the fine-aggregate portion are not larger than 1/4-inch in diameter. HMA and WMA mixtures are easiest to break apart after a brief cooling period while the mix is still warm. A portable electric fan may be used to speed the cooling process. Experience has shown that it is best to not cool SMA and OGFC mixes with a fan, but rather stir the mix in ambient temperatures until the mix begins to "clump" then spread the mix into a thin layer and allow to cool. Once cool to touch break the mix up by hand in the same manner as HMA and WMA mixtures.

5.6.1.4 Calibrate metal bowls by weighing under water using the bowl option. The volume of the metal bowls may not be measured using the pycnometer method.

5.6.1.5 Place the entire amount of each sample in appropriate container and weigh to the nearest 0.1 gram. Add water at 77 ± 2 ºF to cover the sample by 1-1/4 to 2 inches. A few drops of a dilute (10%) liquid detergent (such as Joy or equivalent), to act as a wetting agent, may be added to the water to facilitate the release of entrapped air.

5.6.1.6 Remove entrapped air by subjecting the contents of the container to a partial vacuum which will result in 30 mm Hg or less absolute pressure for 15 ± 2 minutes. Check the residual pressure in the container using a gage or closed end manometer with an accuracy of ± 3 mm, attached independently to the container. The container and contents shall be shaken vigorously at intervals of about two (2) minutes in order to assist the removal of air bubbles. A mechanical shaker may be used if test results are available from the Contractor that demonstrate that results approximately equal to hand shaking can be obtained (±0.008). If the mixture is exposed to air after the vacuum is released, the test results are invalid and the vacuum procedure must be conducted again.

5.6.1.7 Volume Determination

5.6.1.7.1 Flask - Fill flask with water taking care to avoid adding air bubbles during this process (causes a low value of G_{mm}). Adjust the temperature of the added water such that the temperature of the water in the flask is 77 ± 2 ºF. Check the temperature of the water in the flask and weigh 10 ± 1 minutes after the completion of the vacuum. Calculate the G_{mm} to three decimal places as follows:

Without Dry Back Correction:

$$G_{mm} = \frac{A}{A + D - E}$$

With Dry Back Correction:

$$G_{mm} = \frac{A}{A1 + D - E}$$

Where: A = Dry Mass of Test Specimen in Grams
A1 = SSD Mass of Test Specimen (Dry Back Mass) in Grams
D = Calibration Mass of Flask Filled with Water in Grams
E = Final Mass of Flask, Test Specimen, and Water in Grams

Example:
A = 2048.4 g
A1 = 2050.4 g
D = 1856.0 g
E = 3051.5 g

Without Dry Back Correction:

$$G_{mm} = \frac{2048.4}{2048.4 + 1856.0 - 3051.5} = 2.402$$

With Dry Back Correction:

$$G_{mm} = \frac{2048.4}{2050.4 + 1856.0 - 3051.5} = 2.396$$

5.6.1.7.2 Bowl - Suspend the bowl and contents in water at 77±2°F taking care to avoid adding air bubbles (causes a low value of G_{mm}). Weigh 10 ± 1 minutes after the completion of the vacuum. For calculations, use the equations in Subsection 5.6.1.7.1 except the "D" mass is the mass of the bowl under water and the "E" mass is the mass of the sample and bowl under water.

5.6.1.8 When the dry back is required, drain water from sample, taking care to prevent loss of any mix. Spread sample in a thin layer in a tared pan before an electric fan to speed evaporation and removal of surface moisture. After the bottom of the pan is visibly dry, weigh at 15 minute intervals, and when the loss in weight is less than 0.5 g for this interval, the sample may be considered to be surface dry. The procedure requires about 2 hours and shall be accompanied by intermittent stirring of the sample. Conglomerations of mixture shall be broken up by hand. Water contained in the voids of a conglomeration cause an error in the test results (G_{mm} low). Care must be taken to prevent loss of particles of mixture. The dry back correction is defined as the G_{mm} calculated without the dry back minus the G_{mm} calculated with the dry back. Average the dry back correction for the two tests for each sample. The dry back correction will always be zero or a positive number.

The above dry back procedure shall be conducted on the first two sets of samples tested. After that, the dry back shall only be conducted on every eighth test. For the

first two samples, the dry back for test 1 shall be used to calculate G_{mm} for test 1.

The calculations for test 2 shall be the average dry back correction from tests 1 and 2. After the first two tests, the dry back correction shall be the average of all previous dry back tests. For subsequent days of production, use the dry back correction available at the start of the day for all tests conducted that day even if a new dry back correction is determined during the day. An example of the dry back correction calculations for a project is given on the attached dry back summary sheet (Figure 1). The correction shall be used as given in the following schedule:

Day 1 Test 1 - Use dry back from test 1.
Test 2 - Use average dry back from tests 1 and 2. Test 3 - Use average dry back from tests 1 and 2. Test 4 - Use average dry back from tests 1 and 2.

Day 2 Test 5 - Use average dry back from tests 1 and 2.
Test 6 - Use average dry back from tests 1 and 2. Test 7 - Use average dry back from tests 1 and 2.

Day 3 Test 8 - Use average dry back from tests 1 and 2.
Test 9 - Use average dry back from tests 1 and 2. Test 10 - Use average dry back from tests 1 and 2.* Test 11 - Use average dry back from tests 1 and 2.*

Day 4 Test 12 - Use average dry back from tests 1, 2, and 10.
Test 13 - Use average dry back from tests 1, 2, and 10.

FIGURE 1
(Example Maximum Specific Gravity Dry Back Correction Calculations)

Maximum Specific Gravity Dry Back Correction Summary Sheet

Date	Test	(X) G_{mm}	(Y) G_{mm} w/Dry Back	(X-Y) Difference	Cum. Difference	No. of Tests	Avg. Difference	Corrected G_{mm}
Day 1	1	2.508	2.505	0.003	0.003	1	0.003	2.505
	2	2.508	2.503	0.005	0.008	2	0.004	2.504
	3	2.518	-	-	-	-	0.004	2.514
	4	2.514	-	-	-	-	0.004	2.510
Day 2	5	2.509	-	-	-	-	0.004	2.505
	6	2.503	-	-	-	-	0.004	2.499
	7	2.502	-	-	-	-	0.004	2.498
Day 3	8	2.515	-	-	-	-	0.004	2.511
	9	2.505	-	-	-	-	0.004	2.501
	10	2.507	2.500	0.007	-	2*	0.004	2.503
	11	2.504	-	-	-	-	0.004	2.500
Day 4	12	2.501	-	-	0.015	3	0.005	2.496
	13	2.498	-	-	-	-	0.005	2.493

5.6.1.9 On the first day of production of a mix design, the Engineer may designate one of the retained samples for the Contractor to cool to ambient air temperature overnight, heat in a 230ºF convection oven for two hours, and quarter for testing. The Contractor shall then determine the maximum specific gravity in accordance with Section 5.6 of this Manual and develop a reheat calibration factor.

Determine the maximum specific gravity Reheat Correction Factor (MRCF) by the second day of production if the QA tests are being conducted on reheated samples to compare the average G_{mm} of an unreheated sample to the average G_{mm} of a reheated sample.

The MRCF will be considered accurate for the entire production of a particular mix design, but may be repeated at the discretion of the Contractor or the Engineer in the field QC laboratory. This factor is only used to correct reheated results to agree with the original results when the tests are performed on reheated samples. If the comparison of the reheated G_{mm} to the original G_{mm} shows a difference of 0.005 or less, then a MRCF shall not be used. It is expected that the MRCF value will be less than 1.000. If the MRCF value is between 1.000 and 1.015, use 1.000. If above 1.015, retest. Calculate the MRCF to three decimal places using the following formula.

$$MRCF = \frac{G_{mm}(Unreheated)}{G_{mm}(\mathrm{Re}\,heated)}$$

5.6.1.10 Determine the corrected G_{mm} for reheated samples using the following formula:

Corrected G_{mm} = G_{mm} (Reheated) x MRCF

5.7 Moisture Damage Testing

5.7.1 Tensile Strength Ratio, TSR. Conduct the TSR tests according to MT-63 on samples of HMA mixture from the plant. Test a minimum of four specimens (2 wet / 2 dry). The TSR specimens shall have a 150 mm diameter and should be approximately 95 mm in height. Divide the specimens into two groups of approximately equal voids in the required void range. The saturation procedure, soaking and strength tests may be conducted in an off-site laboratory. The gyratory machine should be set to provide samples that are 95 mm in height. Use the following procedures to determine the approximate sample weight to provide the desired height. If the Gyratory Correction Factor for Mixture Sample is not determined for the sample obtained for TSR testing, use an approximate value based on recent Gyratory testing. It is recommended that a trial batch be produced to verify the estimated sample weight.

Mixture Data:

Maximum Specific Gravity (G_{mm}) = 2.396

Calculate $Gmb_{Estimated}$ required to produce sample with 7% air voids.

$Gmb_{Estimated}$ (at 7% air voids) = (93 x 2.396) / 100 = 2.228

Calculate the sample mass necessary to produce the 95 mm height for specimens with a diameter of 150 mm.

Sample Mass = 2.228 x 95 x 17.6715 = 3,740 g of mix.

NOTE: 17.6715 is a constant for 150 mm specimens.

5.7.2 Boiling Water Test. Conduct boiling water tests according to MT-59 at least once per day of production. The extent of stripping (coating loss) is determined by visual examination of the sample and estimating the proportion of stripped particles. If the amount of stripped particles exceeds 5 percent, some modification of the mixture is required to reduce the potential for moisture damage (see Subsection 401.02.5.3 of the specifications).

5.8 Calculating Air Voids, P_a

5.8.1 The air void determination is a relationship between maximum specific gravity

(G_{mm}) and the mixture bulk specific gravity [$Gmb_{Measured}$ (at N_{Design})]. Air voids can be calculated for laboratory compacted specimens and sawed (or cored) specimens from compacted pavements.

5.8.2 Mixture air voids for each sample shall be calculated using the average of the two maximum specific gravity (G_{mm}) tests and the average of the two bulk specific gravity [$Gmb_{Measured}$ (at N_{Design})] tests, according to the following formula (calculate to one decimal place):

$$Air_Voids(P_a),\% = \left[\frac{(G_{mm} - G_{mb})}{G_{mm}}\right] \times 100$$

Example:

G_{mm} = 2.396

$Gmb_{Measured}$ (at N_{Design}) = 2.299

$$Air_Voids(P_a),\% = \left[\frac{(2.396 - 2.299)}{2.396}\right] \times 100 = 4.0\%$$

5.9 Calculating Voids In Mineral Aggregate, VMA

5.9.1 The VMA measures the void spaces between the aggregate particles in a compacted paving mixture. The VMA includes the air voids and the effective asphalt content. It is expressed as a percent of the total volume of the mixture.

5.9.2 VMA is calculated using the combined aggregate bulk specific gravity (G_{sb}) for the aggregate blend from the mix design, the asphalt content determined on the sample (P_b), and the average compacted specimen bulk specific gravity of the two specimens at N_{Design} ($Gmb_{Measured}$) according to the following formula (calculate to one decimal point):

$$VMA,\% = 100 - \left[\frac{G_{mb} \times (100 - P_b)}{G_{sb}}\right]$$

Example:

P_b = 5.4%

$Gmb_{Measured}$ (at N_{Design}) = 2.299

G_{sb} = 2.574

$$VMA,\% = 100 - \left[\frac{2.299 \times (100 - 5.4)}{2.574} \right] = 15.5\%$$

5.9.3 When any HMA plant aggregate cold feed bin percentage is changed by five percent or more from the job mix formula, calculate a new combined aggregate bulk specific gravity (G_{sb}) using the following formula:

$$G_{sb} = \frac{100}{\left[\frac{\%Agg.\#1}{G_{sb}Agg.\#1} \right] + \left[\frac{\%Agg.\#2}{G_{sb}Agg.\#2} \right] + etc.}$$

Example:

Aggregate #1		Aggregate #2	
G_{sb}	= 2.692	G_{sb}	=2.524
Percent	= 30	Percent	= 70

$$G_{sb} = \frac{100}{\left[\frac{30}{2.692} \right] + \left[\frac{70}{2.524} \right]} = 2.572$$

5.10 Gradation Of Extracted Aggregate From Mixture

5.10.1 Use appropriate sample from Subsection 5.3.4.

5.10.2 Perform the test in accordance with Mississippi Test Method MT-31.

5.11 Field Adjustment of Job-Mix Formula, JMF. The JMF may be adjusted in the field based on production test results according to the procedures in Subsection 4.2.3.

5.12 Documentation. Document all observations, records of inspections, adjustments to the mixture, and test results on a daily basis.

Maintain a running average calculation for all tests listed in Subsection 5.2.3.1.7. If single tests are performed as a check on individual mixture properties, between regular samples, without performing all tests listed in Subsection 5.2.3.1.7, the results of those individual tests **must not** be included in the running average calculations for that particular property.

Record the results of observations and records of inspection as they occur in a permanent field record.

Record all process adjustments and job mix formula changes on the air void charts.

Provide copies of all test data sheets and the QC test results on a form similar to MDOT Form TMD-005 to the Engineer on a daily basis (before 9:00 AM the day after production). Fourteen days after the completion of the project, provide the Engineer with the original testing records and control charts in a neat and orderly manner.

5.13 JMF Limits, Warning Limits and Warning Bands.

JMF limits are the specified tolerances to the job mix formula beyond which the mixture is unacceptable and subject to removal.

Warning limits are the specified tolerances to the job mix formula beyond which the mixture is unsatisfactory and subject to a price reduction. These limits serve as a warning to make adjustments before unacceptable mixture is produced.

Warning bands are defined as the area between the warning limits and the JMF limits.

The JMF limits and warning limits for the job mix formula are based on a running average of the last four test data points.

The specified JMF limits and warning limits are as given in Subsection 401.02.5.5 of the contract specifications.

5.14 Corrective Action. Document all corrective action and include all test values in the project records, in the running average calculations and on the control charts. Take corrective action according to the procedures required in Subsection 401.02.5.8

of the contract specifications.

5.14.1 Examples of Corrective Action. These examples are based on the following data: ABC Asphalt from Jackson, Mississippi was the successful bidder on a project that required approximately 10,000 tons of a ST 12.5 mm mixture. Assume that all density and aggregate testing met the project requirements. Copies of the Summary Report of QC Mixture Properties (Form TMD-006) and the appropriate QC Charts for each example are provided in Appendix 3. The mixture production records for the project were as follows:

Date	Tons Produced
2/23	1,800
2/24	1,460
2/25	2,000
2/26	1,440
2/27	1,950
2/28	1,450
Total	10,100

5.14.1.1 Example 1. The Contractor's production started out with the air voids slightly low and the asphalt binder content slightly high. The field density results were okay but just meeting the minimum specification. The Contractor was reluctant to change the mixture because of concern for possible field density problems. On 2/25 after test 7, the Contractor notified the MDOT QA person that the air voids were trending towards the warning limit. On 2/26 after test 9, the Contractor notified MDOT that the second running average for air voids exceeded the warning limits and that they planned to reduce the asphalt binder content by 0.2 percent to bring it in line with the design value and as a result, increase air voids. The reduction in asphalt binder content was dialed into the plant and production continued. The Contractor closely monitored the field density with a nuclear gauge and modified the number of roller passes to compensate for the mixture change. The running average for air voids at test 13 (four tests after the change was made) was back inside the warning limits. Based on the specification, the Contractor is paid at a pay factor of 1.0 for all the mix produced to that point.

5.14.1.2 Example 2. The Contractor's production starts out with the air voids slightly low and the asphalt binder content slightly high. The field density results were okay but just meeting the minimum specification. The Contractor was reluctant to change the mixture because of concern for possible field density problems. On 2/25 after test 6, the Contractor notified the MDOT QA person that the air voids were trending towards the warning limit. On 2/25 after test 8, the contractor notified MDOT that the second running average for air voids exceeded the warning limits. Production had already shut down for the day. The next morning prior to production, the Contractor notified MDOT that they planned to make a minor gradation change in an attempt to increase the VMA, which should also increase the air voids. The running average for air voids at test 12 (four tests after the change was made) was still in the warning bands. Production continued this way until 2/28 when the Contractor finally adjusted the asphalt binder content. Based on the specifications,

the Contractor will receive reduced pay for unsatisfactory mixture from the plant tonnage at the stop point (second running average of four exceeds the warning limits) to the tonnage when the running average is back within the warning limits. For this project, the mixture subject to reduced payment includes 410 tons produced on 2/25 (stop point - 1,590 tons until the end of the day - 2,000 tons) all the tons produced on 2/26 and 2/27 and 349 tons produced on 2/28. The total quantity of mixture subject to reduced payment is 4,149 tons. The payment factor of 0.70 is determined according to the table in Subsection 401.02.6.3 of the contract specifications.

5.14.1.3 Example 3. The Contractor's production starts out with the air voids slightly low and the asphalt binder content slightly high. The field density results were okay but just meeting the minimum specification. The Contractor was reluctant to change the mixture because of concern for possible field density problems. On 2/25 after test 6, the Contractor failed to notify the MDOT QA person that the air voids were trending towards the warning limit. On 2/25 after test 8, the Contractor ignored the fact that the second running average for air voids exceeded the warning limits and continued production. According to the specifications, failure to stop production and make the necessary adjustments when required shall subject all mixture produced from the stop point tonnage to the tonnage point when the running average is back within the warning limits to be considered unsatisfactory. For this example, the stop point is test 8 and the tonnage when the running average is back within the warning limits is test 14. As in the case of the previous example, this represents 4,149 tons of mixture. The payment factor of 0.70 is determined according to the table in Section 401.02.6.3 of the contract specifications.

5.14.1.4 Example 4. The Contractor's production starts out with the air voids slightly low and the asphalt binder content slightly high. The field density results were okay but just meeting the minimum specification. On 2/26 at test 10, the individual test results for asphalt binder content and air voids exceeded 1.7 times the JMF limits. MDOT tested the retained sample for test 10 and confirmed the results within the allowable differences in Subsection 907-401.02.6.2 of the contract specifications. The Engineer investigated the problem and found that fat spots were apparent on the pavement and that roadway density was above 96 percent, both confirming high asphalt and low air voids. A review of plant operations indicate that the asphalt pump malfunctioned approximate two truckloads prior to test 10 and continued for the rest of the day. This represented 30 tons for the two trucks plus the 206 tons to complete the day (test point - 1,234 tons until end of day - 1440 tons). Because this mixture was placed in a busy intersection, the Engineer required the 236 tons of mixture to be removed and replaced at no additional cost to the state.

5.15 Trouble Shooting

5.15.1 Effective Specific Gravity (G_{se}). The calculation of the effective specific gravity will provide a useful tool to the Quality Control Technician. The effective specific gravity is calculated primarily from the maximum specific gravity (G_{mm}) of a sample and the asphalt content (P_b). It defines the relationship between the weight

of the aggregate and the bulk volume of the aggregate minus the volume of absorbed asphalt. The effective specific gravity should be a constant for most Mississippi mixtures. It will change however, if the specific gravity of one of the major aggregate components change or if the proportion of aggregates with different specific gravities in the blend change. For most QMP projects, changes in the effective specific gravity will result from errors in testing or sampling for G_{mm} or P_b determinations. When deviations exceeding 0.012 occur in the effective specific gravity, check test results against previous data and verify that testing is correct. The G_{se} value is calculated using the following equation:

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

Where:

P_b = Percent of Asphalt Binder in Sample
G_{mm} = Maximum Specific Gravity of Sample
G_b = Specific Gravity of Asphalt Binder at 77°F / 77°F (typical value approximately 1.030)

Example:

P_b = 5.4
G_{mm} = 2.396
G_b = 1.034

$$G_{se} = \frac{100 - 5.4}{\frac{100}{2.396} - \frac{5.4}{1.034}} = 2.591$$

5.15.2 Changes in Mixture Volumetrics. The volumetric properties of a mixture are normally defined as the air voids (Pa) and the voids in the mineral aggregate (VMA).

The air voids for a given compaction level are controlled by the asphalt binder content and the VMA of the mixture. If the asphalt binder content remains constant, changes

in the mixture VMA will cause a corresponding change in the mixture air voids. An increase in the asphalt binder content of 0.1 percent can be expected to lower the air voids by approximately 0.25 percent if everything else remains approximately the same.

The VMA of a mixture for a given compaction level is controlled by the gradation and shape of the aggregate. For most mixtures, we can assume that the shape of the component aggregate will remain constant. The dust proportion of the gradation [material passing the No. 200 sieve] has by far the greatest influence on the VMA. A one percent increase in dust in the mixture will lower the VMA by approximately 0.9 percent. Control of the dust at a HMA plant is of primary importance during a QMP project. Studies have found that a number of HMA plants equipped with baghouses generate more dust than what is contained in the cold feed aggregates. A number of Contractors are adding extra dust to the mixture design to compensate for this.

CHAPTER 6
MDOT QUALITY ASSURANCE PROGRAM

6.1 Materials Samples

6.1.1 Asphalt Binder Material. Procedures for acceptance of asphalt binder are set out in Section 2.1.2 of the Materials Division Inspection, Testing and Certification Manual.

Obtain a random sample of asphalt binder at the minimum frequency of one per 200,000 gallons, and submit to the Materials Division for testing under AASHTO T 315.

Immediately upon determining that a sample of asphalt binder fails to conform to specification requirements, notify the Contractor and asphalt supplier. The Contractor is to suspend operations immediately. The Contractor along with the asphalt supplier must determine the cause and take appropriate action to correct the problem. The Contractor may resume operations after the problem has been corrected. Determine the acceptability of any mixture placed with the non-complying asphalt binder in accordance with Subsection 105.03 of the Mississippi Standard Specifications for Roads and Bridge Construction.

6.1.2 Hydrated Lime. As a minimum, obtain one sample (one quart in size) of hydrated lime per project. If the source changes or there is a suspected problem, resample. Sample hydrated lime from the Contractor's storage tank in accordance with AASHTO T 218. Place sample in a sealed one quart metal container, and submit to the Materials Division for testing.

6.2 HMA Quality Assurance Requirements.

6.2.1 General. Acceptance for mixture quality (VMA and air voids @ N_{Design}, gradation, and asphalt content) is based on the Contractor's QC test results performed as set out in Chapter 5 of this manual, and verified by MDOT's QA program as set out below.

6.2.2 Samples. As a part of the QA program, verification tests will be performed on samples taken by the Contractor under the direct supervision of the Engineer at a time specified by the Engineer. The Contractor's split portion of the QA verification sample will not be included in the QC running average. However, the test results should be retained for the dispute resolution process (See *MDOT – Asphalt QC/QA Dispute Resolution Flow Chart).*

6.2.3 Testing Frequency. QA **v**erification testing frequency must be equal to or greater than 10 percent of the tests required for Contractor QC. At least one sample must be tested from the first two days of production. When a problem develops on the project such that an investigation is conducted to resolve testing differences, the

District will increase sampling frequency to the same frequency required for Contractor testing until the problem is resolved.

Any or all of the Contractor retained samples may be tested as necessary for validation of Contractor QC test results and mixture quality. The Contractor is required to keep the retained QA split samples (A+D) for 14 calendar days from the date of sampling (401.02.5.3(j)).

6.2.4 Quality Assurance Verification Testing. Perform the tests in accordance with procedures contained in Chapter 5 of this manual. Round all test results in accordance with Subsection 700.04 of the Mississippi Standard Specifications for Road and Bridge Construction. All testing and data analysis for QA must be performed by a CAT-I Technician or by an assistant under the direct supervision of the CAT-I Technician.

For maximum specific gravity testing, verify the Contractor's dryback procedure on the first sample tested by MDOT. If the MDOT dryback correction is within ± 25 % of the Contractor's value, future MDOT testing may use the Contractor's value. If the dryback values are not within the above tolerance, find out why the problem exists and continue MDOT dryback testing until the results agree.

Provide the test results to the Contractor within two asphalt production days after the sample has been obtained.

6.2.5 Verification of Quality Control Test Results. For the Contractor's QC test results to be used in making the acceptance decision, the average of the previous four (4) QC tests must compare to the QA verification test result and the QA verification test results must meet mixture JMF production requirements. If four QC tests have not been tested at the time of the first verification test, the verification test results will be compared to the average of the preceding QC tests (one, two or three tests). If the verification test is the first material tested on the project or if a significant process adjustment (one that is expected to change the test results) was made just prior to the verification test, the verification test results will be compared to the average of four subsequent QC test results. For all other cases after a significant process adjustment, the verification test results will be compared to the average of the preceding QC tests (taken after the adjustment) as in the case of a new project start-up when four QC tests are not available.

In the event that the above comparison of test results is outside the allowable differences (Subsection 907-401.02.6.2 of the contract specifications), or the QA verification test results fail to meet the JMF specification requirements for asphalt content, air voids or VMA, investigate the reason immediately. The investigation may include testing of the retained QA split samples (A+D), review and observation of the Contractor's testing procedures and equipment, and a comparison of split sample test results by the Contractor's QC laboratory, the District's QA laboratory, and the Materials Division. See Section 6.6 of this manual for a guideline on conducting the investigation.

If reasons for the differences cannot be determined or if the Contractor's tests are proven

incorrect, the QA verification test results will be used in place of the QC data and the appropriate payment for the HMA will be based on the Specifications (401.02.6.3).

Periodically witness the sampling and testing being performed by the Contractor. Promptly notify the Contractor both verbally and in writing of any observed deficiencies (evaluation forms contained in the appendix may be used for this purpose).

When differences in procedures exist between the Contractor and the Engineer which cannot be resolved, a decision on which procedure is correct will be made by the State Materials Engineer, acting as the referee. The Contractor will be promptly notified in writing of the decision. If the deficiencies are not corrected, the Engineer will stop production until corrective action is taken.

6.3 HMA Plant Production Review Guidelines. The District QA program shall follow the following guidelines:

6.3.1 Prestart-up.

The District Materials Section should supply the QA team with:

- The lab number of the aggregate quality test reports for the aggregate sources being used.
- A copy of the Contractor's mix design and the "Tentatively Approved" (TMD-042) mix design report from the Materials Division.
- The contract special provisions.

The quality assurance team should:

- Verify that the QC team personnel have the proper certifications.
- Verify that the HMA mixing plant inspection has been accomplished as per Section 1.1.2 of the Materials Division Inspection, Testing and Certification Manual and that the automatic plant control systems are functioning.
- Review QC and QA equipment calibration data as required in Section 3.2 of this manual to determine that calibrations are up to date (according to AASHTO R 18) and determine if the following equipment complies with the appropriate specifications:

  Sieves
  Shaker
  Balances (QA team check with known weight)

  Gyratory compactor-Ensure inside diameter of gyratory molds meets tolerances specified in Section 4.2 of AASHTO T 312. Molds found to be outside the tolerance should be discarded.

  Vacuum pumps, hoses, bowl or flask, manometer gauge and hookup, etc.
  Water baths, thermometers, ovens
  Fax and copy machine

- Review with the QC team's proposed sampling locations and splitting

procedures.

- Review procedure for determining the reheat correction factors for G_{mb} and G_{mm} and the dryback correction procedure.
- Verify that the Hydrated Lime feed system meets the requirements of 401.03.2.1.1 and 401.03.2.1.2 and that the Contractor has the required hydrated lime inventory (401.02.3.1).

6.3.2 Start-up Day. A member of the District QA team should be at the QC laboratory on start-up day. This person should:

- Verify that the Contractor is producing the "Tentatively Approved" mixture design.
- Verify the source of supply of the asphalt binder. Materials from different sources should not be mixed without prior written approval of the Engineer (401.03.2.1.5).
- Verify that the maximum amount of material being fed through a single cold feed is 45 percent (401.03.2.1.2)
- Verify that the RAP scalping screen is in place and functioning (401.02.3.1).
- Observe sampling and splitting procedures.
- Observe testing procedures including reducing the field sample to testing size.
- Check nuclear asphalt content gauge calibration using standard pan or verify that the incinerator oven has been properly calibrated.
- Verify that the mixture moisture content determined for correcting the asphalt content meets the requirements of 401.03.2.1.3.

Review data calculations to include:

- Asphalt content (P_b).
- Mix air voids (P_a).
- Voids in the Mineral Aggregate (VMA).
- Running average (if applicable).

Compare Contractor process control data with the Job Mix Formula (JMF) data as soon as possible (voids, VMA, G_{mm}, G_{mb}, asphalt content and gradation).

Arrange to have a verification sample tested by the QA team and compare results with the QC data as soon as possible. These sample test results may be used as one of the required 10% QA verification tests.
Designate one of the retained samples for the Contractor to use for determining reheat correction factors if appropriate.

6.3.3 During Production.
Periodically witness the sampling and testing being performed by the Contractor. Promptly notify the Contractor both verbally and in writing of any observed deficiencies. Use the evaluation forms (QMP Inspector's Checklist) in the Appendix to document any observed testing deficiencies. Have the Contractor's technician sign

a copy of the evaluation form.

Review the plant production requirements.

- Verify that the Contractor is producing the "Tentatively Approved" mixture design.
- Verify the source of supply of the asphalt binder. Materials from different sources should not be mixed without prior written approval of the Engineer (401.03.2.1.5).
- Verify that the maximum amount of material being fed through a single cold feed is 45 percent (401.03.2.1.2).
- Verify that the RAP scalping screen is in place and functioning (401.02.3.1).
- Verify that the mixture moisture content determined for correcting the asphalt content meets the requirements of 401.03.2.1.3.

Check the random sampling procedure.

- Make sure the QC team is using the random number table correctly and that they are calculating random numbers for four samples each day.
- Compare the estimated tonnage used for determining sample location with actual tonnage produced.
- The QC team is not allowed to inform the plant when the random verification sampling will be done.

Samples:

- Insure all required samples are being taken and tested.
  Random samples.
  Boiling Water Test.
  Tensile strength ratio tests have been conducted at proper intervals.
  Aggregate stockpile samples.
  Fine aggregate angularity index.
- That proper sampling and splitting procedures are being used and the field sample size is at least the minimum required.
- That the retained samples are properly labeled and stored in a dry protected area.

Testing:

- Observe the reduction of the field samples to test size.
- Observe testing procedures, paying attention to the particulars; such as temperature of test samples before compaction, aging time, cooling of compacted samples in mold, times allotted between tasks, dry backs, etc.
- Review data calculations.

Control Charts:

- Are the required control charts present and up to date?
- Are the control limits plotted correctly?
- Is the data being plotted correctly?

- Are the charts posted in the laboratory?

Insure that all required documentation of records is being accomplished and is up to date.

- Does a record of inspection and observations exist?
- Are the plant adjustments to mixtures noted in the records?
- Are the test reports and records of adjustments provided to the QA team by 9:00 AM the following day?
- Is the hydrated lime inventory accurate and up to date?

If the QA team finds that the Contractor's operation is deficient in any of the above areas, record the deficiency on paper, provide a copy to the contractor, have the Contractor sign a copy of the notice and notify the District Materials Engineer immediately.

6.4 Roadway Production Review Guidelines.

The performance of a HMA pavement is controlled by many factors. Two of the most important are the proper operation of the HMA plant and the use of good construction practices during the paving operations. Both areas of operation individually and together can change the life of a HMA pavement by a factor of 2 or more. In general, the Specifications cannot make a contractor use good paving practices. However, MDOT (in Subsection 401.03 of the Specifications) has adopted the "Hot-Mix Asphalt Paving Handbook" as the guideline for good construction practices. The forms for "Asphalt Roadway Inspection Checklist" and "Asphalt Plant Inspection Checklist" in the appendix contain a number of the recommendations from the handbook. The project inspector shall complete the checklists for each paving project and provide a copy of the checklists to the contractor. It is expected that the Contractor will work to improve their operations and resolve deficiencies noted on the checklists. If the Contractor does not make any improvements to the operation or equipment, the Project Engineer should be notified and meetings should be held with the management of the contracting firm.

The following are specific items contained in the Specifications that affect the performance of the HMA pavement. The Specifications require that these items be addressed on each paving project. In all cases, the production of HMA may be halted if the Contractor is in violation or fails to comply with these requirements. When a violation of a specific item occurs, the project inspector should notify the Project Engineer of the problem. The Project Engineer should then notify the Contractor of the specific problem and that action is expected to resolve the problem. Those items that affect the final performance of the pavement should be dealt with immediately.

6.4.1 Placement Operations.

- Truck Tickets - Verify that the truck scales meet the requirements of 401.03.2.1.11 and that they have been checked and certified within the last 6 months. When the Contractor uses an electronic weighing system, require random loads (minimum one per week) to be checked for tare weight and gross weight on certified platform

scales.

- Verify that the electronic printed ticket, if used, contains the information required in 401.03.2.1.11, with sufficient copies.
- Mixture release agent - Verify that a light coating was applied (no ponds in the bottom of truck) and the Contractor did not use diesel fuel or other nonapproved petroleum-based products.
- Weather limitations - Verify that the weather conditions meet the requirements in 401.03.1.1.
- Condition of underlying surface - Verify that the underlying surface has been prepared according to the requirements in 401.03.6.
- Tack Coat - Verify that the tack coat has been applied in a uniform manner and if asphalt emulsion is used, that it "breaks" prior to placement of the HMA.
- HMA Paver - Verify that automatic grade controls are used and that the paver does not cause tearing, pulling or gouging of the HMA mat. Pavers are to be operated according to the guidelines provided in the "Hot Mix Asphalt Paving Handbook".
- Rollers - Verify that the rollers meet the requirements of 401.03.5 and that they are operated according to the guidelines provided in the "Hot-Mix Asphalt Paving Handbook". Rollers that leak fuel or lubricants shall not be allowed.
- Mixture Temperature – Check the temperature of the mixture periodically throughout the day and record the readings on the weight tickets. Reject any loads that exceed 340°F. Truckloads that have excessive smoking should be checked for temperature.
- Materials transfer equipment - Verify that approved materials transfer equipment is used for the top intermediate lift and the top lift as required in 401.03.9.
- Defective Mixture - Reject any mixture that is obviously defective. Mixtures with excessive asphalt, uncoated aggregate, or obviously missing one of the aggregate sizes are three examples of what would be considered defective mixture.
- Finished surface - Verify that the finished surface of any HMA layer does not contain areas of segregation, bleeding, shoving, rutting, raveling, slippage, cracking or other pavement distress. If any of these distresses are determined to exist in the new pavement, stop production until the problem is solved.

6.4.2 Test Strip. Construction of a test strip at the beginning of lift placement is not a specification requirement. Should the Contractor, at his option, elect to construct a test strip, the density testing procedures found in Chapter 7 of this field manual will be applicable.

6.4.3 Pavement Smoothness. Monitor the testing for pavement smoothness, if required, for the layer being placed.

- Verify that the profilograph supplied by the Contractor meets the Specification requirements.
- Verify that the Contractor operates the profilograph according to the procedures in the specifications (401.02.6.5).

6.5 Required Plant Shutdowns.

In the following situations, the District QA team is required to shut the Contractor's HMA plant down (notify the Contractor that MDOT will not pay for any additional mixture produced)

- When the Contractor violates specific mixture requirements such as:
    1. The Contractor exceeds the maximum natural sand requirement (401.02.1.2.2).
    2. The Contractor is not adding hydrated lime to the mixture (401.02.3.1).
    3. The Contractor exceeds the maximum limestone requirement for top lifts (401.02.3.1).
    4. The Contractor exceeds the maximum RAP requirement (401.02.3.1).
    5. Mixture fails either MT-63 or MT-59 stripping requirements (401.02.5.3(f)).
- Due to unsatisfactory mixture production such as segregation, bleeding, shoving, rutting, raveling, cracking or other pavement distress (401.02.3.2).
- Failure of the Contractor to correct deficiencies in sampling and testing procedures (401.02.6.2).
- When the average daily roadway density does not meet 92.0 percent or 93.0 percent (as applicable) compaction for three consecutive days (401.02.6.4.1).

The QA team is required to reject any mixture that is obviously defective material or mixture (401.02.6.3).

6.6 Guidelines for the Resolution of Differences between Quality Control and Quality Assurance Test Results.

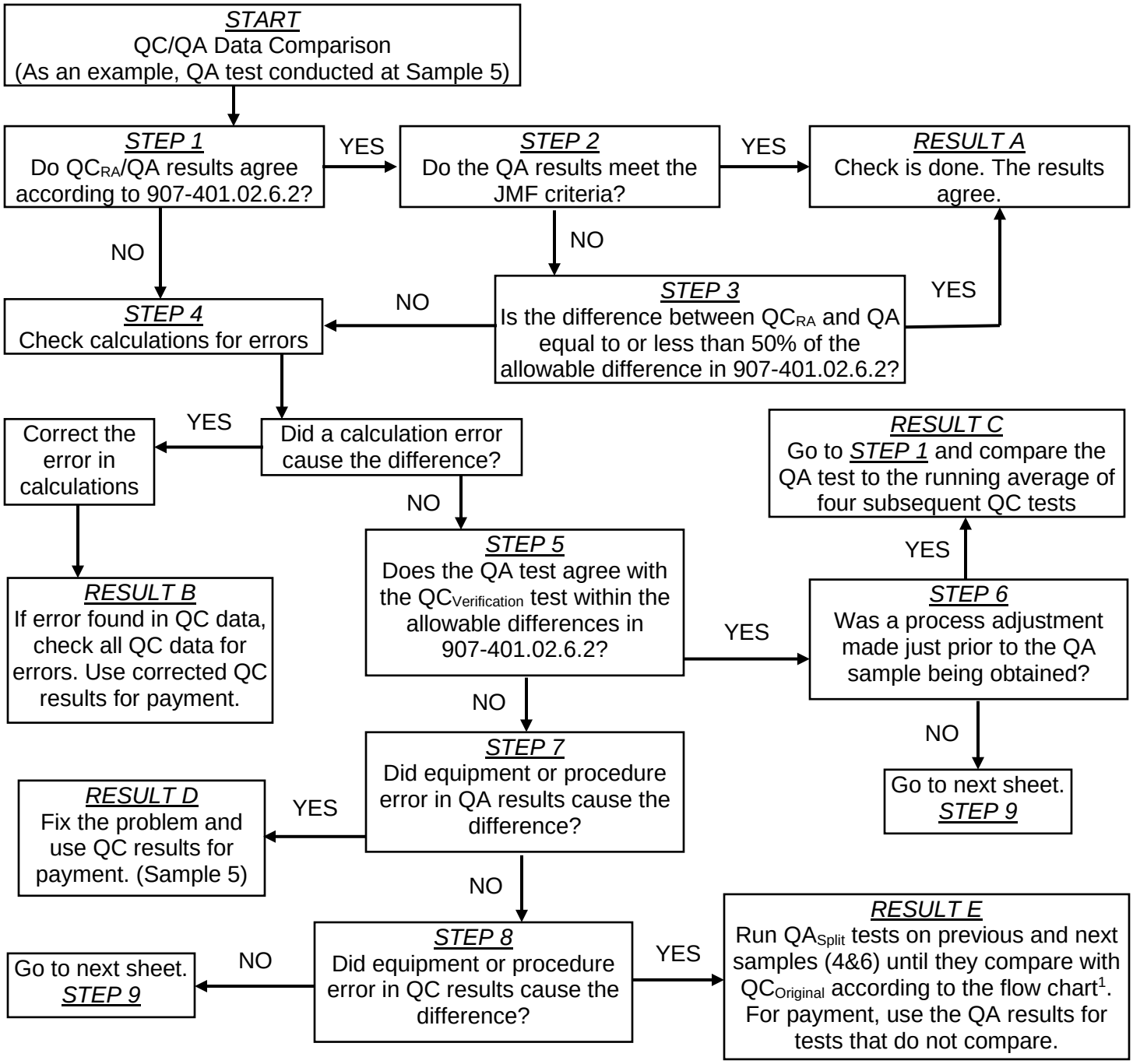
The procedures shown on the following pages may be used to resolve differences between QC and QA results.
The study should be limited to the particular test that does not agree. If a test is used in the calculation of more than one mixture property, then all properties should be recalculated.

The following flow chart has been established for use as a guide to resolve differences between QC and QA results:

Mississippi DOT – Asphalt QC/QA Dispute Resolution Flow Chart

Definitions:

QC and $QC_{Original}$ = test results on the samples tested in the Contractor's lab during construction
QC_{RA} = the running average of the Contractor's test results for the preceding tests or the subsequent tests as required by Section 907-401.02.6.2 of the specifications
QA and $QA_{Verification}$ = the routine District quality assurance verification tests
$QC_{Verification}$ = tests conducted by the Contractor on a split of QA verification sample
QC_{Split} = tests conducted by the Contractor on a split of the retained QC samples
QA_{Split} = tests conducted by District on a split of the retained QC samples
MD = Materials Division tests on either splits of the retained QC samples or other samples to resolve differences in test results between MDOT and the Contractor



[1] The results check according to the flow chart if you obtain a YES reply from *STEP 3*.

STEP 9

Split the next and previous QC retained samples[2] (4&6). If dispute resolution reaches this step, increase the QA sampling and testing to the same frequency required of the Contractor. These samples may be used as part of the dispute resolution process.

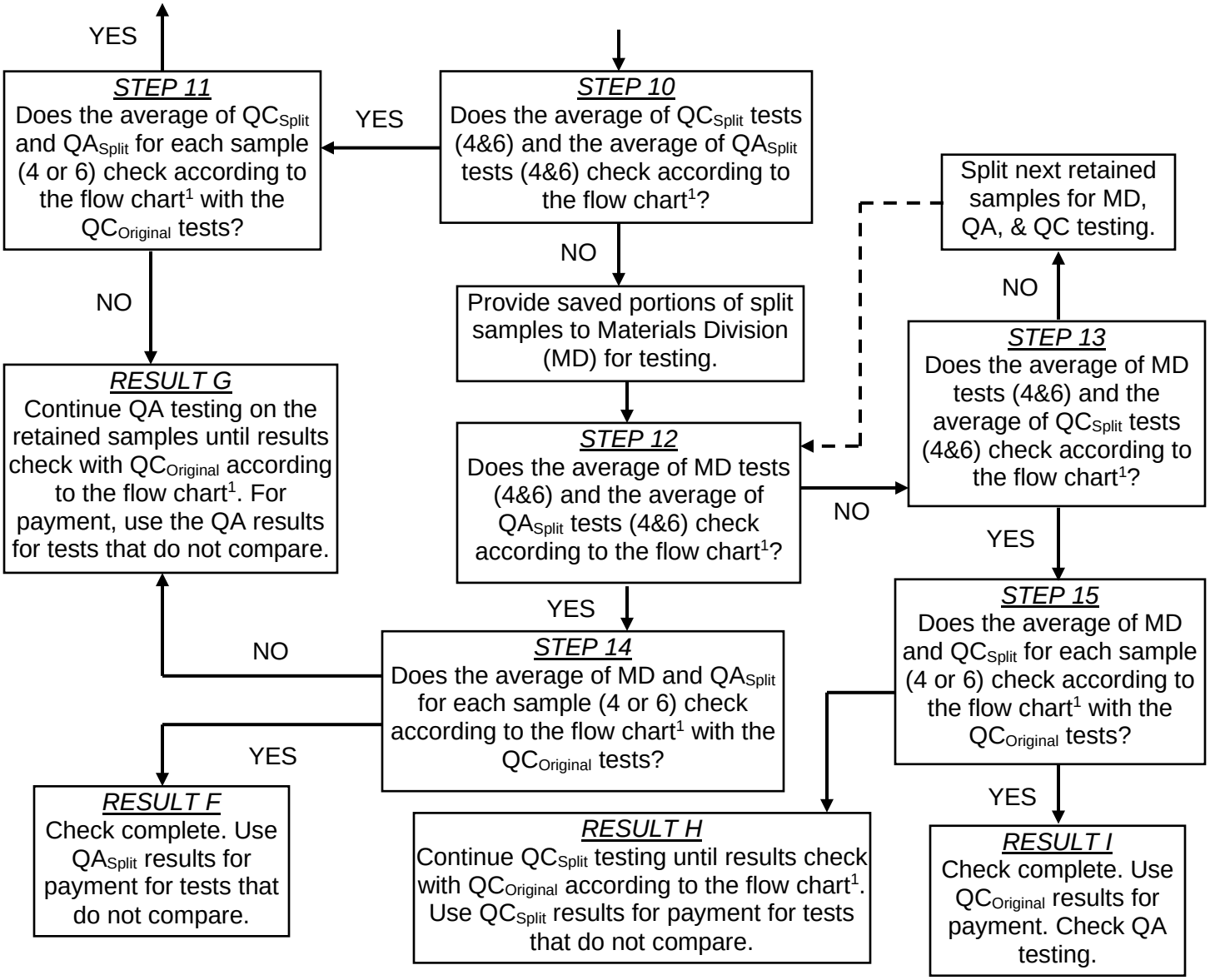
For Gmm and Gradation, split the sample into three parts. Conduct QC and QA tests on two of the parts and save the third part for Materials Division (MD) testing, if necessary.

For Gmb, split the sample into two parts. Conduct QC and QA tests on the two parts. If MD testing is required, use the first and second QA samples obtained as part of the increased sampling frequency for the dispute resolution. Split each sample three ways for QC, QA, and MD checks on the mixture.

For Asphalt Content, split the sample into two parts. Conduct QC and QA tests on the two parts. If MD testing is required, both the QC and the QA labs will submit their test pans and gauge calibrations to the MD lab.

RESULT F

Check complete. Use QA_{Split} results for payment for the tests that do not compare.



[1] The results check according to the flow chart if you obtain a YES reply from *STEP 3*.

[2] Previous and Next samples reference chronological order of retained QC samples. In this example, QA sample 5 was taken at the same time as QC sample 5. If QA and QC were not taken at the same time, then select the previous and next QC retained samples that chronologically bracket the QA sample in question.

6.6.2 Example of the Resolution of Differences between QC and QA test results. These examples are based on the data previously presented in Section 5.14.1 and 5.14.1.1 of this manual. ABC Asphalt from Jackson Mississippi was the successful bidder on the project. The production tonnages and QC test results are shown as Example 1 in Appendix 3.

6.6.2.1 Example 1.

Basic Data - The District Materials Laboratory obtains their second Quality Assurance (QA) verification sample at test 5 on the second day of production. The District had previously tested a sample from test 1 and confirmed the Contractor's results. A summary of the Contractor's and the District's results for test 5 are as follows:

Item	QC_{RA} Test 1-4	$QC_{Verification}$ Test 5	$QA_{Verification}$ Test 5	JMF
Asphalt Binder, %	5.72	5.62	5.58	5.6 ± 0.4
G_{mm}	2.467	2.475	2.452	
G_{mb}	2.385	2.392	2.398	
Air Voids	3.4	3.4	2.0	4.0 ± 1.3
VMA	14.5	14.2	13.9	13.1 Minimum

Problem Evaluation - An evaluation of each of the control items in *Step 1* of the flow chart indicates that the comparison between QC_{RA} and $QA_{Verification}$ for Asphalt Binder Content (AC), Maximum Specific Gravity (G_{mm}), and Gyratory Compacted Bulk Specific Gravity (G_{mb}) meet the allowable differences in Subsection 907-401.02.6.2 of the specifications. See the following table:

Item	Actual Difference	Allowable Difference	Meets Requirement?
Asphalt Binder, %	0.14	0.40	Yes
G_{mm}	0.015	0.020	Yes
G_{mb}	0.013	0.030	Yes

Therefore, the answer to the question in *Step 1* of the HMA QC/QA Dispute Resolution Flow Chart for these three items is yes. This response leads to *Step 2*.

In *Step 2*, the question is "Do the $QA_{Verification}$ results meet the JMF criteria?" The answer to that question is no. The Air Voids are low in the above table (2.0 test value – specification minimum 2.7). This response leads to *Step 3*.

In *Step 3*, the question "Is the difference between QC_{RA} and $QA_{Verification}$ test results equal to or less than 50% of the allowable difference in 907-401.02.6.2?" The answer to that question is contained in the following table:

Item	Actual Difference	Allowable Difference	50% of Allowable Difference	Meets Requirement?
Asphalt Binder, %	0.14	0.40	0.20	Yes
G_{mm}	0.015	0.020	0.010	No
G_{mb}	0.013	0.030	0.015	Yes

Based on the results in the above table, Asphalt Binder Content and G_{mb} meet the requirements of *Step 3* and therefore, the check on these items is complete. The results for G_{mm} do not meet the requirements of *Step 3* and therefore, the evaluation must proceed to *Step 4*.

For *Step 4*, the District checked both the QC and QA calculations and did not find any problems.

Next, the District went to *Step 5* and compared the G_{mm} value for $QA_{Verification}$ (2.452) to the G_{mm} value for $QC_{Verification}$ (2.475) on sample 5. The difference between the two results was 0.023 which exceeds the allowable difference of 0.020 in Subsection 907-401.02.6.2 of the specifications. Therefore, the investigation proceeds to *Step 7* and then *Step 8*.

The investigation of the equipment and procedures for *Steps 7* and *Step 8* did not find any errors in either the QC or QA operations.

Therefore, the investigation proceeds to *Step 9*. For *Step 9*, the District splits the previous and next QC retained samples for evaluation. If a QA sample is available for the "next sample" due to the increased frequency of testing required by the specifications for dispute resolution, it should be used in the resolution process. For this example, the increase frequency of District testing did not occur until test 8. Therefore, QC retained samples 4 and 6 are split into three parts for G_{mm} testing as required in Step 9. One part of each split samples is provided to the Contractor for G_{mm} testing. One part is tested by the District QA lab and one part is held for testing by the Materials Division if necessary. If possible, the Contractor should watch the District run the tests and the District should watch the Contractor run the tests. The results of the Contractor and District tests for G_{mm} on the splits of the two samples are compared to each other in *Step 10*.

For *Step 10*, the results are said to check if the average of the two tests conducted by each laboratory (average of samples 4 and 6) agree according to *Step 3* of the flow chart (equal to or less than 50% of the allowable difference in Subsection 907-401.02.6.2 of the Specifications). The results of the G_{mm} tests for samples 4 and 6 are averaged for each lab and shown in the following table:

Sample	G_{mm} QC_{Split}	G_{mm} QA_{Split}	Difference	*Step 3* Requirement	Check
4	2.472	2.462			
6	2.474	2.470			
Average	2.473	2.466	0.007	0.010	Yes

According to *Step 10* of the flow chart, the above check on the QC and QA combined average results on the splits of the two samples agree. This leads to *Step 11* of the flow chart.

For *Step 11*, it must be determined if the split tests on the retained portions of sample 4 and sample 6 each agree with the original QC tests ($QC_{Original}$). When making this comparison, the average G_{mm} value for the QC_{Split} and QA_{Split} tests on each sample is compared to the $QC_{Original}$ value. The same process of responding to the question in *Step 3* of the flow chart is used. The following table summarizes the results of that comparison:

Sample	G_{mm} $QC_{Original}$	G_{mm} Ave. QC_{Split} & QA_{Split}	Difference	*Step 3* Requirement	Check
4	2.466	2.467	0.001	0.010	Yes
6	2.460	2.472	0.012	0.010	No

The above table shows that the *Step 11* check on results for sample 4 was successful (Result F) and for sample 6 was not successful (Result G). As a result of sample 6 tests, the District lab is required to continue testing samples until agreement is reached with the $QC_{Original}$ results. For this investigation, it is recommended that two or three additional samples be split to help resolve the problem as soon as possible. The results of the QA_{Split} test on sample 7 and the $QA_{Verification}$ test on sample 8 (first sample available as a result of the increased QA sampling for the dispute resolution process) are shown in the following table:

Sample	G_{mm} $QC_{Original}$	G_{mm} QA_{Split}	G_{mm} $QA_{Verification}$	Difference	*Step 3* Requirement	Check
7	2.462	2.451	-	0.011	0.010	No
8	2.468	-	2.466	0.002	0.010	Yes

The results of the investigation indicate that the QA tests confirmed the project data at sample 8. Therefore, the QA results for G_{mm} are substituted for the original QC results for tests 5, 6, and 7. As a result of the new G_{mm} values, the percent air voids and percent roadway compaction are recalculated and the appropriate pay factors applied to the data for the HMA production represented by tests 5, 6 and 7.

6.6.2.2 Example 2.

Basic Data - The District Materials Laboratory obtains their third Quality Assurance (QA) verification sample at test 10 on the fourth day of production. A summary of the Contractor's and the District's results for test 10 are as follows:

Item	QC_{RA} Test 11-14*	$QC_{Verification}$ Test 10	$QA_{Verification}$ Test 10	JMF
Asphalt Binder, %	5.61	5.62	5.49	5.4 ± 0.4*
G_{mm}	2.472	2.474	2.467	
G_{mb}	2.387	2.381	2.341	
Air Voids	3.4	3.8	5.1	4.0 ± 1.3
VMA	14.3	14.6	15.9	13.1 Minimum

* A JMF change was made to the asphalt content at test 9 (this is considered a significant process adjustment). Therefore, the QC_{RA} data used to check the accuracy of the Contractor's data shall be the average of the 4 subsequent tests according to the specifications.

Problem Evaluation - An evaluation of each of the control items in *Step 1* of the flow chart indicates that Asphalt Binder Content (AC) and Maximum Specific Gravity (G_{mm}) meet the allowable differences in Subsection 907-401.02.6.2 of the specifications. However, the Gyratory Compacted Bulk Specific Gravity (G_{mb}) does not meet the specification requirements. See the following table:

Item	Actual Difference	Allowable Difference	Meets Requirement?
Asphalt Binder, %	0.12	0.40	Yes
G_{mm}	0.005	0.020	Yes
G_{mb}	0.046	0.030	No

Therefore, the answer to the question in *Step 1* of the HMA QC/QA Dispute Resolution Flow Chart for G_{mb} is no. This response leads to *Step 4*.

Step 4 requires that the data be checked for calculation errors. In this example, the District checked both the QC and QA calculations and found that they were correct.

Next, the District went to *Step 5* and compared the G_{mb} value for $QA_{Verification}$ (2.341) to the G_{mb} value for $QC_{Verification}$ (2.381) on sample 10. The difference between the two results was 0.040 which exceeds the allowable difference of 0.030 in Subsection 907-401.02.6.2 of the specifications. Therefore, the investigation proceeds to *Step 7* and *Step 8*.

The investigation of the equipment and procedures for *Steps 7* and *Step 8* did not find any errors in either the QC or QA operations. Therefore, the investigation proceeds to *Step 9*.

For *Step 9*, the District splits the previous and next QC retained samples for evaluation. If a QA sample is available for the "next sample" due to the increased frequency of testing required by the specifications for dispute resolution, it should be used in the resolution process. For this example, the increase frequency of District testing did not occur until test 14. In this example, QC retained samples 9 and 11 are split into two parts for G_{mb} testing in *Step 9*. One part of each split samples is provided to the Contractor for G_{mb} testing and one part is tested by the District QA lab. If possible, the Contractor should watch the District run the tests and the District should watch the Contractor run the tests. The results of the Contractor and District tests for G_{mb} on the splits of the two samples are compared to each other in *Step 10*.

For *Step 10*, the results are said to check if the average of the two tests conducted by each laboratory (average of samples 9 and 11) agree according to *Step 3* of the flow chart (equal to or less than 50% of the allowable difference in Subsection 907-401.02.6.2 of the Specifications). The average results for each labs G_{mb} tests on samples 9 and 11 are shown in the following table:

Sample	G_{mb} QC_{Split}	G_{mb} QA_{Split}	Difference	*Step 3* Requirement	Check
9	2.384	2.344			
11	2.388	2.340			
Average	2.386	2.342	0.044	0.015	No

According to *Step 10* of the flow chart, the above check on the QC and QA combined average results on the splits of the two samples do not agree. This leads to *Step 12* of the flow chart.

For *Step 12*, we must provide splits of the samples to the Materials Division for three way testing. Because the normal retained QC samples are too small for this purpose when testing gyratory samples, we make a three-way split on samples 14 and 15 which represent the first two samples that the District obtained as part of their increased sampling frequency in the dispute resolution process. In Step 12, we compare the average Materials Division's results to the average District's results on samples 14 and 15. The results are evaluated by the same process of responding to the question in *Step 3* of the flow chart as previously used. The following table summarizes the results of that comparison:

Sample	G_{mb} $QA_{Verification}$	G_{mb} $MD_{Verification}$	Difference	*Step 3* Requirement	Check
14	2.346	2.398			
15	2.360	2.390			
Average	2.353	2.394	0.041	0.015	No

The above table shows that the *Step 12* check on the average of the results from the Materials Division and the District lab does not check. This leads to *Step 13*.

For *Step 13*, the average Materials Division's results are compared to the average Contractor's results. The results are evaluated by the same process of responding to the question in *Step 3* of the flow chart as previously used. The following table summarizes the results of that comparison:

Sample	G_{mb} $QC_{Verification}$	G_{mb} $MD_{Verification}$	Difference	*Step 3* Requirement	Check
14	2.392	2.398			
15	2.380	2.390			
Average	2.386	2.394	0.008	0.015	Yes

The above table shows that the *Step 13* check on the average of the results from the Materials Division and the Contractor's lab check. This leads to *Step 15*.

For *Step 15*, the average of the Materials Division's results and the Contractor's results for samples 14 and 15 individually are compared to the original QC results to determine if they were correct. The results are evaluated by the same process of responding to the question in *Step 3* of the flow chart as previously used. The following table summarizes the results of that comparison:

Sample	G_{mb} $QC_{Original}$	G_{mb} Ave $MD_{Verification}$ & $QC_{Verifiecation}$	Difference	*Step 3* Requirement	Check
14	2.389	2.395	0.006	0.015	Yes
15	2.390	2.385	0.005	0.015	Yes

The above table shows that the original QC test results have been confirmed. According to Result I, all the QC testing is correct and the District needs to check the calibration of their gyratory compactor and procedures for bulk specific gravity.

CHAPTER 7
ROADWAY DENSITY

7.1 Purpose. This chapter establishes standard procedures for the determination of roadway density on a project.

7.2 Definitions

Gauge Bias - The average of the individual bias values determined during one day of production testing and all previous bias update determinations for the project.

Pavement Cores – Pavement cores shall be obtained using a 4.0 to 6.0 inch inside diameter coring bit. For a "25 mm" mixture, a 6.0-inch inside diameter coring bit shall be used. Sawed samples, if used, shall have a surface area approximately equivalent to the cores.

Random Density Testing Sites - The testing sites for density determination selected at random from each lot in accordance with the Table of Random Numbers as set out in S.O.P. No. CSD-50-70-54-000. The random numbers selected shall be recorded. **NOTE**: When widening is placed with the lane lift(s), the width of the widening shall be excluded in determining the transverse location of random testing sites.

Unit Weight Constant - The value of 62.24 pcf used to convert from specific gravity to unit weight.

7.3 Roadway Density Measurements

7.3.1 The primary method to determine roadway density is by measurement with a calibrated nuclear gauge adjusted for testing bias.

7.3.2 On the first day of production and once each production week (a production week is defined as - six (6) days of mixture production or the time to produce 5,000 tons of mixture whichever comes later), cores will be obtained from the roadway to measure density and to establish the nuclear gauge bias (correction factor). MDOT may use cores to verify the nuclear gauge results at any time.

7.3.3 Cores will be used to verify lot compaction penalties and to identify the limits for pavement removal.

7.4 First Production Day

7.4.1 The production will be divided into lots according to the procedures as defined in Subsection 401.02.6.4 of the specifications (a minimum of four lots shall be tested).

7.4.2 Select one random density testing site for each density lot as defined in Section 7.2.

7.4.3 Nuclear Density Testing

1. Select a nuclear gauge testing location within the allowable tolerance specified in S.O.P. No. CSD-50-70-54-000 from the previously established random density test site.
2. Place the nuclear gauge with the sides of the gauge parallel to the centerline of roadway. Mark the outline of the gauge on the pavement.
3. Irregularities in the area of the test site shall be filled with dry fine sand, native fines, cement, fly ash, or other similar dry material.
4. Take one (1) four-minute density count and record the wet density in the space provided on Form TMD-004.

7.4.4 Core Density Testing

1. Core the pavement at the approximate center of the nuclear gauge test location for each testing site.
2. Damaged cores will not be used for testing. Take a replacement core(s) for any core(s) damaged during the coring process.
3. Determine the core density according to AASHTO T 166 Method C (use AASHTO T 275 or AASHTO T 331 when the water absorption exceeds two (2) percent of the sample volume). **Note:** ASTM D 7227 may be utilized to dry cores to expedite the process.

7.4.5 Calculating the Nuclear Gauge Bias

1. Subtract the nuclear gauge density from the core density for each test site to determine the bias (this value should generally be a positive number).
2. Average the bias values to determine the gauge bias for use with future nuclear gauge testing. If the gauge bias exceeds 6.0, discard results; check gauge and core testing program for possible errors; repeat the first day density testing (nuclear and cores) on the next production day to establish the gauge bias.
3. If any of the individual bias values differ from the gauge bias by more than the allowable bias variation given in Table 7-1, any individual bias that exceeds the tolerance shall be discarded and a new bias shall be determined from the original density test site. Select a new gauge location within the allowable tolerance specified in S.O.P. No. CSD-50-70-54-000 of the test site location. A new gauge bias shall be calculated and used to replace the original value using the procedures outlined above.

Table 7-1 Allowable Variation from Average for Individual Bias Values

Gauge Bias Value, pcf	Allowable Individual Bias Variation, pcf
-3.0 to -0.1	1.5
0.0 to 3.0	1.5
3.1 to 6.0	3.0

Example:

The following test results are from the first day of Production:

The Contractor produced 2000 tons of HMA. Based on the requirements of Subsection 907-401.02.6.4 of the specifications, the production is divided into 5 equal lots of 400 tons each. The Engineer selects two test sites in each lot using the appropriate procedure for determining the random density test sites. The test results are as follows:

Lot	Core Density, pcf	Nuclear Density, pcf	Bias, pcf
1	138.2	135.1	3.1
2	136.6	134.0	2.6
3	137.4	135.5	1.9
4	142.0	135.4	6.6
5	138.7	135.5	3.2
Average			3.5

Based on the above data, the gauge bias is calculated by averaging the individual bias values.

Gauge Bias = 3.5 pcf
Allowable Individual Bias Variation (Table 7-1) = 3.5 ± 3.0 pcf

Therefore, the acceptable range of individual bias values = 0.5 to 6.5 pcf

A review of the individual bias values in the above table indicates that the test result for Lot 4 exceeds the allowable bias deviation from the average.

Select a new gauge location within the allowable tolerance specified in S.O.P. No. CSD-50-70-54-000 of the test site for location 4. Determine new test values for nuclear density and core density using the above procedures. The new test results are as follows:

Lot	Core Density, pcf	Nuclear Density, pcf	Bias, pcf
Lot 4	141.3	137.3	4.0

Substitute the new bias (4.0) for the original Lot 4 result.

The corrected Gauge Bias	=	(3.1+2.6+1.9+4.0+3.2) / 5
	=	15.2 / 5
	=	3.0 pcf

The acceptable range of individual bias values now becomes = 1.5 to 4.5 pcf

The bias values determined for each individual test site are within the allowable difference. Therefore, the gauge bias of 3.0 pcf should be used for further testing until a bias update is required.

7.4.6 Roadway Density acceptance for the first day of production.

1. Calculate the percent compaction payment according to the procedures contained in

Subsection 401.02.6.4.1 of the specifications.

2. Any lot, or portion thereof with a density below the density requirement and not allowed to remain in place at a reduced pay in accordance with the specifications shall be removed and replaced at no additional cost to the State.
3. When the density of a lot does not meet the requirement to remain in place, the limits of the lot to be removed and replaced will be established by testing the pavement as set out in Section 7.9 below. A corrected lot will be retested for acceptance as set out in Section 7.10 below.

7.5 Compaction Effort For Lot To Lot Operations. Once the Contractor establishes a compaction process that produces an acceptable roadway density, that process **should** be used for daily compaction operations and **should** only be changed when conditions under which the original process was established have changed.

7.6 Nuclear Density Procedure For Determining Acceptance of Lots

7.6.1 In all cases except when a nuclear gauge bias is being established, the nuclear gauge will be used to determine roadway density.

7.6.2 A lot is equal to the quantity of mixture as defined in Subsection 401.02.6.4 of the specifications.

7.6.3 Two nuclear density test sites will be selected at random from each lot in accordance with the procedures set out in Subsection 7.2. The two density test results will be averaged to determine compliance with the compaction requirements for the lot.

7.6.4 When the difference between the two (2) nuclear density readings exceeds 3 pounds per cubic foot (pcf) and either or both readings indicate less than the required density (92% or 93%, as specified), test an additional three (3) random sites in the lot and average all five (5) readings to determine compliance with the compaction requirements for the lot. When the difference between the two (2) nuclear density readings exceeds 3 pounds per cubic foot (pcf) and <u>both</u> readings indicate meeting the required density (92% or 93%), no further testing in the lot is required. The lot density will be the average of the two (2) nuclear density readings.

7.6.5 If the nuclear gauge testing indicates that a lot is in penalty or requires removal and replacement for compaction, the Contractor is required to obtain a core from each of the original nuclear density test sites in the lot within 24 hours of being notified of the need for such cores. MDOT will test the cores according to the above procedures. The results of the cores will be averaged and used for the determination of payment for compaction.

7.6.6 When the average core density for a lot does not meet the requirement to remain in place, the limits of the lot to be removed and replaced will be established by testing the pavement as set out in Section 7.9 below. A corrected lot will be retested for acceptance as set out in Section 7.10 below.

Example:

The Contractor produces 1460 tons of HMA for the day in 12-foot wide lane that resulted in a total of 10,000 feet of paving. The project was a single lift construction with a MT mixture (Target Compaction from Subsection 401.02.6.4.1 = 92.0 percent). The specifications require the production to be divided into four Lots each 2,500 feet long. Using random numbers, MDOT selects two locations in each Lot and measures the density using MT-16, Method C, for the nuclear gauge. The test results in pcf and the results corrected for bias (3.0 pcf from previous example) are as follows:

	Site 1	Site 2	Average	Adjusted
Lot 1	132.2	134.6	133.4	136.4
Lot 2	131.1	132.1	131.6	134.6
Lot 3	130.4	128.6	129.5	132.5
Lot 4	134.6	130.4	132.5	135.5

Prior to calculating pay factors, the individual tests from each lot must be tested for uniformity according to Subsection 7.6.4. The maximum deviation between the two individual gauge readings for a lot is 3 pcf.

Lot	Allowable Deviation, pcf	Actual Deviation, pcf	Result
1	3.0	2.4	Okay
2	3.0	1.0	Okay
3	3.0	1.8	Okay
4	3.0	4.2	Retest

Because the variation between the two samples for Lot 4 exceeds the allowable deviation, MDOT will locate three additional test sites in the Lot and test for density with the nuclear gauge. The three new readings and the two original readings in pcf will be averaged to represent the lot density.

	Site 1	Site 2	Site 3	Site 4	Site 5	Ave.	Adj.
Lot 4	134.6	130.4	131.5	131.9	133.0	132.3	135.3

Based on the above data, MDOT can determine the compaction payment for each of the Lots. The mixture quality control testing at the plant indicated that average maximum specific gravity (density) for the day was 2.356 (146.6 pcf).

For Lot 1, the percent compaction = (136.4 / 146.6) x 100 = 93.0%

Lot	Avg Lot Density, pcf	Percent Compaction	Pay Factor
1	136.4	93.0	1.00
2	134.6	91.8	0.90
3	132.5	90.4	0.70
4	135.3	92.3	1.00

Based on the above density testing, the Contractor will receive 100 percent of the unit price per ton for the material represented by Lot 1 and 4, because Lots 2 and 3 are in penalty, a core testing program must be conducted to determine the final pay factors.

7.7 Nuclear Gauge Bias Update

1. The bias for the nuclear gauge will be updated as required in Subsection 7.3.2.
2. Compaction acceptance for the bias update lots shall be based on cores.
3. The day's production will be divided into lots according to the procedures as defined in Subsection 401.02.6.4 of the specifications (for the bias update, a minimum of four lots shall be tested).
4. A new gauge bias number will be established according to the procedures outlined in Subsection 7.4.5; except, if any of the individual bias values differ from the gauge bias by more than the allowable bias variation given in Table 7-1, a new bias update shall be conducted on the next paving day.
5. The new gauge bias value will be compared to the average of all previous gauge bias value(s) that have met the following criteria.
6. If the deviation between the new gauge bias value and the average of all previous gauge bias value(s) is less than or equal to the limits in Table 7-2, the new gauge bias should be averaged with all previous gauge bias values that have met the above criteria and the new average value shall be used for future density testing on the project.
7. If the deviation between the new gauge bias value and the average of all previous gauge bias value(s) exceeds the limits in Table 7-2, a new bias update shall be conducted on the next paving day. The nuclear gauge shall not be used to accept density on the project until a bias within the above limits can be established or reasons for the variation can be explained. Construction can continue using cores to accept density until the problem with the gauge bias has been corrected. Bias values exceeding the above limits will not be used in calculations for density or average gauge bias values.

Table 7-2
Allowable Variation between New Gauge Bias Value
and Average of All Previous Gauge Bias Values

Average of Previous Gauge Bias Values, pcf	Allowable Bias Variation, pcf
-3.0 to -0.1	1.5
0.0 to 3.0	1.5
3.1 to 6.0	3.0

Example:

On the seventh day of paving, the Contractor produced 2,400 tons of mixture. The specifications require that the day's production be divided into 6 lots. Total production for the project to date was 10,000 tons. Therefore, a bias update is required on the seventh day of paving. Compaction acceptance for the day will be based on one randomly selected core from each lot. The test results in pcf are as follows:

Lot	Core Density, pcf	Nuclear Density, pcf	Lot Bias
1	138.7	135.2	3.5
2	137.9	136.0	1.9
3	135.8	133.3	2.5
4	136.2	133.5	2.7
5	134.1	131.0	3.1
6	137.7	135.3	2.4
Average			2.7

Based on the above data, the Gauge Bias = 2.7 pcf

The Allowable Individual Bias Variation (Table 7-1) = 2.7 ± 1.5 = 1.2 to 4.2 pcf

The results indicate that all tests results were within the allowable lot bias difference.

Next, the bias value just determined (2.7 pcf) is compared to the previous Gauge Bias values using the procedures in Subsection 7.7-7.

Allowable Gauge Bias Deviation (Table 7-2) = 1.5 pcf

The actual deviation between the new gauge bias (2.7 pcf) and the previous average gauge bias (3.0 pcf) is 0.3 pcf. This value is less than the maximum deviation allowed. Therefore, the gauge bias value used for future nuclear gauge testing is the average of 2.7 pcf and 3.0 pcf (all previously acceptable values), which equals 2.9 pcf.

Payment for compaction is calculated using the core test results for the paving day used for updating the bias value.

7.8 Limits On Daily Compaction. At any time the average daily compaction (the total of the percent compaction for the lots produced in one day divided by the total number of lots for the day) does not meet the minimum percent compaction requirement for 100 percent pay for two consecutive days, the Contractor shall notify the Engineer of proposed changes to the compactive effort. If the average daily compaction does not meet the minimum percent compaction requirement for 100 percent pay for a third consecutive day, the Contractor shall stop production and determine the cause of the problem.

Example:

The Contractor is producing a mixture that has a 92 percent minimum compaction requirement for 100% payment.

	Compaction Results, percent		
	Day 1	Day 2	Day 3
Lot 1	93.2	92.4	91.8
Lot 2	92.0	91.2	92.2
Lot 3	90.6	90.4	91.7
Lot 4	92.5	92.3	
Lot 5		91.9	
Average	92.1	91.6	91.9

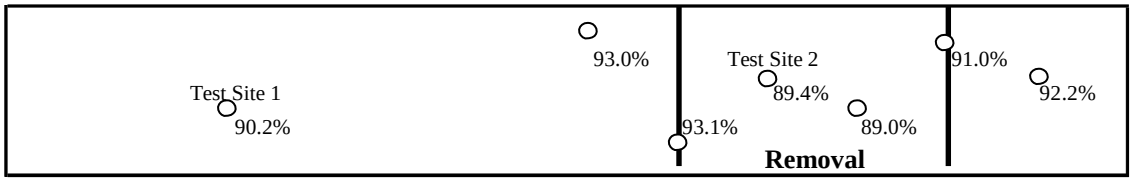
The above results indicate that the Contractor has failed to meet the minimum requirement for average daily compaction for two consecutive days. The Contractor is required to notify the Engineer of proposed changes to the compaction process. If the average percent compaction for the fourth day of production does not equal 92.0 percent or more, the Contractor is required to stop production.

7.9 Procedure For Determining Limits For Removing Lot(s) or Part Thereof Not Allowed To Remain In Place. After determining that the lot compaction is below the lower limit allowed for the mixture to remain in place, proceed to establish limits for removal of this lot or portion thereof as follows:

1. Establish the limits of portion(s) of the lot to be removed by use of **cores**. Determine the limits of removal for each core test site location that is less than the minimum allowable percent compaction.
2. Measure roadway density with cores at fifty-foot (50') intervals in each direction from the original test site(s) in the lot until at least two (2) density tests in each direction equal or exceed the minimum allowable percent compaction. Do not enter into an adjacent lot. The density sites are to be located using the random chart in a transverse direction. If all of the density tests for any of the investigation sites (4 total - two in each direction) exceed the compaction criteria for removal, replace the original compaction result with the average of the four new core tests, calculate the pay quantities and do not remove any pavement represented by that site.
3. The area of removal is defined as the full lane width between the first of the two consecutive readings in each direction from the test site that equaled or exceeded the minimum compaction requirement. Based on the procedure in paragraph 2 above, the minimum possible area of removal will be 150' long by the full lane width.

Examples.

Limits of Removal (One Removal Area)



The average core compaction for Lot 1 was 89.8 percent which requires removal. To determine the limit of removal, evaluate the percent compaction at each site. Results show the percent compaction at Test Site 1 is 90.2 % which exceeds the requirement for removal. Test Site 2 yields a percent compaction of 89.4% which does not exceed the requirement for removal. Test Site 2 must be evaluated using the procedures outlined in Section 7.9.

Cores were obtained at 50' intervals in each direction from Test Site 2. The limits of removal were established and are shown by a dashed line in the above illustration.

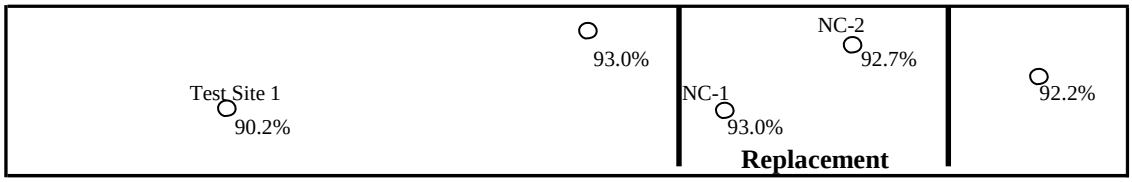
Limits of Removal (Two Removal Areas)

The average core compaction of Lot 1 was 89.4 percent which requires removal. The limits of removal were established at each test site as per Section 7.9 and are shown by dashed lines.

7.10 Procedure For Re-evaluating Corrected Lot. When removal is required and the limits for removal have been determined as outlined in Section 7.9 above, the replacement shall be made in accordance with the specifications. After the replacement is completed, the replacement area and the non-removal part of the lot requiring replacement will be divided into two separate lots and evaluated for percent compaction. For the replacement lot, take two randomly located nuclear gauge readings and calculate compaction according to the above procedures. For the non-replacement lot, use the average of the original test results from the lot for the test site(s) that were not removed and the two core density tests results (one on either side of the removal area) for each removal area in the lot to calculate payment. **NOTE:** If the original lot had one removal area, then the non-removal area would be evaluated based on the average of the remaining original core density test site(s) and the two core density test results (one on either side of the removal area). If the original lot had two or more removal areas, then the non-removal area would be evaluated using the average of the core density tests taken outside the removal areas (one on each side of each removal area).

Examples.

Re-Evaluating a Corrected Lot (One Replacement Area)



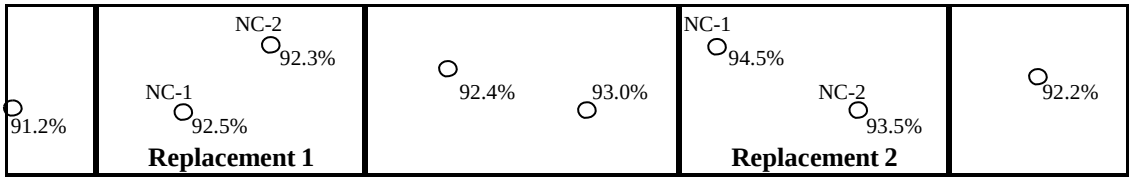
After replacement is complete, the replacement area and non-removal area will be divided into two separate lots and evaluated for compaction. For the replacement lot take two randomly located nuclear gauge readings (NC-1 and NC-2).

Average Compaction for Replacement Area=(93.0+92.7) / 2=92.9%

For the non-removal area, use the average of the original test sites that were not removed and the two core density results (one on either side of the removal area) to calculate payment.

Average Compaction for Non-Removal Area=(90.2+93.0+92.2) / 3=91.8%

Re-Evaluating a Corrected Lot (Two Replacement Areas)



After replacement is complete, two randomly located nuclear gauge readings are taken in each replacement area.

Average Compaction for Replacement Area 1 = (92.3+92.5) / 2=92.4% Average Compaction

for Replacement Area 2= (94.5+93.5) / 2=94.0%

For the non-removal area, average the core density tests taken outside the removal areas.

Average Compaction for Non-Removal Area=(91.2+92.4+93.0+92.2) / 4=92.2%

APPENDIX 1

MISSISSIPPI TEST METHODS and MDOT SOPs

MT6- Nuclear Determination of Bitumen Content of Bituminous Paving Mixtures

PURPOSE: To establish a standard procedure for determining the bitumen content of hot bituminous paving mixtures by use of a nuclear bitumen content gauge.

1. APPARATUS

1.1 Troxler Asphalt Content Gauges, Models 3241-A, 3241-B and 3241-C; CPN Corporation AC-2 Asphalt Content Gauge, or approved equal.

1.2 Balance - Mettler PC 16, or approved equal.

1.3 Mechanical convection oven capable of maintaining a temperature of 300°F ± 5°F.

1.4 Thermometer with a temperature range of 50° to 400°F (10° to 204°C) with sensitivity of 5°F (2.8°C).

1.5 Miscellaneous Equipment

1.5.1 3/4-inch board approximately 14 inches square.

1.5.2 Supply of wrapping paper to cover board.

1.5.3 A trowel or small spade for use in filling specimen container.

1.5.4 A supply of rags and solvent for cleaning equipment.

2. CALIBRATION OF GAUGES

2.1 Troxler Asphalt Content Gauge, Model 3241-A.

2.1.1 Prepare three (3) calibration specimens in accordance with the gauge instruction manual. The specimens must be prepared at the same weight within ±1 gram. The aggregate blend and asphalt cement to be used in the mix must be used to prepare the specimens. Prepare one specimen at 1% higher than the design bitumen content, one specimen at the design bitumen content, and one specimen at 1% lower than the design bitumen content. All calibration specimens shall be prepared and tested at a uniform temperature within ± 10°F (6°C) and as close as possible to the job-mix temperature. (This may necessitate heating the specimens in an oven at a temperature not to exceed the job-mix temperature.)

2.1.2 Using two (2) of the calibration specimens (one at 1% higher than the design bitumen content and one at 1% lower than the design bitumen content), calibrate the gauge in accordance with the gauge instruction manual.

2.1.3 Check the gauge calibration by taking the average of fifteen (15) 4-minute counts using the calibration specimen prepared at the design bitumen content. If the average is ± 0.06% or more from the design bitumen content, check the gauge calibration procedures. If the average is less than ± 0.06% from the design bitumen content, adjust the intercept to make the gauge read the design bitumen content. This adjustment is accomplished by using the calibration offset procedure as set out in the gauge instruction manual.

2.2 Troxler Asphalt Content Gauges, 3241-B and 3241-C; CPN Corporation AC-2 Asphalt Content Gauge.

2.2.1 Prepare three (3) or more calibration specimens in accordance with the gauge instruction manual. The specimens must be prepared at the same weight within ± 1 gram. The aggregate blend and asphalt cement to be used in the mix must be used to prepare the specimens. The range of bitumen content of the specimens (lowest to the highest) shall not exceed three percent (3%) and shall encompass and be equally distributed above and below the design bitumen content. All calibration specimens shall be prepared and tested at a uniform temperature within ± 10°F (6°C) and as close as possible to the job-mix temperature. (This may necessitate heating the specimens in an oven at a temperature not to exceed the job -mix temperature.)

2.2.2 Using the three (3) or more calibration specimens prepared as outlined in Subsection 2.2.1, calibrate the gauge in accordance with the gauge instruction manual.

2.2.3 Check gauge calibration (correlation factor, fit coefficient or correlation coefficient; acceptable value is 0.995 or greater) for acceptance in accordance with the gauge instruction manual.

2.3 Record calibration and supporting data (background count; temperature and weight of calibration specimens).

2.4 Gauge must be calibrated for each job-mix formula. A new calibration will be required when there is a change in aggregate or bitumen source. When gauge repairs are made, check calibration.

3. PREPARATION OF TEST SPECIMEN

3.1 Obtain a representative sample of the mix and reduce to test specimen size in accordance with AASHTO T 248, Method B.

3.2 Fill specimen pan with the mix to within ± 1 gram of the weight of the calibrated specimen.

3.3 Measure and record the temperature of the test specimen. All test specimens shall be tested at a temperature within ± 10°F (6°C) of the calibrated specimens.

4. PROCEDURE

4.1 With the proper job-mix calibration in the gauge, place the test specimen in the gauge chamber and take a sixteen (16) minute-measure count in accordance with the gauge instruction manual.

NOTE: (FOR CENTRAL LABORATORY USE ONLY) When it is necessary to test a specimen after it cools, heat the test specimen in an oven to 290°F - 300°F for a minimum of three (3) hours before testing.

4.2 The sixteen (16) minute-measure count is the bitumen content of the specimen.

4.3 Remove specimen from the gauge, empty and clean the specimen pan.

5. REPORT

Report the bitumen content to the nearest 0.01 percent.

6. CORRECTED BITUMEN CONTENT

The reported bitumen content shall be corrected for moisture as set out in S.O.P. No. TMD-11-31-00-000

MT-16 Nuclear Method for Field In-Place Density Determination

PURPOSE: To establish procedures for the use of surface moisture-density nuclear gauges the determination on in-place densities.

1. SCOPE

This method of test provides a nondestructive measurement on in-place density and moisture content of various courses (embankment, subbases, bases and pavements).

2. APPARATUS

2.1 An approved direct read-out surface moisture-density nuclear gauge equipped with a data processor module.

2.2 A portable reference standard.

2.3 A scraper plate/drill rod guide, drill rod.

2.4 Miscellaneous hand tools, such as shovel, hammer, etc.

2.5 A supply of fine sand or native fines.

3. METHOD OF TEST

3.1 METHOD A. Method A was for use of the early model nuclear gauges which have been replaced with the direct read-out nuclear gauges covered under Method B. The designation for Method A has been retained to prevent cross-reference problems in the text of other methods and specifications.

3.2 METHOD B. For determination of in-place density of soil and soil-aggregate mixtures. For this method a coarse grain soil is defined as a soil containing 25% or more retained on the No. 10 sieve. A fine grain soil is defined as a soil containing less than 25% retained on the No. 10 sieve.

3.2.1 STANDARD COUNT. Obtain a standard count using the portable reference standard in accordance with the procedure set out in the gauge instruction manual. The standard count should be taken in the vicinity of the test site. A standard count should be taken at least twice a day or more frequently if transporting, background radiation or other conditions necessitate. Record the standard moisture count and the standard density count. If a moisture or density count varies significantly from previous counts, there may be a problem with the nuclear gauge.

3.2.2 MOISTURE GAUGE BIAS. The nuclear gauge measures moisture content based on total hydrogen in the soil. Some soils may contain chemically-bound hydrogen which would result in an erroneous moisture content if it is not corrected. This condition may occur in soils or soil-aggregate mixtures containing high gypsum content, lime, cement, high calcium content, etc. A moisture correction factor for such conditions must be determined and applied in accordance with the gauge instruction manual. The correction factor with a plus (+) or minus (-) sign is to be programmed into the nuclear gauge and recorded on the appropriate field density report, TMD-522 or TMD-524.

3.2.3 PREPARATION OF TEST SITE

3.2.2.1 For coarse grain soils, prepare test site to a plane surface that extends at least three inches (3”) beyond the gauge on all sides after rotating the gauge one hundred eighty degrees (180°). Minor depressions in the test site not exceeding one-eighth inch (1/8”) in depth may be filled with native fines or fine sand and struck off to a plane surface.

3.2.2.2 For fine grain soils, prepare test site to a plane surface the size of which is at least one gauge length plus six inches (6") by one gauge width plus six inches (6"). Minor depressions may be filled as set out for coarse grain soils.

3.2.4 Program proctor density into the gauge as set out in the gauge instruction manual. If the soil contains material coarser than the 1/2-inch sieve, be sure the proctor has been corrected for the plus 1/2-inch material in accordance with MT-10.

3.2.5 MOISTURE AND DENSITY TEST. Using the scraper plate/drill rod guide, make a hole with the drill rod two inches (2") deeper than the test depth. Place the gauge in position and inset the probe into the hole to the test depth. With operator facing the front of the gauge, pull the gauge toward you to insure that the probe is in contact with the wall of the probe hole.

For coarse grain soils, take one (1) two-minute count. Rotate the gauge one hundred eighty degrees (180°). Take one (1) two-minute count. After each two-minute count, read and record moisture content in percent, dry density in PCF, and the percent of standard density. Average the two readings for moisture content, dry density and percent of standard density, and record on the appropriate field density report, TMD-522 or TMD-524.

For fine grain soils, take one (1) four-minute count. Read the moisture content in percent, dry density in PCF and the percent of Standard Density, and record on the appropriate field density report, TMD-522 or TMD-524.

3.3 METHOD C: For determination of in-place density of hot-mix asphalt pavement.

3.3.1 STANDARD COUNT: Obtain standard count as set out in Subsection 3.2.1.

3.3.2 DENSITY TEST: All density counts are to be taken in the backscatter mode. Small irregularities in test site should be filled with fine sand or native fines. Place the gauge on the test site with sides of gauge parallel to centerline of roadway. Take one (1) four-minute density count and record the wet density in pounds per cubic foot in the space provided on Form TMD-004.

4. TRAINING

Gauge operators must attend the Mississippi Department of Transportation Training Course for Radiation Safety Procedures for Nuclear Probes and Nuclear Gauge Operation, or other approved course. The gauge operator should be an experienced technician. Upon completion of the training course, the gauge operator will receive a minimum of one week on-the-job training in the principles of nuclear testing and safety procedures.

5. GAUGE PRECISION

5.1 This is a method to determine whether or not the gauge results are valid. This check should be made periodically to insure that the gauge is in proper working order.

5.2 Obtain and record ten (10) one-minute standard density and standard moisture counts. No more than three (3) of either of the ten (10) counts should vary more than plus (+) or minus (-) two (2) standard deviations from the average. All counts should fall within the range of plus (+) or minus (-) three (3) standard deviations from the average.

5.3 Should a gauge not meet this precision requirement, the gauge is to be delivered to the Central Laboratory for repairs.

MT-24 Determination of the Specific Gravity of Fine Aggregate Using the LeChatelier Flask

SCOPE: This method sets forth procedures to be followed in determining the specific gravity of fine aggregate using the Le Chatelier flask.

1. APPARATUS

1.1 The Standard Le Chatelier Flask. This flask shall conform to the dimensions shown in AASHTO T-133 (Specific Gravity of Hydraulic Cement).

1.2 Balance. A balance having a capacity of one kilogram or more and sensitive to 0.1 g or less.

2. PREPARATION OF SAMPLE

Air dry to constant mass approximately 120 g representative of the fine aggregate passing the No. 4 sieve.

3. PROCEDURE

3.1 Pour approximately 4000 mL of water into a pan and bring to room temperature.

3.2 Fill the Le Chatelier flask with water or kerosene at room temperature to a point on the stem between the zero and the 1 mL marks. Dry the inside of the flask above the level of the liquid, if necessary, after pouring. Record the reading at this water level on the flask (First Reading).

3.3 Measure the mass of a representative sample of the fine aggregate to between 55 and 60 g.

3.4 Introduce the sample at room temperature in small amounts into the flask, taking care to avoid splashing. The flask may be vibrated to prevent the material from sticking to the side.

3.5 Twirl the flask until no more air bubbles rise to the surface of the liquid.

3.6 Take the final reading with the liquid at a point in the upper series of gradations.

4. CALCULATION

The difference between the first and final readings represents the volume of liquid displaced by the fine aggregate used in the test. The specific gravity shall be calculated as follows:

$$\text{Sp. Gr.} = \frac{\text{mass of fine aggregate in g}}{\text{displaced vol. in mL}}$$

5. REPRODUCIBILITY

Duplicate determinations of specific gravity by this method should agree within 0.01. At least one (1) duplicate test is usually performed.

6. REPORT

Report the specific gravity to the nearest 0.01.

MT-31 Quantitative Analysis of Hot Bituminous Mixtures

SCOPE: This method sets out alternate procedures for determining the percent bitumen and aggregate gradation of bituminous paving mixtures. ALTERNATE METHOD NUMBER I is the cold-solvent extraction procedure which requires determination of ash content. ALTERNATE METHOD NUMBER II, which does not require determination of ash content, utilizes the Nuclear Asphalt Content Gauge for determination of bitumen content. ALTERNATE METHOD NUMBER III utilizes the Nuclear Asphalt Content Gauge for determination of bitumen content and a nonmechanical extraction procedure.

ALTERNATE METHOD NUMBER I

This method shall be in accordance with AASHTO T 164, Method A, and AASHTO T 30 except when the Recovery of Asphalt from Solution by Abson Method (AASHTO T 170) is not required, the following solvents may be used:

Biodegradable, Nontoxic Asphalt Extractant: MDOT-Approved

ALTERNATE METHOD NUMBER II

1. APPARATUS

1.1 Apparatus as required by S.O.P. TMD-11-76-00-000.

1.2 Pan, flat, approximately 12 in. x 8 in. x 1 in. deep.

1.3 Balance, AASHTO M 231.

1.4 Extraction Apparatus. Consisting of a bowl with at least 1000-gram capacity and an apparatus in which the bowl may be revolved at controlled variable speeds up to 3600 RPM. The apparatus shall be provided with a container for catching the solvent thrown from the bowl and a drain for removing the solvent. The apparatus shall be installed in a hood to provide proper ventilation.

1.5 Filter rings to fit rim of the extraction bowl.

1.6 Solvents, as required by Alternate Method Number. 1

1.7 Oven, capable of maintaining a uniform temperature of 230°± 9°F.

1.8 Sieves, as required by the gradation specifications and meeting the requirements of AASHTO M 92.

1.9 Liquid Detergent (powder detergents are not permitted).

1.10 Apparatus required by S.O.P. TMD-11-06-00-000.

2. BITUMEN CONTENT OF PAVING MIXTURE

Determine the bitumen content in accordance with MT-6.

3. EXTRACTION OF AGGREGATE

3.1 PREPARATION OF SAMPLES

3.1.1 Prepare an extraction test sample of the size as required in Table 1, AASHTO T 164, weighed to the nearest 0.1 gram and a test sample (approximately 500 grams) weighed to the nearest 0.1 gram for moisture determination from the paving mixture used in the Bitumen Content Determination in Section 2.

3.2 PROCEDURE

3.2.1 Determine moisture content of the 500-gram sample in accordance with S.O.P. TMD-11-76-00-000.

3.2.2 Place the extraction sample in bowl of the centrifuge, distributing it uniformly; cover with solvent and allow sufficient time (30 minutes to 1 hour) for solvent to disintegrate the sample.

3.2.3 Place the bowl containing the sample and solvent in the extracting apparatus.

3.2.4 Fit filter ring to the bowl, clamp cover on the bowl, and place a container under the drain.

3.2.5 Start centrifuge revolving slowly and gradually increase the speed to a maximum of 3600 RPM or until the solvent ceases to flow from drain.

3.2.6 Stop the machine and add approximately 200 ml of solvent and repeat the procedure until the extract is no darker than a light straw color.

3.2.7 Remove filter from bowl and dry in air. Remove the mineral matter adhering to the filter and add to the aggregate bowl.

4. MECHANICAL ANALYSIS OF THE EXTRACTED AGGREGATE

4.1 SAMPLE

4.1.1 The sample shall consist of all the extracted material in Section 3.

4.2 PROCEDURE

4.2.1 Shall be in accordance with AASHTO T 30 except that the total extracted weight of mineral aggregate shall be calculated.

4.3 CALCULATIONS

4.3.1 Correct asphalt content for moisture as follows:

$$AC, \% = G - M$$

Where:
AC = percent bitumen corrected for moisture
G = percent asphalt from gauge as a percent
M = moisture content as a percent

4.3.2 Calculate dry weight of sample as follows:

$$W_s = W-(W \times (M/100))$$

Where: W_s = dry sample weight in grams
W = weight of sample taken for extraction in grams
M = moisture content as a percent

4.3.3 Calculate total extracted weight of mineral aggregate as follows:

$$W_1 = W_s (1-(AC/100))$$

Where: W_1 = total extracted weight of mineral aggregate in grams
AC = percent bitumen corrected for moisture (see Subsection 4.3.1)

4.3.4 Calculate the percent passing each sieve as follows:

$$\% \text{ Passing} = \frac{W_1 - W_2}{W_1} \times 100$$

Where: W_1 = total extracted weight of mineral aggregate in grams (see Subsection 4.3.3)
W_2 = accumulated weight of material on each sieve in grams

4.4 Report the percent passing each sieve to the nearest 0.1%.

ALTERNATE METHOD NUMBER III

5. APPARATUS

5.1 Apparatus as required by S.O.P. TMD-11-76-00-000.

5.2 Pan, bottom diameter of approximately 8 in. and depth of 5 in. (min).

5.3 Balance, AASHTO M 231.

5.4 Solvents, biodegradable, nontoxic extractant, MDOT-approved.

5.5 Oven, capable of maintaining a uniform temperature of 230° ± 9°F.

5.6 Sieves, as required by the gradation specifications and meeting the requirements of AASHTO M 92.

5.7 Apparatus required by S.O.P. TMD-11-06-00-000.

5.8 Miscellaneous rubber gloves, eye protectors, spatula, trowel and thermometer.

6. BITUMEN CONTENT OF PAVING MIXTURE

Determine the bitumen content in accordance with S.O.P. TMD-11-06-00-000.

7. AGGREGATE GRADATION

7.1 PREPARATION OF SAMPLES

7.1.1 Prepare sample from paving mixture used in Bitumen Content Determination in Section 6.

7.1.2 Heat the sample in an oven (or sand bath) to 230° ± 9°F until the sample is soft enough to be separated with a spatula or trowel.

7.1.3 Mix the sample uniformly and quarter in accordance with AASHTO T 248, Method B.

7.1.4 Select an extraction test sample of the size as required in Table 1, AASHTO T 164, weighed to the nearest 0.1 gram and a test sample (approximately 500 grams) weighed to the nearest 0.1 gram for moisture determination.

7.2 PROCEDURE

7.2.1 Determine moisture content of the 500-gram sample in accordance with S.O.P. TMD-11-76-00-000.

7.2.2 Place the extraction sample in pan and cover with extractant. Gently agitate the sample frequently with a spatula or trowel, allowing sufficient time (20 - 30 min. for virgin mixtures; 45 min. - one hour for recycle mixtures) for the extractant to dissolve the bitumen from the aggregate. Decant extractant, pouring over a No. 8 sieve nested over a No. 200 sieve. Add additional increments of extractant (approx. 500 ml) and agitate for a minimum of two (2) minutes before decanting. Discontinue the extractant rinses when the extractant becomes a straw color. Begin rinsing and decanting with water until the wash water is clear. (NOTE: Care must be taken while agitating and decanting to prevent loss of particles.)

7.2.3 Dry sample to constant weight in an oven (or sand bath) at a temperature of 230° ± 9°F.

7.2.4 Screen the sample over sieves required by the job-mix formula and weigh the material retained on each sieve to the nearest 0.1 gram.

7.3 CALCULATIONS. Conduct the calculations according to the equations given in Section 4.3 of this S.O.P.

7.4 Report the percent passing each sieve to the nearest 0.1%.

MT-59 Determination of Loss of Coating of HMA (Boiling Water Test)

PURPOSE: This method is intended to provide a rapid test that will give an indication of the resistance of a bituminous paving mixture to stripping with or without an antistripping additive. The bituminous paving mixture may be either plant-mixed or laboratory-mixed. This test may be performed in the field, District or Central Laboratories. The loss of adhesion of asphalt from the aggregate particles, if any, is determined subjectively by visually examining the proportion of stripped aggregate particles.

1. APPARATUS

1.1 Oven. Capable of maintaining constant temperatures with ± 5°F.

1.2 Balance. Capacity of approximately 2 kilograms or more and sensitive to 1 g or less.

1.3 Burner or Hot Plate. A burner shall be equipped with a ring-stand and a ceramic-centered iron wire gauze to prevent localized over heating of the beaker. A hot plate shall be properly shielded to uniformly distribute the heat across the surface.

1.4 Beaker. Stainless steel or Pyrex at least 1000 mL capacity.

1.5 Thermometers. Armored glass or dial-type with metal stem, having a temperature range of 50 to 400°F, sensitive to ± 5°CF.

1.6 Stirring Rods. Glass or stainless steel.

1.7 Miscellaneous. Asbestos gloves, pans, beaker tongs, spatula, etc.

1.8 Distilled or deionized water.

2. PREPARATION OF LABORATORY MIXTURES

2.1 PREPARATION OF ANTISTRIPPING ADDITIVE. When the bituminous paving mixture requires the use of an antistripping additive to prevent stripping, the additive shall be prepared, as follows,depending on the type to be used:

2.1.1 LIQUID ANTISTRIPPING ADDITIVE. When a liquid antistripping additive is to be used, the asphalt cement in sufficient quantity for the test shall be heated to 149°C in an oven. The selected quantity of additive shall be added based, on percent by mass of the asphalt cement. Immediately mix the contents thoroughly for two (2) minutes using a stainless steel or glass stirring rod. Maintain the treated asphalt cement at 149°C until it is used. If the treated asphalt cement is not used on the same day in which it is prepared, or if it is allowed to cool so that it would require reheating, it shall be discarded.

2.1.2 POWDERED SOLID ANTISTRIPPING ADDITIVE. When a powdered solid antistripping additive is to be used, the batch of mineral aggregate shall be dried, composited, and heated to 149°C. The selected quantity of additive shall be added to the aggregate based on percent by mass of total aggregate, and the entire mass shall be thoroughly mixed until a uniform distribution of additive has been achieved. Care shall be taken to minimize loss of additive to the atmosphere in the form of dust. After mixing, maintain the treated aggregateat the temperature required for mixing until it is used.

2.2 PREPARATION OF BITUMINOUS PAVING MIXTURE. Prepare approximately 1000 g of the mixture in accordance with the job-mix formula using the procedure set out in MT-34M. Spread the mixture in a pan and allow to cool completely to room temperature no longer than twenty-four (24) hours.

3. PREPARATION OF SAMPLES OF PLANT-PRODUCED MIXTURE

3.1 Obtain a sample of the mixture from a truck using standard sampling techniques. Using a sample splitter or the quartering method, select approximately 1000 grams of the mixture. If the test sample is not to be tested in the field laboratory, place in a sealed container and transport to the laboratory.

3.2 Allow the sample to cool completely to room temperature.

4. PROCEDURE

4.1 Fill the beaker with distilled or deionized water and bring to a boil on the properly adjusted burner or hot plate.

4.2 Transfer approximately 200 g of the sample into the boiling water and boil for a period of ten (10) minutes.

4.3 Remove from heat, drain off water, empty the contents onto a white paper towel, and allow to dry.

5. DETERMINATION OF STRIPPING

5.1 The extent of stripping is indicated by visually examining the portion of stripped aggregate particles. The stripping is rated subjectively and shall be no more than 5%.

5.2 If the stripping exceeds 5%, a new dosage rate of antistripping additive shall be established using MT-63M. If the mixture did not contain an antistripping additive, an additive shall be incorporated in accordance with MT-63M.

MT-63 Resistance of Bituminous Paving Mixtures to Stripping (Vacuum Saturation Method)

PURPOSE: To establish a standard procedure for determining the need for antistripping additives, the effectiveness of antistripping additives, and for establishing dosage rates in bituminous paving mixtures.

1. APPLICABLE TEST METHODS

1.1 AASHTO T 166, Bulk Specific Gravity of Compacted Bituminous Mixtures.

1.2 AASHTO T 209, Maximum Specific Gravity of Bituminous Paving Mixtures.

1.3 MT-78, Volumetric Design of Hot Bituminous Paving Mixtures Using the SUPERPAVE Gyratory Compactor (S.O.P. TMD 11-78-00-000).

2. APPARATUS

2.1 In addition to the apparatus set out in the above “Applicable Test Methods,” the following apparatus is required:

2.1.1 Steel Loading Strips for 6-Inch Diameter Test Specimens. Steel loading strips, 0.75 inch wide, with a concave surface having a radius of curvature equal to the nominal radius of the 6-inch diameter test specimen. The length of the loading strip shall exceed the thickness of the test specimen. The edges of the strips shall be rounded by grinding.

2.1.2 Vacuum chamber, equipped with gauge, capable of withstanding 30 inches of mercury. The chamber shall be large enough to hold at least two (2) 6-inch specimens submerged in water with space on all sides.

2.1.3 Vacuum pump capable of pulling twenty-nine (29) inches of mercury or more.

2.1.4 Constant temperature water bath at least 8 inches deep and thermostatically controlled so as to maintain the bath at 77 ± 1.8°F. The tank shall have a false bottom or a shelf for supporting the immersed specimen.

2.1.5 Distilled or deionized water.

3. PREPARATION OF ANTISTRIPPING ADDITIVE

3.1 When the bituminous mixture requires the use of an antistripping additive to prevent stripping, as determined by this test method, the additive shall be prepared as follows, depending on the type to be used:

3.1.1 LIQUID ANTISTRIPPING ADDITIVE. When a liquid antistrippin additive is to be used, the asphalt binder in sufficient quantity for the test shall be heated to 300°F in an oven. The selected quantity of additive shall be added based on percent by mass of the asphalt binder. Immediately mix the contents thoroughly for two minutes using a stainless steel or glass stirring rod. Maintain the treated asphalt binder at 300°F until it is used. If the treated asphalt binder is not used on the same day in which it is prepared, or if it is allowed to cool so that it would require reheating, it shall be discarded.

4. PROPORTIONING BITUMINOUS MIXTURES

4.1 The bituminous mixture shall be proportioned in accordance with the job-mix formula from samples of the actual component materials to be incorporated in the work. The mixture shall be proportioned in batches as follows:

4.1.2 Dry each batch of blended mineral aggregate to a constant weight. Add 2.5 ± 0.5 percent water plus the percent of water absorption for the blend as determined by AASHTO T84 and T85 to each aggregate batch. Mix the batch so that the water is uniformly distributed. The damp aggregate should be allowed to sit for approximately four hours prior to introducing the hydrated lime. Add 1 % hydrated lime to the aggregate as a percent by dry weight of total aggregate. Mix the combined materials until a uniform distribution of lime has been achieved. Care shall be taken to minimize the loss of lime to the atmosphere in the form of dust.

4.1.3 One batch shall be prepared for the determination of maximum specific gravity in accordance with AASHTO T 209. If the maximum gravity test was previously performed during the development of the job-mix formula using the same material samples, this step may be omitted.

4.1.4 One batch for each laboratory compaction operation. Approximately 3800 grams are required for each compacted 6-inch diameter by 3.75-inch high test specimen. A minimum of four(4) 6-inch diameter test specimens is required for performance of this test.

5. PREPARATION OF LABORATORY COMPACTED SPECIMEN

5.1 Preparation of 6-Inch Diameter Test Specimens.

5.1.1 Mixing and compaction shall be performed in accordance with MT-78 with the following exceptions:

5.1.1.1 Compact four(4) specimens to 7.0 ± 1 percent air voids or other void level expected in the field. This level of voids can be obtained by adjusting the number of gyrations of the Gyratory Compactor or by setting the compactor to produce 3.75-inch high specimens and adjusting the mix weight to get the proper air void level. The exact procedure must be determined experimentally for each mixture.

5.1.1.2 Cool specimens in the mold for approximately 15 minutes in front of a fan blowing room temperature air, extract the samples from molds, and continue curing at room temperature at least overnight not to exceed twenty-four (24) hours.

6. DENSITY AND VOID DETERMINATION

6.1 Determine the maximum specific gravity in accordance with AASHTO T 209.

6.2 Determine the bulk specific gravity of each of the compacted specimens in accordance with AASHTO T 166, Method A. Record the volume of the specimens in cubic centimeters. The term (B-C) in T 166 Method A is the volume of the specimen in cubic centimeters.

6.3 Calculate the percent air voids in each of the compacted specimens by the following formula:

$$\% \text{ Air Voids} = 100 \left[1 - \frac{G_{mb}}{G_{mm}}\right]$$

Where: G_{mb} = Bulk Specific Gravity
G_{mm} = Maximum Specific Gravity

6.4 Calculate the volume of air voids (V_a) in cubic centimeters for each of the compacted specimens according to the following formula:

$$V_a = \frac{\text{Volume of Specimen, cc x \% Air Voids}}{100}$$

7. CONDITIONING OF COMPACTED SPECIMENS

7.1 Sort the specimens into two subsets (2 - 6 inch diameter specimens per subset) so that the average air voids of the two subsets are approximately equal. One subset is to be stored at room temperature until the indirect tensile strength is to be determined. The other subset is to be subjected to moisture-conditioning in an attempt to induce moisture-related damage (stripping).

7.2 Place the subset to be moisture-conditioned in the vacuum chamber, fill with distilled or deionized water at room temperature until the specimens are completely submerged, and saturate under vacuum until the voids are 55 to 80 percent filled as follows:

7.2.1 Saturate by applying a partial vacuum such as 20 inches of mercury for five (5) minutes. NOTE: Experience with partial vacuum at room temperature indicates that the degree of saturation is very sensitive to the magnitude of the vacuum and practically independent of the duration. The level of vacuum needed appears to be different for different mixtures.

7.2.2 Remove the specimens from the vacuum chamber and determine the saturated surface dry mass in air in accordance with AASHTO T 166, Method A.

7.2.3 Calculate the volume of absorbed water (V_{ws}) in cubic centimeters by subtracting the mass in air of the specimen determined in Subsection 6.2 from the saturated surface-dried mass in air determined in Subsection 7.2.2.

7.2.4 Calculate the degree of saturation (W_s) from the following formula.

$$W_s = \frac{V_{ws}}{V_a} x100$$

Where, W_s = Degree of saturation after vacuum, percent
V_{ws} = Volume of absorbed water after vacuum, cc
V_a = Volume of air voids from Subsection 6.4, cc.

If the degree of saturation is between 55% and 80%, proceed to Subsection 7.3.

If the degree of saturation is less than 55%, place the specimen back in the vacuum chamber and repeat the procedure beginning with Subsection 7.2, but at a slightly higher vacuum. Repeat the procedure until the required degree of saturation is obtained. If the degree of saturation is more than 80%, the specimen has been damaged and must be discarded, in which case a new specimen must be molded and the process repeated.

7.3 Place the vacuum saturated specimens in a distilled or deionized water bath (unagitated) at 140°F and moisture condition for twenty-four (24) hours.

7.4 Remove the specimens from the 140°F water bath and place them in the 77°F water bath for two (2) hours ± 30 minutes.

7.5 Remove the moisture-conditioned specimens from the 77°F water bath and determine the bulk specific gravity in accordance with AASHTO T 166, Method A. Record the volume of the specimens in cubic centimeters. The term (B-C) in T 166, Method A, is the volume of the specimens in cubic centimeters.

7.6 Calculate the volume of absorbed water (V_{wm}) in cubic centimeters by subtracting the mass in air of the specimen determined in Subsection 6.2 from the saturated surface dried mass in air determined in Subsection 7.5.

7.7 Calculate the degree of saturation (W_m) of the moisture-conditioned specimens from the following formula.

$$W_m = \frac{W_{wm}}{V_a} x100$$

Where, W_m = degree of saturation following moisture conditioning, percent
V_{wm} = volume of absorbed water following moisture conditioning, cc
V_a = volume of air voids from Subsection 6.4, cc

NOTE: Degree of saturation exceeding 80 percent is acceptable in this step.

7.8 Measure the diameter of the moisture-conditioned specimens to the nearest 0.01-inch using calipers.

7.9 Adjust the temperature of the unconditioned specimens in the subset which has been curing at room temperature by placing them in the 77°F water bath for thirty (30) minutes ± 5 minutes.

8. INDIRECT TENSILE STRENGTH

8.1 Determine the indirect tensile strength of each specimen at 77°F from both the unconditioned subset and the conditioned subset.

8.1.1 Place the specimen on edge and centered with the breaking head of the testing machine. Center the loading strip on top of the specimen so that the concave surface fits the curvature of the specimen circumference.

8.1.2 Apply diametrical load at the rate of 2 inches per minute until the maximum load is reached. Record the maximum load (P) in pounds (the Marshall breaking press has a loading rate of 2 inches per minute).

8.1.3 Continue loading until specimen can be separated at the failure plane for visual examination of the degree of particle stripping.

8.1.4 Calculate the indirect tensile strength from the following formula:

$$S_t = \frac{8.1935PD}{V}$$

Where, S_t = Indirect tensile strength, psi

P = Maximum load at failure, pounds

D = Diameter of specimen in inches. The diameter of the unconditioned specimen equals the inside diameter of the mold in which the specimen was compacted. The diameter of the moisture-conditioned specimen was determined by measurement in Subsection 7.8.

V = Volume of specimen as tested in tension in cubic centimeters. See Subsection 6.2 for volume of unconditioned specimen and Subsection 7.5 for the volume of the moisture-conditioned specimen.

9. TENSILE STRENGTH RATIO

9.1 Calculate the average indirect tensile strength of the unconditioned subset (S_{tu}).

9.2 Calculate the average indirect tensile strength of the moisture-conditioned subset (S_{tm}).

9.3 Determine the tensile strength ratio from the following formula:

$$TSR = \frac{S_{tm}}{S_{tu}} x100$$

Where: TSR = Tensile strength ratio, percent

S_{tm} = Average indirect tensile strength of the moisture-conditioned specimens, psi.

S_{tu} = Average indirect tensile strength of the unconditioned specimens, psi.

10. DEGREE OF PARTICLE STRIPPING

10.1 After testing under Subsection 8.1.3, separate each moisture-conditioned specimen at the failure plane. Examine each exposed face for loss of asphalt from the aggregate surfaces.

10.2 Estimate subjectively the proportion of stripped aggregate particles and record in percent.

11. DETERMINING THE NEED FOR ANTISTRIPPING ADDITIVE

11.1 If the results of this test on the bituminous paving mixtures without antistripping additive meets all of the specification requirements, the mixture is considered to be sufficiently resistant to stripping; therefore, it will not require the use of an antistripping additive.

12. DETERMINING THE EFFECTIVENESS OF ANTISTRIPPING ADDITIVE AND ESTABLISHING DOSAGE RATES

12.1 In order to determine the effectiveness of the antistripping additive and determine the dosage rate, the bituminous paving mixture must be tested with and without the additive proposed for use in the mixture.

12.2 To be approved, the type additive proposed for use must result in the bituminous paving mixture's conformance to all of the specification requirements. Also, the dosage rate shall be the lowest necessary (Manufacturer's Recommended Rate or higher) to result in the bituminous paving mixtures conformance to all of the specification requirements.

12.3 The average indirect tensile strength of the moisture-conditioned specimens containing the additive must be greater than the average indirect tensile strength of the moisture-conditioned specimens without the additive.

12.4 The dosage rate selected in the laboratory shall be tentative until tests have been performed on the plant-produced mixture.

13. REPORT

13.1 Average degree of saturation after application of vacuum.

13.2 Average degree of saturation after moisture-conditioning.

13.3 Average indirect tensile strength without antistripping additive of unconditioned specimens and of moisture-conditioned specimens.

13.4 Average indirect tensile strength with antistripping additive of unconditioned specimens and of moisture-conditioned specimens.

13.5 Tensile Strength Ratio (TSR) with and without antistripping additive.

13.6 Results of estimated stripping observed when specimen fractures.

13.7 Type antistripping additive and dosage rate required. If no additive is required, so indicate.

14. JOB CONTROL ACCEPTANCE TESTING

14.1 Job control acceptance testing for resistance of plant-produced mixtures to stripping will be performed in accordance with Sections 1 through 13 of this S.O.P. except for the following modifications:

14.1.1 Subsection 5.2.1.2. Curing will not be required overnight. Cool in front of a fan at room temperature a minimum of three (3) hours $\pm$ 30 minutes.

14.1.2 Subsections 7.2 and 7.3. Drinking water may be used.

MT-76 Microwave Method for Determining the Moisture Content of Hot Bituminous Mixtures

PURPOSE: To establish an optional test procedure for determining the moisture content of a hot bituminous mixture by utilizing a microwave oven. (For mixtures containing slag, use AASHTO T 110.).

1. APPLICABLE TEST METHODS

1.1 AASHTO T 110, Moisture or Volatile Distillates in Bituminous Paving Mixtures.

1.2 AASHTO T 164, Quantitative Extraction of Bitumen from Bituminous Paving Mixtures.

1.3 AASHTO T 168, Sampling Bituminous Paving Mixtures.

1.4 MT-6M, Nuclear Determination of Bitumen Content of Bituminous Paving Mixtures.

1.5 MT-31M, Quantitative Analysis of Hot Bituminous Mixtures.

2. APPARATUS

2.1 Balance. Minimum capacity of 2 000 g, readable to 0.1 g

2.2 Microwave Oven (800 cooking watts). Minimum capacity of 0. 028 cubic meters with variable power control.

2.3 Pyrex beaker capable of holding 500 g minimum of tap water.

2.4 Pyrex container (pie plate type) capable of holding 500 g minimum sample.

2.5 Thermometer capable of measuring to 180°C, readable to 2°C.

2.6 Scoop, sample container and heat resistant gloves.

3. PROCEDURE

3.1 Set microwave oven variable power control to 50% power.

3.2 Place 500 g of tap water in a Pyrex beaker. Record temperature of water (T1). Set the microwave oven timer for five (5) minutes and heat the 500 g of water. Record the water temperature (T2). The difference between temperatures T1 and T2 should be 20 to 30°C. If the difference is too low (or high), increase (or decrease) the variable power control and repeat applicable part of procedure until the proper power control is established. Verify or establish power control setting for each day of testing by repeating the above steps.

3.3 Place the bituminous mixture test specimen (not less than 500 g) in the tared Pyrex container and determine the wet mass to the nearest 0.1 g.

3.4 Dry the sample in the microwave oven (check mass at 15-minute intervals) using the power control setting established in Subsection 3.2. Continue to dry the test specimen (usually 30 to 45 minutes) until it has reached a constant mass and determine the dry mass to the nearest 0.1 g.

(Avoid overheating the test specimen, an indication of which is a large amount of blue smoke; in which case, discard test specimen and rerun.)

3.5 Determine the percent moisture as follows:

$$\text{Percent Moisture} = \frac{(A - B)}{A} \times 100$$

Where: A = Wet mass of test specimen
B = Dry mass of test specimen

4. REPORT

Report the moisture content to the nearest 0.01 percent.

MT-78 Volumetric Mix Design Procedure for Dense-Graded Asphalt Mixtures Using the Superpave Gyratory Compactor

SCOPE: This method sets out the procedure to be followed in the volumetric design of dense-graded asphalt mixtures using the SUPERPAVE Gyratory Compactor. This procedure determines the proper proportioning of component aggregates and asphalt binder content that conforms to specification requirements when blended together in the laboratory. **NOTE**: **This procedure shall be used for volumetric design of Warm Mix Asphalt Mixtures. Laboratory mixing and compaction design temperatures for Warm Mix Asphalt shall be the same as those specified for Hot Mix Asphalt.**

1. DEFINITIONS

1.1 **OPTIMUM ASPHALT BINDER CONTENT.** The asphalt binder content of a paving mixture that satisfies the applicable volumetric design criteria as determined when utilizing the SUPERPAVE Gyratory Compactor.

1.2 **VOIDS IN THE MINERAL AGGREGATE, VMA.** The volume of intergranular void space between the aggregate particles of a compacted mixture that includes the air voids and the effective asphalt binder content, expressed as a percent of the total volume of the sample.

1.3 **EFFECTIVE ASPHALT BINDER CONTENT.** The total asphalt binder content of a mixture minus the portion of asphalt binder that is absorbed into the aggregate particles.

1.4 **AIR VOIDS.** The total volume of the small pockets of air between the coated aggregate particles throughout a compacted mixture.

1.5 **VOIDS FILLED WITH ASPHALT, VFA.** The portion of the volume of intergranular void space between the aggregate particles (VMA) that is occupied by the effective asphalt binder.

1.6 **N_{ini}.** The number of required revolutions of the Gyratory compactor representing the compactibility of the mixture received from the asphalt spreader. N_{ini} revolutions shall be specified in the contract.

1.7 **N_{des}.** The number of revolutions of the Gyratory compactor required for design characteristics of the job-mix formula. N_{des} revolutions, specified in the contract, shall produce a density meeting the mixture volumetric requirements of the specifications.

1.8 **N_{max}.** The number of required revolutions of the Gyratory compactor representing the density of the pavement layer at the end of design life. N_{max} revolutions shall be specified in the contract.

2. REFERENCE TEST METHODS

Tests required in the design of hot mix asphalt mixtures are as follows:

AASHTO T 11	Materials Finer than 0.075 mm (No. 200) Sieve in Mineral Aggregates by Washing
AASHTO T 27	Sieve Analysis of Fine and Coarse Aggregates
AASHTO T 37	Sieve Analysis of Mineral Filler for Bituminous Paving Materials
AASHTO T 84	Specific Gravity and Absorption of Fine Aggregate
AASHTO T 85	Specific Gravity and Absorption of Coarse Aggregate
AASHTO T 166	Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
AASHTO T 209	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
AASHTO T 269	Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
AASHTO T 308	Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

AASHTO T 312	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
ASTM C 604	True Specific Gravity of Refractory Materials by Gas Comparison Pycnometer
ASTM D 3289	Specific Gravity or Density of Semi-Solid and Solid Bituminous Materials by Nickel Crucible
MT-24	Determination of the Specific Gravity of Fine Aggregates Using the Le Chatelier Flask (formerly S.O.P TMD-11-24-00-000)
MT-31	Quantitative Analysis of Hot Bituminous Mixtures (formerly S.O.P. TMD-11-31-00-000)

3. APPARATUS

The apparatus required for the design of hot mix asphalt mixtures are those set out in the standards listed in Section 2 of this test method.

4. PROCEDURES

4.1 GRADATIONS. Perform sieve analysis for the coarse and fine aggregate component sizes according to AASHTO T 27 and T 11 and on mineral filler, according to AASHTO T 37.

4.2 AGGREGATE SPECIFIC GRAVITIES. Perform a minimum of two specific gravity tests on each aggregate according to AASHTO T 84 and T 85, on the hydrated lime according to MT-24 or ASTM C 604, and the asphalt binder according to ASTM D 3289 (77/77°F). If an aggregate has greater than 25 percent passing the No. 4 sieve and greater than 25 percent retained on the No. 4 sieve, conduct both a coarse and fine aggregate specific gravity on the material and combine the results according to equation in Section 5.1. Modify AASHTO T 84 as follows:

a. Conduct tests on washed material passing the No. 4 sieve.
b. Conduct the drying for the SSD determination in a flat bottom pan in which moisture is easily visible on the bottom.
c. Define the SSD point at the time when moisture is no longer visible in the bottom of the pan when the material is moved across the bottom, the material is free flowing during this movement, and the surface of the aggregate does not change color with stirring.

4.3 RAP MATERIALS

4.3.1 Gradation. Determine the gradation on representative samples of the processed RAP materials after extraction of the asphalt binder according MT-31.

4.3.2 Asphalt Content. Determine the asphalt binder content of the RAP using a standard asphalt extraction procedure. If the incinerator oven is used, estimate the appropriate correction factor based upon previous testing of mixtures with similar aggregate. See Section 8.10 for further requirements.

4.3.3 Aggregate Specific Gravities. Test extracted RAP aggregate for specific gravity according to the procedures in Section 4.2 of this S.O.P. Aggregate obtained from the incinerator oven extraction procedure may not be used for aggregate specific gravity testing.

4. 4 REQUIRED AGGREGATE BLEND. Determine by trial and error method, the percentages of each aggregate necessary to produce a blended material meeting the gradation requirements of the specifications.

4.5 PREPARATION OF GYRATORY TEST SPECIMENS.

4.5.1 General. Prepare a minimum of four (4) sets of Gyratory specimens with asphalt binder content at 0.5 percent intervals. Prepare the sets such that at least one set is above the optimum asphalt content and one set is below the optimum asphalt content. Each set shall consist of a minimum of two (2) specimens.

4.5.2 Preparation of Aggregates. Dry each aggregate component to be used in the mixture to constant mass in an oven at a temperature of 230 ± 9ºF.

Estimate the mass of each aggregate component required to produce a batch that will result in a compacted specimen 150 mm in diameter and approximately 115 mm in height. This will normally require approximately 4500 g of mixture. (**Note**: It is generally desirable to prepare a trial specimen prior to preparing all the aggregate batches. If the trial specimen does not meet the height requirement, adjust the amount of material used for the specimens accordingly).

Separate each individual aggregate into the appropriate sizes as follows:

Plus 1”
1” to 3/4”
3/4” to 1/2”
1/2” to 3/8”
3/8” to No. 4
No. 4 to No. 8
Passing No. 8

If any of the size fractions represent less than 5 percent of the individual aggregate, they may be combined with the next smaller size fraction.

Weigh cumulatively into a separate pan for each test specimen the required quantity of each aggregate component.

A minimum of eight (8) pans of the batched aggregates will be needed for the Gyratory test specimens. Additionally, two (2) pans will be required for the maximum specific gravity (G_{mm}) samples, and two (2) pans for testing at N_{max}.

Place the asphalt binder to be used in an oven and heat to mixing temperature. The temperature to which the asphalt binder must be heated to produce a kinematic viscosity of 170 ± 20 mm^2/s shall be the mixing temperature. This temperature will be determined from a current temperature-viscosity curve for the particular source of asphalt binder being used. (**Note:** For polymer modified asphalt binders use the manufacturer’s recommended mixing temperature.)

Place the pans of batched aggregates in the oven and heat to mixing temperature, but not to exceed 50ºF above the required mixing temperature.

Charge the mixing bowl with the heated aggregate in one pan and dry mix thoroughly. Form a crater in the dry blended aggregate and weigh the required amount of the heated asphalt binder into the mixture. Mechanically mix the aggregate and asphalt binder as quickly and thoroughly as possible to yield a paving mix having a uniform distribution of asphalt binder.

After completion of mixing, place the mix in a curing oven at 5ºF to 10ºF above compaction temperature for approximately 1-1/2 hours in a round (6.5” to 7.5” in diameter) covered container to allow for absorption. A 10# ink can from Inmark Inc. (205-856-9077) or a paint can without a top lip has been found suitable for aging the mixture. The compaction temperature shall be the temperature to which the asphalt binder must be heated to produce a kinematic viscosity of 280 ± 30 mm^2/s. This temperature will be determined from a current temperature-viscosity curve for the particular asphalt binder being used. (**Note:** For polymer modified asphalt binder use the manufacturer’s recommended compaction temperature).

4.5.3 Compaction of Gyratory Test Specimens. Check calibration of Gyratory compactor in accordance with Operations Manual. (It is recommended that this be performed on at least a monthly basis.) Maintain records of calibration results and adjustments to the equipment. Verify 600 kPa ± 18 kPa ram pressure with load cell. Verify 1.16 ± 0.02º internal angle tilt setting. Verify height calibration

using spacer provided by manufacturer. Set number of gyrations to N_{des}. Set dwell at the appropriate number of gyrations or dwell time, according to manufacturer's instructions. This is typically 5 gyrations for most Troxler compactors, or 5 seconds for most Pine compactors. Other manufacturers are similar.

Place a compaction mold and base plate in curing oven for 30 to 60 minutes prior to the estimated beginning of compaction (during the absorption period).

After completion of absorption period, remove the heated mold and base plate from the oven and place a paper disc on the bottom of the mold.

Check the compaction temperature of the mix by means of a calibrated probe, prior to removal from the oven. Remove a container of mixture from the oven and place the mixture into the mold in one lift by pouring uniformly through a funnel, taking care to avoid segregation in the mold. After all the mix is in the mold, level the mix. If no calibrated probe was available for the mix in the oven, check for compaction temperature with a calibrated dial thermometer and place another paper disc on top of the leveled material. Load the specimen mold with the paving mix into the compactor and center the mold under the loading ram.

Lower the ram until the pressure on the specimen reaches 600 kPa ± 18 kPa. Begin compaction.

Record specimen height after each revolution to the nearest 0.1 mm. Continue compaction until N_{des} gyrations are reached and the gyratory mechanism shuts off.

Remove the angle from the mold assembly, apply dwell gyrations, raise the loading ram, remove mold from the compactor, provide a cooling period of 10 ± 2 minutes for the mold and specimen in front of a fan, extrude the specimen from the mold and immediately remove the paper discs from top and bottom of the specimen.

After specimen cools to room temperature (usually overnight), weigh and record the mass of the extruded specimen, $W_{m,}$ to the nearest gram.

Determine the required characteristics of the compacted mixture at N_{ini} and N_{des} levels of compaction.

Repeat procedures in Subsection 4.5.3 for each Gyratory test specimen.

4.5.4 Specific Gravity of Compacted Specimens (G_{mb}). Determine the specific gravity of the compacted specimens according to AASHTO T 166.

4.5.5 Maximum Specific Gravity of Bituminous Mixture (G_{mm}). Determine the maximum specific gravity according to AASHTO T 209 in duplicate at an asphalt content near the expected optimum level and average the results. Perform this test on samples which have completed the absorption period. (See Subsection 4.5.2)

5. COMPUTATIONS

5.1 BULK SPECIFIC GRAVITIES OF BLENDED AGGREGATE. When the total aggregate consists of separate fractions of coarse aggregate, fine aggregate, hydrated lime, and mineral filler (when used), all having different specific gravities, the bulk specific gravity (G_{sb}) for the total blended aggregate is calculated as follows:

$$G_{sb} = \frac{P_1+P_2+....+P_n}{\frac{P_1}{G_1}+\frac{P_2}{G_2}+....+\frac{P_n}{G_n}}$$

Where: G_{sb} = bulk specific gravity of the total aggregate
P_1, P_2, P_n = percentages by mass of aggregates 1, 2, n; and
G_1, G_2, G_n = bulk specific gravities of aggregates 1, 2, n
(Note: The apparent specific gravity of hydrated lime and mineral filler shall be used in lieu of the bulk specific gravity.)

5.2 EFFECTIVE SPECIFIC GRAVITY OF AGGREGATE. The effective specific gravity of the aggregate, G_{se}, is determined as follows:

$$G_{se} = \frac{100-P_b}{\left(\frac{100}{G_{mm}}\right)-\left(\frac{P_b}{G_b}\right)}$$

Where: G_{se} = effective specific gravity of aggregate
P_b = asphalt binder, percent by mass of mixture
G_{mm} = maximum specific gravity of paving mixture
G_b = specific gravity of asphalt binder at 25°C

Note: The volume of asphalt binder absorbed by an aggregate is almost invariably less than the volume of water absorbed. Consequently, the value for the effective specific gravity of an aggregate should be between its bulk and apparent specific gravities. When the effective specific gravity falls outside these limits, its value must be assumed to be incorrect. The calculations, the maximum specific gravity of the total mix by AASHTO T 209, and the composition of the mix in terms of aggregate and total asphalt binder content, should then be rechecked for the source of the error.

5.3 MAXIMUM SPECIFIC GRAVITY OF MIXTURES WITH DIFFERENT ASPHALT BINDER CONTENT. In designing a paving mixture with a given aggregate, the maximum specific gravities, G_{mm}, at different asphalt binder contents are needed to calculate the percentage of air voids for each asphalt binder content. After calculating the effective specific gravity of the aggregate, the maximum specific gravity for any other asphalt binder content can be obtained as shown below. For all practical purposes, the effective specific gravity of the aggregate is constant because the asphalt binder absorption does not vary appreciably with variations in asphalt binder content.

$$G_{mm} = \frac{100}{\left(\frac{P_s}{G_{se}}\right)+\left(\frac{P_b}{G_b}\right)}$$

Where: G_{mm} = maximum specific gravity of paving mixture (no air voids)
P_s = aggregate, percent by total mass of mixture = (100 – P_b)
P_b = asphalt binder, percent by total mass of mixture
G_{se} = effective specific gravity of aggregate
G_b = specific gravity of asphalt binder

5.4 ASPHALT BINDER ABSORPTION. Asphalt binder absorption, P_{ba}, expressed as a percentage by mass of aggregate is determined as follows:

$$P_{ba} = 100\left(\frac{G_{se}-G_{sb}}{G_{sb}G_{se}}\right)G_b$$

Where:
- P_{ba} = absorbed asphalt binder, percent by mass of aggregate
- G_{se} = effective specific gravity of aggregate
- G_{sb} = bulk specific gravity of aggregate
- G_b = specific gravity of asphalt binder

5.5 EFFECTIVE ASPHALT BINDER CONTENT OF A PAVING MIXTURE. The effective asphalt binder content, P_{be}, of a paving mixture is determined as follows:

$$P_{be} = P_b - \left(\frac{P_{ba}}{100}\right)P_s$$

Where:
- P_{be} = effective asphalt binder content, percent by mass of mixture
- P_b = total asphalt binder content, percent by mass of mixture
- P_{ba} = absorbed asphalt binder, percent by mass of aggregate
- P_s = aggregate, percent by mass of mixture, = (100 - P_b)

5.6 PERCENT VMA IN COMPACTED PAVING MIXTURE. The voids in the mineral aggregate, VMA, is determined as follows:

$$V_{MA} = 100 - \left(\frac{G_{mb}P_s}{G_{sb}}\right)$$

Where:
- V_{MA} = voids in mineral aggregate (percent of bulk volume)
- G_{sb} = bulk specific gravity of aggregate
- G_{mb} = bulk specific gravity of compacted mixture (AASHTO T 166)
- P_s = aggregate, percent by total mass of mixture, = (100 - P_b)

5.7 CALCULATION OF PERCENT AIR VOIDS IN COMPACTED MIXTURE. The air voids, P_a, in a compacted paving mixture is determined as follows:

$$P_a = 100\left(\frac{G_{mm}-G_{mb}}{G_{mm}}\right), \quad \text{or} \quad P_a = 100\left[1-\left(\frac{G_{mb}}{G_{mm}}\right)\right]$$

Where:
- P_a = air voids in compacted mixture, percent of total volume
- G_{mm} = maximum specific gravity of paving mixture (or as determined directly for a paving mixture by AASHTO T 209)
- G_{mb} = bulk specific gravity of compacted mixture

5.8 VOIDS FILLED WITH ASPHALT. The percent voids filled with asphalt, VFA, is determined for 4.75 mm mixtures as follows:

$$V_{FA} = 100\frac{(VMA - P_a)}{VMA}$$

Where: V_{FA} = voids filled with asphalt, percent of VMA
V_{MA} = voids in mineral aggregate, percent of bulk volume
P_a = air voids in compacted mixture, percent of total volume

5.9 SPECIFIC GRAVITY OF COMPACTED SPECIMENS AT N_{INI}. The bulk specific gravity (G_{mb}) at N_{ini} is calculated as follows:

$$G_{mb} \text{ (at } N_{ini}) = \frac{h_{des}}{h_{ini}}\left(G_{mb}\ (at N_{des})\ \right)$$

Where: G_{mb} = Bulk specific gravity of the specimen at "x" gyrations
h_{des} = Height in millimeters of specimen at N_{des}
h_{ini} = Height in millimeters of specimen at N_{ini}

5.10 PERCENT COMPACTION OF GYRATORY SPECIMEN. Determine percent compaction, C_x, as follows:

$$C_x = \frac{G_{mb}}{G_{mm}}\ 100$$

Where: C_x = Corrected relative density expressed as a percentage of maximum specific gravity after "x" gyrations
G_{mb} = Bulk specific gravity of the specimen at "x" gyrations
G_{mm} = Maximum specific gravity of the mix

6. DETERMINATION OF OPTIMUM ASPHALT BINDER CONTENT

6.1 GRAPHICAL PLOT. Prepare a graphical plot for the following values at the various percentages of asphalt binder:

Air Voids vs. Asphalt Binder Content
VMA vs. Asphalt Binder Content
VFA vs. Asphalt Binder Content (4.75 mm mixtures only)
% Density @ N_{ini} vs. Asphalt Binder Content

6.2 DESIGN CRITERIA. The designed mixture shall at optimum asphalt binder content conform to all the required design criteria set out in the current version of Section 907-401 of the Specifications.

6.3 PROCEDURE FOR DETERMINING OPTIMUM ASPHALT BINDER CONTENT.

6.3.1 From the graphical plot of the air voids vs. asphalt binder content curve, select the asphalt binder content corresponding to 4.0 percent air voids.

6.3.2 Determine if the selected asphalt binder content meets all the required design criteria in the current version of Section 907-401 of the Specifications and that the selected asphalt binder content does not exceed the asphalt binder content at the lowest point of the VMA vs. Asphalt Binder content curve. The mix should be redesigned if these criteria cannot be met.

6.3.3 Prepare two additional gyratory specimens compacted to N_{max} at the optimum asphalt content. Determine the average G_{mb} value for the specimens according to AASHTO T 166. Calculate the percent compaction according to equation 5.10. Compare the percent compaction at N_{max} to the maximum limit allowed in the specifications. If the mixture does not meet this requirement, the design fails and a new design is required.

7. RESISTANCE TO STRIPPING

7.1 Check the designed mixture in accordance with MT-63 and MT-59 to determine if an antistripping additive will be required.

7.2 If an antistripping additive is required, establish the dosage rate in accordance with MT-63 using samples of the additive to be used on the project.

7.3 Final determination of the requirement for antistripping additive and dosage rate will be established by field testing in accordance with MT-63 and MT-59.

8. REPORT

Submit the mixture design report on Form TMD-042 (or similar type document), and include as a minimum:

8.1 Project Identification Information

8.2 Name of Contractor(s)

8.3 Type and Source of Component Materials

8.4 Job-Mix Formula With All Supporting Test Data (laboratory worksheets).

8.5 Optimum Asphalt Binder Content.

8.6 % Density @ N_{max} at Optimum Binder Content

8.7 Plant Mixing Temperature. Specify the mixture temperature at the discharge from the mixer. The temperature specified shall provide an asphalt binder viscosity of between 150 and 300 mm^2/sec. (Note: For polymer modified asphalt binders, use the plant mixing temperature recommended by the binder manufacturer. Provide a copy of the manufacturer's recommendation.)

8.8 Type, Brand Name, and Dosage Rate of Antistripping Additive. If no additive is required, so state.

8.9 Seven (7) preblended batches of the virgin aggregate (batch weights should be such that the proper height specimen is produced in the gyratory compactor and also allow for the incorporation of RAP if it is used).

8.10 A 20,000 gm batch of the proposed RAP material. If the incinerator oven was used for determining asphalt content of RAP for the mix design, the correction factor used for the determination must be provided with the RAP sample.

8.11 Two (2) liters of the asphalt binder required for the design.

8.12 If Warm Mix Asphalt Technology is to be used during production the following additional information will be required:

8.12.1 Warm Mix Process/Product to be used during production

8.12.2 Anticipated Water Dosage Rate, By Percent of Asphalt Binder. If no water is required, so state.

8.12.3 Anticipated Additive Dosage Rate. If no additive is required, so state.

8.12.4 Anticipated Plant Production Temperature

MT-80 Volumetric Mix Design Procedure for Stone Matrix Asphalt (SMA) Using the Superpave Gyratory Compactor

SCOPE: This method establishes the procedure for the volumetric mix design of Stone Matrix Asphalt (SMA) mixtures. The design is based on the volumetric properties of the SMA including air voids, voids in the mineral aggregate, voids in the coarse aggregate, draindown, and mortar properties.

1. DEFINITIONS

1.1 STONE MATRIX ASPHALT (SMA). SMA is type of hot mix asphalt comprised of a high percent of coarse aggregate, a high content of mineral filler, and a polymer modified asphalt binder, along with stabilizing fibers.

1.2 SMA MORTAR. The mixture of polymerized liquid asphalt binder, mineral filler, and stabilizing fiber.

1.3 VOIDS IN THE COARSE AGGREGATE (VCA). The volume between the coarse aggregate particles, including the mineral filler, the fine aggregate, air voids, polymerized liquid asphalt binder, and fiber.

2. REFERENCED TEST METHODS

AASHTO Standards

T 11	Amount of Material Finer than 0.075 mm (No. 200) Sieve
T 19	Unit Weight and Voids in Aggregate
T 27	Sieve Analysis of Fine and Coarse Aggregates
T 37	Sieve Analysis of Mineral Filler for Road and Paving Materials
T 84	Specific Gravity and Absorption of Fine Aggregate
T 85	Specific Gravity and Absorption of Coarse Aggregate
T 166	Bulk Specific Gravity of Bituminous Paving Mixtures
T 209	Maximum Specific Gravity of Bituminous Paving Mixtures
T 269	Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
T 312	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
MP1	Specification for Performance Graded Asphalt Binder
TP1	Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)
TP5	Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)

Mississippi Test Methods

MT-81	Preparation and Testing of Stone Matrix Asphalt (SMA) Mortars
MT-82	Draindown Testing of Stone Matrix Asphalt (SMA) Mixtures

3. APPARATUS

The apparatus required for the design of Stone Matrix Asphalt (SMA) mixtures are those set out in the standards listed in Section 2 of this S.O.P.

4. PROCEDURE

4.1 GRADATIONS. Perform sieve analysis for the coarse and fine aggregate component sizes according to AASHTO T 27 and T 11 and on mineral filler, according to AASHTO T 37.

4.2 AGGREGATE SPECIFIC GRAVITIES. Perform a minimum of two specific gravity tests on each aggregate according to AASHTO T 84 and T 85, on the hydrated lime according to MT-24 or ASTM C 604, and the

asphalt binder according to ASTM D 3289 (77/77°F). If an aggregate has greater than 25 percent passing the No. 4 sieve and greater than 25 percent retained on the No. 4 sieve, conduct both a coarse and fine aggregate specific gravity on the material and combine the results according to equation in Section 5.1. Modify AASHTO T 84 as follows:

a. Conduct tests on washed material passing the No. 4 sieve.
b. Conduct the drying for the SSD determination in a flat bottom pan in which moisture is easily visible on the bottom.
c. Define the SSD point at the time when moisture is no longer visible in the bottom of the pan when the material is moved across the bottom, the material is free flowing during this movement, and the surface of the aggregate does not change color with stirring.

4.3 REQUIRED AGGREGATE BLEND. Determine by trial and error method, the percentages of each aggregate necessary to produce a blended material meeting the gradation requirements of the specifications. The specification ranges for SMA mixtures are based on percent passing by volume. These volume-based gradations are converted to weight (mass) for mixture design and control. An example of a gradation by volume is given in Section 11 of this S.O.P.

In preparation for mortar testing as outlined in Section 8 of this S.O.P., obtain at least 200 grams of the filler (passing the No. 200 sieve) in a separate container.

Determine the dry rodded unit weight of the coarse aggregate fraction of the aggregate blend in accordance with AASHTO T-19. This value will be designated VCA_{dr}. The coarse aggregate fraction consists of all aggregate retained on the break point sieve in the aggregate blend. The following table indicates the break point sieves for various nominal maximum size SMA mixes.

Mixture Size (NMS)	Break Point Sieve
1 in (25 mm)	No. 4 (4.75 mm)
¾ in (19 mm)	No. 4 (4.75 mm)
½ in (12.5 mm)	No. 4 (4.75 mm)
3/8 in (9.5 mm)	No. 8 (2.36 mm)

The calculation of the VCA_{dr} for the blend is given as follows:

$$VCA_{dr} = \left(\frac{G_{ca}\gamma_w - \gamma_s}{G_{ca}\gamma_w}\right)100$$

Where: VCA_{dr} = voids in coarse aggregate in a dry rodded condition
G_{ca} = bulk specific gravity of coarse aggregate (aggregate retained on the break point sieve)
γ_w = unit weight of water (998 kg/m^3)
γ_s = unit weight of the coarse aggregate fraction in the dry-rodded condition (kg/m^3)

4.4 PREPARATION OF GYRATORY TEST SPECIMENS.

4.4.1 General. Prepare a minimum of four (4) sets of Gyratory specimens with asphalt binder content at 0.5 percent intervals. Prepare the sets such that at least one set is above the optimum asphalt content and one set is below the optimum asphalt content. Each set shall consist of a minimum of three (3) specimens.

4.4.2 Preparation of Aggregates. Dry each aggregate component to be used in the mixture to constant mass in an oven at a temperature of 230 ± 9ºF.

Estimate the mass of each aggregate component required to produce a batch that will result in a compacted specimen of correct size. For gyratory compacted specimens the correct size is 150 mm in

diameter and approximately 115 mm in height and normally requires approximately 4500 grams of mixture. (**Note**: It is generally desirable to prepare a trial specimen prior to preparing all the aggregate batches. If the trial specimen does not meet the height requirement, adjust the amount of material used for the specimens accordingly).

Separate each individual aggregate into the appropriate sizes as follows:

Plus 1”
1” to 3/4”
3/4” to 1/2”
1/2” to 3/8”
3/8” to No. 4
No. 4 to No. 8
Passing No. 8

If any of the size fractions represent less than 5 percent of the individual aggregate, they may be combined with the next smaller size fraction.

Weigh cumulatively into a separate pan for each test specimen the required quantity of each aggregate component.

A minimum of eight (8) pans of the batched aggregates will be needed for the test specimens. Additionally, two (2) pans will be required for the maximum specific gravity (G_{mm}) samples.

Place the asphalt binder to be used in an oven and heat to mixing temperature. Since polymer modified asphalt binders will be used, use the manufacturer’s recommended mixing temperature.

Place the pans of batched aggregates in the oven and heat to mixing temperature, but not to exceed 50ºF above the required mixing temperature. Stabilizing fiber is added to the aggregate blend at the time of mixing. Do not add the fiber to the aggregate prior to heating.

Charge the mixing bowl with the heated aggregate in one pan and dry mix thoroughly. Add the required amount of the stabilizing fiber and mix thoroughly. If the fiber is not thoroughly mixed with the aggregate prior to the addition of the liquid asphalt binder, the fiber will clump and the results will be invalid. Once the aggregate and fiber are thoroughly mixed, form a crater in the aggregate/fiber blend and weigh the required amount of heated asphalt binder into the mixture. Mechanically mix the aggregate, asphalt binder, and stabilizing fiber as quickly and thoroughly as possible to yield a paving mix having a uniform distribution of asphalt binder and fiber.

After completion of mixing, place the mix in a curing oven at 5ºF to 10ºF above compaction temperature for approximately 1-1/2 hours in a round (6.5” to 7.5” in diameter) covered container to allow for absorption. A 10# ink can from Inmark Inc. (205-856-9077) or a paint can without a top lip has been found suitable for aging the mixture. Use the binder manufacturer’s recommended compaction temperature.

4.5.3 Compaction of Gyratory Test Specimens. Check the calibration of the Gyratory compactor in accordance with Operations Manual. (It is recommended that this be performed on at least a monthly basis.) Maintain records of calibration results and adjustments to the equipment. Verify 600 kPa ± 18 kPa ram pressure with load cell. Verify 1.16 ± 0.02° internal angle tilt setting. Verify height calibration using spacer provided by manufacturer. Set number of gyrations to N_{design}. Set dwell at the appropriate number of gyrations or dwell time, according to manufacturer’s instructions. This is typically 5 gyrations for most Troxler compactors, or 5 seconds for most Pine compactors. Other manufacturers are similar.

Place a compaction mold and base plate in curing oven for 30 to 60 minutes prior to the estimated beginning of compaction (during the absorption period).

After completion of absorption period, remove the heated mold and base plate from the oven and place a paper disc on the bottom of the mold.

Remove a container of mixture from the oven and place the mixture into the mold in one lift by pouring uniformly through a funnel, taking care to avoid segregation in the mold. After all the mix is in the mold, level the mix, check for compaction temperature and place another paper disc on top of the leveled material. Load the specimen mold with the paving mix into the compactor and center the mold under the loading ram.

Lower the ram until the pressure on the specimen reaches 600 kPa ± 18 kPa. Begin compaction.

Record specimen height after each revolution to the nearest 0.1 mm. Continue compaction until N_{design} gyrations are reached and the gyratory mechanism shuts off.

Remove the angle from the mold assembly, apply dwell gyrations, raise the loading ram, remove mold from the compactor, provide a cooling period of 10 ± 2 minutes for the mold and specimen in front of a fan, extrude the specimen from the mold and immediately remove the paper discs from top and bottom of the specimen.

After specimen cools to room temperature, weigh and record the mass of the extruded specimen, $W_{m,}$ to the nearest gram.

Determine the required characteristics of the compacted mixture at N_{design}.

Repeat procedures in Subsection 4.5.3 for each Gyratory test specimen.

4.5.4 Specific Gravity of Compacted Specimens (G_{mb}). Determine the specific gravity of the compacted specimens according to AASHTO T 166.

4.5.5 Maximum Specific Gravity of Bituminous Mixture (G_{mm}). Determine the maximum specific gravity according to AASHTO T 209, in duplicate, at an asphalt content near the expected optimum level, and average the results. Perform this test on samples that have completed the absorption period. (See Subsection 4.5.2).

5. COMPUTATIONS

5.1 BULK SPECIFIC GRAVITIES OF BLENDED AGGREGATE. When the total aggregate consists of separate fractions of coarse aggregate, fine aggregate, hydrated lime, and mineral filler (when used), all having different specific gravities, the bulk specific gravity (G_{sb}) for the total blended aggregate is calculated as follows:

$$G_{sb} = \frac{P_1+P_2+....+P_n}{\frac{P_1}{G_1}+\frac{P_2}{G_2}+....+\frac{P_n}{G_n}}$$

Where: G_{sb} = bulk specific gravity of the total aggregate
P_1, P_2, P_n = percentages by mass of aggregates 1, 2, n
G_1, G_2, G_n = bulk specific gravities of aggregates 1, 2, n
(**Note:** The apparent specific gravity of hydrated lime and mineral filler shall be used in lieu of the bulk specific gravity.)

5.2 EFFECTIVE SPECIFIC GRAVITY OF AGGREGATE. The effective specific gravity of the aggregate, G_{se}, is determined as follows:

$$G_{se} = \frac{100 - P_b}{\left(\frac{100}{G_{mm}}\right) - \left(\frac{P_b}{G_b}\right)}$$

Where:
G_{se} = effective specific gravity of aggregate
P_b = asphalt binder, percent by mass of mixture
G_{mm} = maximum specific gravity of paving mixture
G_b = specific gravity of asphalt binder at 25°C

Note: The volume of asphalt binder absorbed by an aggregate is almost invariably less than the volume of water absorbed. Consequently, the value for the effective specific gravity of an aggregate should be between its bulk and apparent specific gravities. When the effective specific gravity falls outside these limits, its value must be assumed to be incorrect. The calculations, the maximum specific gravity of the total mix by AASHTO T 209, and the composition of the mix in terms of aggregate and total asphalt binder content, should then be rechecked for the source of the error.

5.3 MAXIMUM SPECIFIC GRAVITY OF MIXTURES WITH DIFFERENT ASPHALT BINDER CONTENT. In designing a paving mixture with a given aggregate, the maximum specific gravities, G_{mm}, at different asphalt binder contents are needed to calculate the percentage of air voids for each asphalt binder content. After calculating the effective specific gravity of the aggregate, the maximum specific gravity for any other asphalt binder content can be obtained as shown below. For all practical purposes, the effective specific gravity of the aggregate is constant because the asphalt binder absorption does not vary appreciably with variations in asphalt binder content.

$$G_{mm} = \frac{100}{\left(\frac{P_s}{G_{se}}\right) + \left(\frac{P_b}{G_b}\right)}$$

Where:
G_{mm} = maximum specific gravity of paving mixture (no air voids)
P_s = aggregate, percent by total mass of mixture = (100 – P_b)
P_b = asphalt binder, percent by total mass of mixture
G_{se} = effective specific gravity of aggregate
G_b = specific gravity of asphalt binder

5.4 ASPHALT BINDER ABSORPTION. Asphalt binder absorption, P_{ba}, expressed as a percentage by mass of aggregate is determined as follows:

$$P_{ba} = 100\left(\frac{G_{se} - G_{sb}}{G_{sb}G_{se}}\right)G_b$$

Where:
P_{ba} = absorbed asphalt binder, percent by mass of aggregate
G_{se} = effective specific gravity of aggregate
G_{sb} = bulk specific gravity of aggregate
G_b = specific gravity of asphalt binder

5.5 EFFECTIVE ASPHALT BINDER CONTENT OF A PAVING MIXTURE. The effective asphalt binder content, P_{be}, of a paving mixture is determined as follows:

$$P_{be} = P_b - \left(\frac{P_{ba}}{100}\right) P_s$$

Where:
- P_{be} = effective asphalt binder content, percent by mass of mixture
- P_b = total asphalt binder content, percent by mass of mixture
- P_{ba} = absorbed asphalt binder, percent by mass of aggregate
- P_s = aggregate, percent by mass of mixture, = (100 - P_b)

5.6 PERCENT VMA IN COMPACTED PAVING MIXTURE. The voids in the mineral aggregate, VMA, is determined as follows:

$$VMA = 100 - \left(\frac{G_{mb} P_s}{G_{sb}}\right)$$

Where:
- VMA = voids in mineral aggregate (percent of bulk volume)
- G_{sb} = bulk specific gravity of aggregate
- G_{mb} = bulk specific gravity of compacted mixture (AASHTO T 166)
- P_s = aggregate, percent by total mass of mixture, = (100 - P_b)

5.7 PERCENT VCA IN COMPACTED PAVING MIXTURE (VCA_{MIX}). The voids in the coarse aggregate, VCA_{mix}, is determined as follows:

$$VCA_{mix} = 100 - \left(\frac{G_{mb}}{G_{ca}}\right) P_{ca}$$

Where:
- VCA_{mix} = voids in coarse aggregate of the mixture
- G_{ca} = bulk specific gravity of coarse aggregate
- G_{mb} = bulk specific gravity of compacted mixture (AASHTO T 166)
- P_{ca} = percent coarse aggregate in mix by weight of total mix

5.8 CALCULATION OF PERCENT AIR VOIDS IN COMPACTED MIXTURE. The air voids, P_a, in a compacted paving mixture is determined as follows:

$$P_a = 100\left(\frac{G_{mm} - G_{mb}}{G_{mm}}\right), \quad \text{or} \quad P_a = 100\left[1 - \left(\frac{G_{mb}}{G_{mm}}\right)\right]$$

Where:
- P_a = air voids in compacted mixture, percent of total volume
- G_{mm} = maximum specific gravity of paving mixture (or as determined directly for a paving mixture by AASHTO T 209)
- G_{mb} = bulk specific gravity of compacted mixture

5.9 PERCENT COMPACTION OF GYRATORY SPECIMEN. Determine percent compaction, C_x, as follows:

$$C_x = \frac{G_{mb}}{G_{mm}} 100$$

Where: C_x = Relative density expressed as a percentage of maximum specific gravity at N_{design} gyrations.
G_{mb} = Bulk specific gravity of the specimen at N_{design} gyrations
G_{mm} = Maximum specific gravity of the mix

6. DETERMINATION OF OPTIMUM ASPHALT BINDER CONTENT

6.1 GRAPHICAL PLOT. Prepare a graphical plot for the following values at the various percentages of asphalt binder:

Air Void vs. Asphalt Binder Content
VMA vs. Asphalt Binder Content
VCA vs. Asphalt Binder Content

6.2 PROCEDURE FOR DETERMINING OPTIMUM ASPHALT BINDER CONTENT.

6.2.1 From the graphical plot of the air voids vs. asphalt binder content curve, select the asphalt binder content corresponding to 4.0 percent air voids.

6.2.2 Determine if the selected asphalt binder content meets all the required design criteria in the specifications and that the selected asphalt binder content does not exceed the asphalt binder content at the lowest point of the VMA vs. Asphalt Binder content curve. The mix should be redesigned if these criteria cannot be met**.**

6.2.3 The VCA_{mix} must be less than the VCA_{dr} at the selected asphalt binder content.

7. RESISTANCE TO STRIPPING

7.1 Check the designed mixture in accordance with MT-63 and MT-59 to determine if an antistripping additive will be required.

7.2 If an antistripping additive is required, establish the dosage rate in accordance with MT-63 using samples of the additive to be used on the project.

7.3 Final determination of the requirement for antistripping additive and dosage rate will be established by field testing in accordance with MT-63 and MT-59.

8. RESISTANCE TO DRAINDOWN

8.1 Evaluate the designed mixture's resistance to draindown in accordance with MT- 82. The draindown value must be less than 0.30 percent as established in the specifications.

9. MORTAR EVALUATION

9.1 Evaluate the designed mixture's mortar properties in accordance with MT- 81. The mortar must meet the properties set out in the specifications.

10. REPORT

Submit the mixture design report on Form TMD-042 (or similar type document), and include as a minimum:

10.1 Project Identification Information

10.2 Name of Contractor(s)

10.3 Type and Source of Component Materials

10.4 Job-Mix Formula With All Supporting Test Data (laboratory worksheets).

10.5 Optimum Asphalt Binder Content.

10.6 **PLANT MIXING TEMPERATURE.** Specify the mixture temperature at the discharge from the mixer. State the plant mixing temperature recommended by the polymer modified binder manufacturer, and provide a copy of the manufacturer's recommendation.

10.7 Type, Brand Name, and Dosage Rate of Antistripping Additive. If no additive is required, so state.

10.8 Five (5) preblended batches of the virgin aggregate (batch weights should be such that the proper height specimen is produced in the gyratory compactor).

10.9 One thousand (1000) grams of the stabilizing fiber.

10.10 Two (2) liters of the asphalt binder required for the design.

11. BLENDING BY VOLUME EXAMPLE

With SMA the specific gravities of different aggregate components are not always similar enough to blend based upon weight (mass); this is especially true when comparing mineral fillers to the other aggregates. Therefore, SMA gradation bands are based upon percent passing by volume. An example of blending of three aggregates and a mineral filler is provided. The first step is to determine the aggregate stockpile gradations and specific gravities. This is provided in Table 1:

Table 1

Sieve	Percent Passing (Based on Mass)			
	Aggregate A	Aggregate B	Aggregate C	Mineral Filler
1 in (25 mm)	100.0	100.0	100.0	100.0
¾ in (19 mm)	95.0	100.0	100.0	100.0
½ in (12.5 mm)	66.0	71.1	97.4	100.0
3/8 in (9.5 mm)	43.0	46.0	84.6	100.0
No. 4 (4.75 mm)	9.0	6.0	48.9	100.0
No. 8 (2.36 mm)	5.0	4.5	27.8	100.0
No. 16 (1.18 mm)	2.9	4.0	16.6	100.0
No. 30 (0.6 mm)	2.5	3.4	10.7	100.0
No. 50 (0.3 mm)	2.0	3.0	7.6	96.0
No. 100 (0.15 mm)	1.5	2.5	6.5	83.0
No. 200 (0.075 mm)	1.0	1.5	4.6	72.5
G_{sb}	2.616	2.734	2.736	2.401

The second step is to determine the percent by weight (mass) retained on each individual sieve. For a given sieve this is calculated by subtracting the percent passing the given sieve from the percent passing the next larger sieve. For example, the percent retained on the No. 4 (4.75 mm) sieve for aggregate A is 43 - 9 = 34. This is not a cumulative weight (mass) retained, it is the weight (mass) retained on the individual sieve. Table 2 shows the percent by weight (mass) retained for each individual sieve. The calculations may be checked by totaling each column to 100.

Table 2

Sieve Size	Percent Retained for Individual Sieves (Based on Mass)			
	Aggregate A	Aggregate B	Aggregate C	Mineral Filler
1 in (25 mm)	0.0	0.0	0.0	0.0
3/4 in (19 mm)	5.0	0.0	0.0	0.0
1/2 in (12.5 mm)	29.0	28.9	2.6	0.0
3/8 in (9.5 mm)	23.0	25.1	12.8	0.0
No. 4 (4.75 mm)	34.0	40.0	35.7	0.0
No. 8 (2.36 mm)	4.0	1.5	21.1	0.0
No. 16 (1.18 mm)	2.1	0.5	11.2	0.0
No. 30 (0.6 mm)	0.4	0.6	5.9	0.0
No. 50 (0.3 mm)	0.5	0.4	3.1	4.0
No. 100 (0.15 mm)	0.5	0.5	1.1	13.0
No. 200 (0.075 mm)	0.5	1.0	1.9	10.5
Pan (-0.075 mm)	1.0	1.5	4.6	72.5
TOTAL (S)	100.0	100.0	100.0	100.0

Because each column totals to 100 percent, we can assume 100 g of each aggregate source and know that the amount in grams retained on each individual sieve is equal to the percent retained on each individual sieve. Using this information and the aggregate's bulk specific gravity we can calculate the volume of aggregate on each individual sieve.

Where γ_w is the unit weight of water (in g/cm^3), the volume of aggregate retained on each individual sieve can be determined from the following equation:

$$V_{agg\ retained} = M_{agg\ retained} / (G_{sb} * \gamma_w)$$

Where: $V_{agg\ retained}$ = Aggregate Volume retained on an individual sieve (cm^3)
$M_{agg\ retained}$ = Aggregate Mass retained on an individual sieve (g)
G_{sb} = Aggregate bulk specific gravity
γ_w = Unit weight of water (g/cm^3)

The following shows how the volume is calculated for the aggregate retained on the No. 4 (4.75 mm) sieve for aggregate C.

Volume = 35.7 g / (2.736 * 1 g/cm^3) = 13.05 cm^3

The volume for all sieves is shown in Table 3.

Table 3

Sieve Size	Volume Retained for Individual Sieves			
	Aggregate A	Aggregate B	Aggregate C	Mineral Filler
1 in (25 mm)	0.00	0.00	0.00	0.00
3/4 in (19 mm)	1.91	0.00	0.00	0.00
1/2 in (12.5 mm)	11.09	10.57	0.95	0.00
3/8 in (9.5 mm)	8.79	9.18	4.68	0.00
No. 4 (4.75 mm)	13.00	14.63	13.05	0.00
No. 8 (2.36 mm)	1.53	0.55	7.71	0.00
No. 16 (1.18 mm)	0.80	0.18	4.09	0.00
No. 30 (0.6 mm)	0.15	0.22	2.16	0.00
No. 50 (0.3 mm)	0.19	0.15	1.13	1.67
No. 100 (0.15 mm)	0.19	0.18	0.40	5.41
No. 200 (0.075 mm)	0.19	0.37	0.69	4.37
Pan (-0.075 mm)	0.38	0.55	1.68	30.20
TOTAL	38.23	36.58	36.55	41.65
G_{sb}	2.616	2.734	2.736	2.401
Blend Percentage	30	30	30	10

The values provided in Table 3 are used to blend the different stockpiles to meet the desired gradation based on volumes. In this procedure the aggregate is blended by weight (mass), then the gradation based on volume is determined. This is a trial and error process. To perform the blending, select the estimated percentages by weight (mass) of the different stockpiles to be used.

The blend percentages in Table 3 are based on weight (mass). This indicates that the volume represented by 30 percent by weight (mass) of aggregate A will be used in blending the stockpiles based on volume. The percent of each stockpile in the blend is multiplied by the volume retained on a given sieve for each stockpile to determine the total volume retained on that sieve. For the No. 4 (4.75 mm) sieve, using the volumes and the blend percentages from Table 3, the total volume retained on the No. 4 (4.75 mm) sieve is calculated as follows:

Total Volume Retained = (0.3*13.00) + (0.3*14.63) + (0.3*13.05) + (0.1*0.0) = 12.20 cm^3

This calculation is performed for each sieve in the gradation. Table 4 shows the volume retained for each sieve in the gradation.

Table 4

Sieve Size	Volume Retained per Sieve, cm^3
1 in (25 mm)	0
3/4 in (19 mm)	0.57
1/2 in (12.5 mm)	6.78
3/8 in (9.5 mm)	6.80
No. 4 (4.75 mm)	12.20
No. 8 (2.36 mm)	2.94
No. 16 (1.18 mm)	1.52
No. 30 (0.6 mm)	0.76
No. 50 (0.3 mm)	0.61
No. 100 (0.15 mm)	0.77
No. 200 (0.075 mm)	0.81
Pan (-0.075 mm)	3.80
TOTAL (S)	37.57

Now, based on the total volume retained per sieve and the summed total volume of the blended aggregates, the percent retained per sieve by volume can be determined for the blend. This is accomplished for a given sieve by dividing the volume retained on that sieve by the total volume of the blend. The following equation illustrates this calculation for the No. 4 (4.75 mm) sieve:

% Volume Retained on the No. 4 (4.75 mm) sieve = 12.20 / 37.57 = 32.48 %

Table 5 shows the percent retained by volume for each individual sieve and converts this to percent passing by volume. Percent passing by volume is calculated by subtracting the cumulative percent retained from 100.

Table 5

Sieve Size	Volume Retained per Sieve, cm^3	Percent Retained Per sieve	Cumulative Percent Retained	Percent Passing By Volume
1 in (25 mm)	0	0.00	0.00	100.0
3/4 in (19 mm)	0.57	1.53	1.53	98.5
1/2 in (12.5 mm)	6.78	18.05	19.58	80.4
3/8 in (9.5 mm)	6.80	18.09	37.66	62.3
No. 4 (4.75 mm)	12.20	32.48	70.14	29.9
No. 8 (2.36 mm)	2.94	7.82	77.96	22.0
No. 16 (1.18 mm)	1.52	4.06	82.02	18.0
No. 30 (0.6 mm)	0.76	2.02	84.04	16.0
No. 50 (0.3 mm)	0.61	1.62	85.65	14.3
No. 100 (0.15 mm)	0.77	2.06	87.71	12.3
No. 200 (0.075 mm)	0.81	2.16	89.88	10.1
Pan (-0.075 mm)	3.80	10.12	100.00	0.0
TOTAL (S)	37.57	100.00		

Next, compare the blend's percent passing by volume to the specifications and adjust the blend percentages to best meet the specification gradation specification values. In Table 6, a typical 3/4 in (19 mm) nominal maximum aggregate size gradation is used.

Table 6

Sieve Size	19.0 mm NMS Gradation Band		Percent Passing By Volume
	Lower	Upper	
1 in (25 mm)	100	100	100.0
3/4 in (19 mm)	90	100	98.5
1/2 in (12.5 mm)	50	74	80.4 *
3/8 in (9.5 mm)	25	60	62.3 *
No. 4 (4.75 mm)	20	28	29.9 *
No. 8 (2.36 mm)	16	24	22.0
No. 16 (1.18 mm)	13	21	18.0
No. 30 (0.6 mm)	12	18	16.0
No. 50 (0.3 mm)	12	15	14.3
No. 100 (0.15 mm)	-	-	12.3
No. 200 (0.075 mm)	8.0	10.0	10.1 *
Pan (-0.075 mm)			0.0

The asterisks show the blend is too fine on four sieves. Too correct this, remove 1½ percent of the mineral filler and 20 percent of the fine aggregate (aggregate C), add 6 percent of the coarse aggregate (aggregate B) and 15 1/2 percent of the most coarse aggregate (aggregate A). The revised stockpile percentages are as follows: Aggregate A: 45.5 percent, Aggregate B: 36 percent, Aggregate C: 10 percent and Mineral Filler: 8.5 percent. The revised percent passing by volume is shown in Table 7.

Table 7

Sieve Size	Volume Retained per Sieve, cm^3	Percent Retained Per sieve	Cumulative Percent Retained	Percent Passing By Volume
1 in (25 mm)	0	0.00	0.00	100.0
3/4 in (19 mm)	0.87	2.30	2.30	97.7
1/2 in (12.5 mm)	8.94	23.69	25.99	74.0
3/8 in (9.5 mm)	7.77	20.59	46.58	53.4
No. 4 (4.75 mm)	12.49	33.07	79.65	20.3
No. 8 (2.36 mm)	1.66	4.41	84.06	15.9
No. 16 (1.18 mm)	0.84	2.23	86.29	13.7
No. 30 (0.6 mm)	0.36	0.96	87.25	12.7
No. 50 (0.3 mm)	0.39	1.05	88.30	11.7
No. 100 (0.15 mm)	0.65	1.73	90.03	10.0
No. 200 (0.075 mm)	0.66	1.75	91.77	8.2
Pan (-0.075 mm)	3.11	8.23	100.00	0.0
TOTAL (S)	37.76	100.00		

Table 8 shows the job mix formula by volume and weight (mass) compared to the specification gradation band.

Table 8

Sieve Size	19.0 mm NMS Gradation Band		Percent Passing By Volume	Percent Passing By Weight (Mass)
	Lower	Upper		
1 in (25 mm)	100	100	100.0	100.0
3/4 in (19 mm)	90	100	98	98
1/2 in (12.5 mm)	50	74	74	74
3/8 in (9.5 mm)	25	60	53	53
No. 4 (4.75 mm)	20	28	20	20
No. 8 (2.36 mm)	16	24	16	15*
No. 16 (1.18 mm)	13	21	14	13
No. 30 (0.6 mm)	12	18	13	12
No. 50 (0.3 mm)	12	15	12	11*
No. 100 (0.15 mm)	-	-	10	9
No. 200 (0.075 mm)	8.0	10.0	8.2	7.6*

The percent passing by weight (mass) is used for mix design and job control. The asterisks show why computing percent passing by volume is needed for SMA mixes.

For the final developed aggregate blend determine the VCA_{dr} of the coarse aggregate fraction of the mix according to AASHTO T-19.

Voids in the Coarse Aggregate - Dry-Rodded Condition (VCA_{dr}):

Since the gradation is a 1 in. (25 mm) maximum (3/4 in. or 19 mm nominal maximum), the VCA_{dr} was determined for aggregate retained on the No. 4 (4.75 mm) sieve. The sieve to use as the break point sieve is shown in Section 4.3 of this S.O.P.

The calculation for VCA_{dr} for the blend is shown below:

$$VCA_{dr} = 100 * (G_{ca} * \gamma_w - \gamma_s) / (G_{ca} * \gamma_w)$$
$$VCA_{dr} = 100 * (2.616 * 998 - 1610) / (2.616 * 998) = 38.33\ \%$$

Where,

γ_s = unit weight of the dry rodded coarse aggregate fraction (kg/m^3)
γ_w = unit weight of water (998 kg/m^3)
G_{ca} = bulk specific gravity of the coarse aggregate

Next, the percent VCA of the compacted mix (VCA_{mix}) is calculated. The calculation for the percent VCA_{mix} is shown below. A liquid asphalt binder content of 6.5 percent and a bulk specific gravity of 2.168 for the compacted specimens are used in this example.

$P_{ca} = P_s * P_{abp}$
$P_{ca} = 93.5 * 0.80 = 74.8\ \%$

$VCA_{mix} = 100 – (G_{mb} / G_{ca})*P_{ca}$
$VCA_{mix} = 100 – (2.168 / 2.616) * 74.8 = 38.01$ percent

Where,

P_{ca}	= percent (by weight [mass] total mix) coarse aggregate retained on break point sieve.
P_s	= percent (by weight [mass] total mix) aggregate in the mix
P_{abp}	= percent (by weight [mass] total aggregate) aggregate retained on the break point sieve, expressed as a decimal
G_{mb}	= bulk specific gravity of the compacted specimen
G_{ca}	= bulk specific gravity of the coarse aggregate

The VCA_{mix} is compared to the VCA_{dr}. The VCA_{mix} is less than VCA_{dr}, so this meets specification.

$VCA_{mix} = 38.01 < 38.33 = VCA_{dr}$

MT-83 Volumetric Mix Design Procedure for Open Graded Friction Course Hot Mix Asphalt Using the Superpave Gyratory Compactor

SCOPE: This method establishes the procedure for the volumetric mix design of Open Graded Friction Course (OGFC) asphalt mixtures. The design is based on the volumetric properties of the OGFC including air voids, permeability, voids in the coarse aggregate, and draindown.

1. DEFINITIONS

1.1 OPEN GRADED FRICTION COURSE (OGFC). OGFC is type of hot mix asphalt comprised of a high percent of coarse aggregate and a polymer modified asphalt binder, along with stabilizing fibers.

1.2 VOIDS IN THE COARSE AGGREGATE (VCA). The volume between the coarse aggregate particles, including the fine aggregate, air voids, polymerized liquid asphalt binder, and fiber.

2. REFERENCED TEST METHODS

AASHTO Standards

T 11	Amount of Material Finer than 0.075 mm (No. 200) Sieve
T 19	Unit Weight and Voids in Aggregate
T 27	Sieve Analysis of Fine and Coarse Aggregates
T 84	Specific Gravity and Absorption of Fine Aggregate
T 85	Specific Gravity and Absorption of Coarse Aggregate
T 209	Maximum Specific Gravity of Bituminous Paving Mixtures
T 269	Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
T 312	Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
T313	Determining the Flexural Creep Stiffness of Asphalt Binder Using the Bending Beam Rheometer (BBR)
T315	Determining the Rheological Properties of Asphalt Binder Using a Dynamic Shear Rheometer (DSR)
M320	Specification for Performance Graded Asphalt Binder

ASTM Standards

D 6752	Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Automatic Vacuum Sealing Method
D 3289	Standard Test Method for Density of Semi-Solid and Solid Bituminous Materials (Nickel Crucible Method)

Mississippi Test Methods

MT-24	Determination of the Specific Gravity of Fine Aggregate Using the Le Chatelier Flask
MT-59	Determination of Loss of Coating of HMA (Boiling Water Test)
MT-63	Resistance of Paving Mixtures to Stripping (Vacuum Saturation Method)
MT-82	Draindown Testing of Stone Matrix Asphalt (SMA) Mixtures
MT-84	Permeability of Open Graded Friction Course Asphalt Mixtures
MT-85	Abrasion Testing of Open Graded Friction Course Asphalt Mixtures

3. APPARATUS

The apparatus required for the design of Open Graded Friction Course (OGFC) mixtures are those set out in the standards listed in Section 2 of this S.O.P.

4. PROCEDURE

4.1 GRADATIONS. Perform sieve analysis for the coarse and fine aggregate component sizes according to AASHTO T 27 and T 11.

4.2 AGGREGATE SPECIFIC GRAVITIES. Perform a minimum of two specific gravity tests on each aggregate according to AASHTO T 84 and T 85, on the hydrated lime according to MT-24 or ASTM C 604, and the asphalt binder according to ASTM D 3289 (77/77°F). If an aggregate has greater than 25 percent passing the No. 4 sieve and greater than 25 percent retained on the No. 4 sieve, conduct both a coarse and fine aggregate specific gravity on the material and combine the results according to equation in Section 5.1. Modify AASHTO T 84 as follows:

a. Conduct tests on washed material passing the break point sieve. (See 4.3)
b. Conduct the drying for the SSD determination in a flat bottom pan in which moisture is easily visible on the bottom.
c. Define the SSD point at the time when moisture is no longer visible in the bottom of the pan when the material is moved across the bottom, the material is free flowing during this movement, and the surface of the aggregate does not change color with stirring.

4.3 REQUIRED AGGREGATE BLEND. Determine by trial and error method, the percentages of each aggregate necessary to produce a blended material meeting the gradation requirements of the specifications.

Determine the dry rodded unit weight of the coarse aggregate fraction of the aggregate blend in accordance with AASHTO T 19. This value will be used to calculate VCA_{dr}. The coarse aggregate fraction consists of all aggregate retained on the break point sieve in the aggregate blend. The following table indicates the break point sieves for various nominal maximum size OGFC mixes.

Mixture Size (NMS)	Break Point Sieve
½ in (12.5 mm)	No. 4 (4.75 mm)
3/8 in (9.5 mm)	No. 8 (2.36 mm)

The calculation of the VCA_{dr} for the blend is given as follows:

$$VCA_{dr} = \left(\frac{G_{ca}\gamma_w - \gamma_s}{G_{ca}\gamma_w} \right) 100$$

Where:
VCA_{dr} = voids in coarse aggregate in a dry rodded condition
G_{ca} = bulk specific gravity of coarse aggregate (retained on the break point sieve)
γ_w = unit weight of water (62.4 lbs/ft^3)
γ_s = unit weight of the coarse aggregate fraction in the dry-rodded condition (lbs/ft^3)

4.4 PREPARATION OF GYRATORY TEST SPECIMENS.

4.4.1 General. Prepare a minimum of four (4) sets of Gyratory specimens with asphalt binder content at 0.5 percent intervals. Prepare the sets such that at least one set is above the optimum asphalt content and one set is below the optimum asphalt content. Each set shall consist of a minimum of three (3) specimens.

4.4.2 Preparation of Aggregates. Dry each aggregate component to be used in the mixture to constant mass in an oven at a temperature of 230 ± 9ºF.

Estimate the mass of each aggregate component required to produce a batch that will result in a compacted specimen of correct size. For gyratory compacted specimens the correct size is 150 mm in diameter and approximately 115 mm in height. (**Note**: It is generally desirable to prepare a trial specimen prior to preparing all the aggregate batches. If the trial specimen does not meet the height requirement, adjust the amount of material used for the specimens accordingly).

Separate each individual aggregate into the appropriate sizes as follows:

3/4" to 1/2"
1/2" to 3/8"
3/8" to No. 4
No. 4 to No. 8
Passing No. 8

If any of the size fractions represent less than 5 percent of the individual aggregate, they may be combined with the next smaller size fraction.

Weigh cumulatively into a separate pan for each test specimen the required quantity of each aggregate component.

A minimum of eight (8) pans of the batched aggregates will be needed for the test specimens. Additionally, two (2) pans will be required for the maximum specific gravity (G_{mm}) samples.

Place the asphalt binder to be used in an oven and heat to mixing temperature. Since polymer modified asphalt binders will be used, use the manufacturer's recommended mixing temperature.

Place the pans of batched aggregates in the oven and heat to mixing temperature, but not to exceed 50ºF above the required mixing temperature. Stabilizing fiber is added to the aggregate blend at the time of mixing. Do not add the fiber to the aggregate prior to heating.

Charge the mixing bowl with the heated aggregate in one pan and dry mix thoroughly. Add the required amount of the stabilizing fiber and mix thoroughly. If the fiber is not thoroughly mixed with the aggregate prior to the addition of the liquid asphalt binder, the fiber will clump and the results will be invalid. Once the aggregate and fiber are thoroughly mixed, form a crater in the aggregate/fiber blend and weigh the required amount of heated asphalt binder into the mixture. Mechanically mix the aggregate, asphalt binder, and stabilizing fiber as quickly and thoroughly as possible to yield a paving mix having a uniform distribution of asphalt binder and fiber.

After completion of mixing, place the mix in a curing oven at 5ºF to 10ºF above compaction temperature for approximately 1-1/2 hours in a round (6.5" to 7.5" in diameter) covered container to allow for absorption. A 10# ink can from Inmark Inc. (205-856-9077) or a paint can without a top lip has been found suitable for aging the mixture. Use the binder manufacturer's recommended compaction temperature.

4.4.3 Compaction of Gyratory Test Specimens. Check the calibration of the Gyratory compactor in accordance with Operations Manual. (It is recommended that this be performed on at least a monthly basis.) Maintain records of calibration results and adjustments to the equipment. Verify 600 kPa ± 18 kPa ram pressure with load cell. Verify 1.16 ± 0.02° internal angle tilt setting. Verify height calibration using

spacer provided by manufacturer. Set number of gyrations to N_{design} (50 gyrations). Set dwell at the appropriate number of gyrations or dwell time, according to manufacturer's instructions. This is typically 5 gyrations for most Troxler compactors, or 5 seconds for most Pine compactors. Other manufacturers are similar.

Place a compaction mold and base plate in curing oven for 30 to 60 minutes prior to the estimated beginning of compaction (during the absorption period).

After completion of absorption period, remove the heated mold and base plate from the oven and place a paper disc on the bottom of the mold.

Remove a container of mixture from the oven and place the mixture into the mold in one lift by pouring uniformly through a funnel, taking care to avoid segregation in the mold. After all the mix is in the mold, level the mix, check for compaction temperature and place another paper disc on top of the leveled material. Load the specimen mold with the paving mix into the compactor and center the mold under the loading ram.

Lower the ram until the pressure on the specimen reaches 600 kPa ± 18 kPa. Begin compaction.

Record specimen height after each revolution to the nearest 0.1 mm. Continue compaction until N_{design} gyrations are reached and the gyratory mechanism shuts off.

Remove the angle from the mold assembly, apply dwell gyrations, raise the loading ram, remove mold from the compactor, provide a cooling period of 10 ± 2 minutes for the mold and specimen in front of a fan, extrude the specimen from the mold and immediately remove the paper discs from top and bottom of the specimen.

After specimen cools to room temperature, weigh and record the mass of the extruded specimen, $W_{m,}$ to the nearest gram.

Determine the required characteristics of the compacted mixture at N_{design} including but not limited to bulk specific gravity, permeability, and abrasion loss.

Repeat procedures in Subsection 4.4.3 for each Gyratory test specimen.

4.4.4 Specific Gravity of Compacted Specimens (G_{mb}). Determine the specific gravity of the compacted specimens according to ASTM D 6752-02a.

4.4.5 Maximum Specific Gravity of Bituminous Mixture (G_{mm}). Determine the maximum specific gravity according to AASHTO T 209, in duplicate, at an asphalt content near the expected optimum level, and average the results. Perform this test on samples that have completed the absorption period. (See Subsection 4.4.2).

5. COMPUTATIONS

5.1 BULK SPECIFIC GRAVITIES OF BLENDED AGGREGATE. When the total aggregate consists of separate fractions of coarse aggregate, fine aggregate, and hydrated lime, all having different specific gravities, the bulk specific gravity (G_{sb}) for the total blended aggregate is calculated as follows:

$$G_{sb} = \frac{P_1+P_2+....+P_n}{\frac{P_1}{G_1}+\frac{P_2}{G_2}+....+\frac{P_n}{G_n}}$$

Where: G_{sb} = bulk specific gravity of the total aggregate
P_1, P_2, P_n = percentages by mass of aggregates 1, 2, n

G_1, G_2, G_n = bulk specific gravities of aggregates 1, 2, n
(**Note:** The apparent specific gravity of hydrated lime shall be used in lieu of the bulk specific gravity)

5.2 EFFECTIVE SPECIFIC GRAVITY OF AGGREGATE. The effective specific gravity of the aggregate, G_{se}, is determined as follows:

$$G_{se} = \frac{100 - P_b}{\left(\frac{100}{G_{mm}}\right) - \left(\frac{P_b}{G_b}\right)}$$

Where:
G_{se} = effective specific gravity of aggregate
P_b = asphalt binder, percent by mass of mixture
G_{mm} = maximum specific gravity of paving mixture
G_b = specific gravity of asphalt binder at 25°C

Note: The volume of asphalt binder absorbed by an aggregate is almost invariably less than the volume of water absorbed. Consequently, the value for the effective specific gravity of an aggregate should be between its bulk and apparent specific gravities. When the effective specific gravity falls outside these limits, its value must be assumed to be incorrect. The calculations, the maximum specific gravity of the total mix by AASHTO T 209, and the composition of the mix in terms of aggregate and total asphalt binder content, should then be rechecked for the source of the error.

5.3 MAXIMUM SPECIFIC GRAVITY OF MIXTURES WITH DIFFERENT ASPHALT BINDER CONTENT. In designing a paving mixture with a given aggregate, the maximum specific gravities, G_{mm}, at different asphalt binder contents are needed to calculate the percentage of air voids for each asphalt binder content. After calculating the effective specific gravity of the aggregate, the maximum specific gravity for any other asphalt binder content can be obtained as shown below. For all practical purposes, the effective specific gravity of the aggregate is constant because the asphalt binder absorption does not vary appreciably with variations in asphalt binder content.

$$G_{mm} = \frac{100}{\left(\frac{P_s}{G_{se}}\right) + \left(\frac{P_b}{G_b}\right)}$$

Where:
G_{mm} = maximum specific gravity of paving mixture (no air voids)
P_s = aggregate, percent by total mass of mixture = (100 – P_b)
P_b = asphalt binder, percent by total mass of mixture
G_{se} = effective specific gravity of aggregate
G_b = specific gravity of asphalt binder

5.4 ASPHALT BINDER ABSORPTION. Asphalt binder absorption, P_{ba}, expressed as a percentage by mass of aggregate is determined as follows:

$$P_{ba} = 100\left(\frac{G_{se} - G_{sb}}{G_{sb}G_{se}}\right)G_b$$

Where:
P_{ba} = absorbed asphalt binder, percent by mass of aggregate
G_{se} = effective specific gravity of aggregate
G_{sb} = bulk specific gravity of aggregate
G_b = specific gravity of asphalt binder

5.5 EFFECTIVE ASPHALT BINDER CONTENT OF A PAVING MIXTURE. The effective asphalt binder content, P_{be}, of a paving mixture is determined as follows:

$$P_{be} = P_b - \left(\frac{P_{ba}}{100}\right) P_s$$

Where:
- P_{be} = effective asphalt binder content, percent by mass of mixture
- P_b = total asphalt binder content, percent by mass of mixture
- P_{ba} = absorbed asphalt binder, percent by mass of aggregate
- P_s = aggregate, percent by mass of mixture, = (100 - P_b)

5.6 PERCENT VCA IN COMPACTED PAVING MIXTURE (VCA_{MIX}). The voids in the coarse aggregate, VCA_{mix}, is determined as follows:

$$VCA_{mix} = 100 - \left(\frac{G_{mb}}{G_{ca}}\right) P_{ca}$$

Where:
- VCA_{mix} = voids in coarse aggregate of the mixture
- G_{ca} = bulk specific gravity of coarse aggregate
- G_{mb} = bulk specific gravity of compacted mixture (AASHTO T 166)
- P_{ca} = percent coarse aggregate in mix by weight of total mix

5.7 CALCULATION OF PERCENT AIR VOIDS IN COMPACTED MIXTURE. The air voids, P_a, in a compacted paving mixture is determined as follows:

$$P_a = 100\left(\frac{G_{mm} - G_{mb}}{G_{mm}}\right), \quad \text{or} \quad P_a = 100\left[1 - \left(\frac{G_{mb}}{G_{mm}}\right)\right]$$

Where:
- P_a = air voids in compacted mixture, percent of total volume
- G_{mm} = maximum specific gravity of paving mixture (or as determined directly for a paving mixture by AASHTO T 209)
- G_{mb} = bulk specific gravity of compacted mixture

6. DETERMINATION OF OPTIMUM ASPHALT BINDER CONTENT

6.1 PROCEDURE FOR DETERMINING MINIMUM ASPHALT BINDER CONTENT.

6.1.1 Asphalt content must meet minimum specification requirements as determined by the bulk specific gravity of the combined aggregate blend.

6.1.2 The VCA_{mix} must be less than the VCA_{dr} at the selected asphalt binder content.

6.2 Procedure For Determining Optimum Asphalt Binder Content

6.2.1. The asphalt content that meets the following criteria shall be selected as optimum asphalt content:

1. Air voids shall be a minimum of 15 percent as determined by ASTM D 6752.

2. The minimum laboratory permeability shall be 30 meters per day as determined by MT-84.

3. Asphalt binder draindown shall not exceed 0.3 percent tested in accordance with MT-82.

4. Aged abrasion loss shall not exceed 40 percent and unaged abrasion loss shall not exceed 30 percent as determined by MT-85.

7. RESISTANCE TO STRIPPING

7.1 Check the designed mixture in accordance with MT-63 and MT-59 to determine if an antistripping additive will be required.

7.2 If an antistripping additive is required, establish the dosage rate in accordance with MT-63 using samples of the additive to be used on the project.

7.3 Final determination of the requirement for antistripping additive and dosage rate will be established by field testing in accordance with MT-63 and MT-59.

8. RESISTANCE TO DRAINDOWN

8.1 Evaluate the designed mixture's resistance to draindown in accordance with MT- 82. The draindown value must be less than 0.30 percent as established in the specifications.

9. PERMEABILITY

9.1 Evaluate the designed mixtures permeability in accordance with MT-84. Permeability must meet the minimum requirements of 30 m/day.

10. REPORT

Submit the mixture design report on Form TMD-042 (or similar type document), and include as a minimum:

10.1 Project Identification Information

10.2 Name of Contractor(s)

10.3 Type and Source of Component Materials

10.4 Job-Mix Formula With All Supporting Test Data (laboratory worksheets).

10.5 Design Asphalt Binder Content.

10.6 **PLANT MIXING TEMPERATURE.** Specify the mixture temperature at the discharge from the mixer. State the plant mixing temperature recommended by the polymer modified binder manufacturer, and provide a copy of the manufacturer's recommendation.

10.7 Type, Brand Name, and Dosage Rate of Antistripping Additive. If no additive is required, so state.

10.8 Seven (7) preblended batches of the virgin aggregate (batch weights should be such that the proper height specimen is produced in the gyratory compactor).

10.9 One thousand (1000) grams of the stabilizing fiber.

10.10 Two (2) liters of the asphalt binder required for the design.

Excerpt from *Materials Division Inspection, Certification Manual*

V 1.0, October 2005

Section 2.1.2 Performance Graded Asphalt Binders

(Replaced TMD-22-07-00-000)

2.1.2 Performance Graded Asphalt Binders – The following section establishes uniform policies and procedures for the sampling, testing, inspection, certification, and acceptance of Performance Graded Asphalt Binders (PGAB) for use in hot-mix asphalt pavement work under the supervision of the Mississippi Department of Transportation.

2.1.2.1 General – Section 2.1.2 specifies requirements and procedures for a certification system that shall be applicable to all suppliers of performance graded asphalt binder. The requirements and procedures shall apply to materials that meet the requirements of AASHTO M 320, Section 5, Materials and Manufacture, and which are manufactured at refineries or mixed at terminals.

2.1.2.2 Referenced Documents – The following is a list of documents referenced in this section (Section 2.1.2):

AASHTO STANDARDS:

M 320—Specification for performance Graded Asphalt Binders

R 29—Practice for Grading or Verifying the Performance Grade of an Asphalt Binder

T 40—Sampling of Bituminous Materials

ASTM STANDARDS:

D 8—Definitions of Terms Relating to Materials for Road and Pavements

D 3665—Random Sampling of Construction Materials

MISSISSIPPI SPECIFICATIONS:

Mississippi Standard Specifications for Road and Bridge Construction, 2004 Edition

Mississippi Standard Specifications for Road and Bridge Construction, 1990 Edition

Mississippi Standard Specifications for Road and Bridge Construction, 1996 Metric Edition

Applicable Notice to Bidders, Special Provisions and Supplemental Specifications

2.1.2.3 Terminology – The following is a list of terms referenced in this section (Section 2.1.2):

AAP—AASHTO Accreditation Program

AMRL—AASHTO Materials Reference Laboratory

Asphalt Binder—an asphalt-based cement that is produced from petroleum residue

either with or without the addition of non-particulate organic modifiers.

ASC—Approved Supplier Certification

HMA—Hot Mix Asphalt

PGAB—Performance Graded Asphalt Binder

MDOT—Mississippi Department of Transportation

Supplier—A Supplier shall be defined as one who produces the final product or who makes the blend or modification that alters the properties of the binder to produce the PGAB specified in AASHTO M 320. A Supplier shall be a refinery or a terminal. If no modification is made to the PGAB after its initial production at the refinery, the refinery shall be the Supplier and must provide the certification. If any modification is made to the PGAB at the terminal, the terminal shall be the Supplier and must provide the certification. No modification of the PGAB will be allowed after delivery to the HMA plant.

Note 1: Various refining techniques can produce equivalent PGAB; however, these asphalts may be incompatible with each other. Suppliers shall confirm compatibility through testing before combining asphalts from different sources.

Specification Compliance Testing—Complete testing in accordance with AASHTO M 320 specification requirements. The procedure for verification of PGAB as described in AASHTO R 29 shall be followed.

Quality Control Testing—The quality control testing shall be described in the Supplier's quality control plan. The Supplier's quality control plan shall be approved by MDOT.

Note 2: Definitions for many terms common to asphalt binder are found in ASTM D 8.

2.1.2.4 Significance and Use – This standard specifies procedures for determining specification compliance of PGAB by a certification system that evaluates quality control and specification compliance tests performed by the Supplier on samples obtained prior to shipment, and verification testing performed by MDOT. Following are activities covered within this

provision:

General requirements that the Supplier shall satisfy to be given approved-supplier status.
Minimum requirements that shall be included in a Supplier's quality control plan.
General requirements that MDOT shall satisfy before certification.
Procedure for shipping PGAB under an ASC system.
Procedure for MDOT monitoring of an ASC system at the shipping facility and HMA facility.
Procedure for field sampling and testing of PGAB shipped under an ASC system.

2.1.2.5 Sampling – All test samples required by this standard shall be obtained in accordance with AASHTO T 40 and ASTM D 3665. The use of a random sampling procedure is mandatory to the establishment of a valid certification program.

2.1.2.6 Testing Requirements – All testing required for this standard shall be performed by a laboratory currently approved by the Materials Division of MDOT. Inspection by AMRL and/or participation in an AMRL or MDOT proficiency samples program shall be used as the basis for approval. AMRL inspection reports along with documentation of resolution of discrepancies in the AMRL report must be provided upon request. In addition, MDOT shall require that the certifying technician participate in a bituminous technician certification program.

2.1.2.7 Supplier Requirements

The Supplier shall submit a written request to the Materials Division of MDOT for authorization to ship PGAB under the ASC system and shall list the PGAB to which the request applies. The Supplier shall allow MDOT representatives to visit the production and/or shipping site to observe the Supplier's quality control activities, to inspect the facilities and to obtain samples for test.

The Supplier shall submit to MDOT for approval a complete quality control plan that complies with the requirements of Section 2.1.2.7(1). The Supplier shall follow the procedures described in the approved quality control plan.

The Supplier shall establish a continuing test record for each test required on each PGAB included in the written request prepared to satisfy the requirements of Section 2.1.2.7.1.

The Supplier shall forward to MDOT the initial series of test data for each performance

grade included in the written request prepared to satisfy the requirements of Section 2.1.2.7.1. The Supplier shall also obtain and provide a split sample for MDOT. For polymer modified PGAB, a written procedure for reheating the sample for testing shall be supplied with the sample.

The Supplier shall submit to MDOT all reports required by this Section 2.1.2 in a form approved by MDOT. A copy of each required report shall be submitted with the Supplier quality control plan for approval.

The Supplier shall have a satisfactory record of compliance with governing specifications. Judgments by MDOT concerning this requirement shall be based on the test results furnished by the Supplier and satisfactory results when the monitoring and field tests are compared with supplier tests.

2.1.2.8 Supplier Quality Control Plan (Minimum Requirements)

2.1.2.8.1 The Supplier's Quality Control Plan shall identify the following:

Facility type (refinery or terminal).
Facility location.
Name and telephone number of the person responsible for quality control at the facility.
The quality control tests to be performed on each PGAB.
Name, address and location of the laboratory performing quality control tests on the PGAB that is shipped.

2.1.2.8.2 The Supplier's Quality Control Plan shall include a declaration stating that if a test result indicates that a shipment of PGAB is not in compliance with the specifications, the Supplier shall:

Immediately notify MDOT of the shipment in question;
Identify the material;
Cease shipment until the material complies with the specifications;
Notify MDOT when shipment resumes;
Implement any mutually agreed upon procedures for the disposition of the material.

2.1.2.8.3 The Supplier's Quality Control Plan shall include procedures that will be taken in the

disposition of any shipment(s) of PGAB not in compliance with the specifications.

2.1.2.8.4 The Supplier's Quality Control Plan shall describe method and frequency for quality control testing and specification compliance testing.

(1) Specification Compliance Testing:

a. INITIAL TESTING: For each PGAB to be supplied, specification compliance testing (complete AASHTO M 320 testing) shall be performed for at least three consecutive lots. A lot may be a fixed batch of material or a specified quantity in a continuous operation (see Note 3). The Supplier and MDOT shall agree on a lot size. MDOT must approve any change to a lot size.

NOTE 3--If a batch operation is used to manufacture the PGAB, a tank will be defined as a lot and the lot size will be the amount of material batched into the tank. If a continuous process (in-line blending or shipment from "live" tanks) is used to manufacture the PGAB, the lot size will be obtained at random during the production for continuous operations. Lot size shall depend on the production method used and the quantity of the PGAB produced. High productions of PGAB will usually have larger lot sizes than low productions of PGAB.

b. Reduced Frequency of Testing for Specification Compliance: If approved by MDOT, the frequency of testing for specification compliance may be decreased to every other lot if the individual AASHTO M 320 test result for every sample of the initial testing is within specification by at least the tolerance of the test method for each of the required test methods. If the tolerance criterion is not met, every lot will continue to be tested for the individual AASHTO M 320 properties until three consecutive lots comply with the tolerance criterion.

(2) Quality Control Testing for Guiding Manufacturer: At least two AASHTO M 320 tests shall be used for monitoring high and low temperature properties of each PGAB. Non-M 320 tests may be used for guiding manufacturer, if approved by MDOT. The use of non-AASHTO M 320 tests does not preclude

the need to meet AASHTO M 320 specifications or to run complete M 320 tests according to the guidelines in this section.

2.1.2.8.5 The Supplier's Quality Control Plan shall include a statement that the Supplier will prepare quarterly summary reports for all quality control and specification compliance tests performed during that period and will submit them to MDOT.

2.1.2.8.6 The Supplier's Quality Control Plan shall provide an outline of the procedure to be followed for checking transport vehicles before loading to prevent contamination of shipments. The outline shall include a statement that the transport vehicle inspection report, signed by the responsible inspector, shall be maintained in the Supplier's records and shall be made available to MDOT on request.

2.1.2.8.7 For each lot of PGAB, the Supplier shall develop a temperature-viscosity curve. A copy of the curve shall be distributed with each copy of the bill of lading.

2.1.2.9 HMA Producer Responsibilities

(1) The HMA producer shall insure that all PGAB incorporated in the work conforms to the requirements of Section 2.1.2 of this manual, and is purchased from an MDOT Approved Supplier.

(2) The HMA producer shall insure that the PGAB does not become mixed with other grades of binders or otherwise contaminated after delivery.

(3) When the HMA producer owns and/or operates the transport vehicles, the HMA producer shall provide the transport vehicle inspection report required in Section 2.1.2.8.6.

2.1.2.10 MDOT Responsibilities

(1) MDOT shall verify that the Supplier's quality control plan is adequate. MDOT representatives may visit the shipping site when necessary.

(2) When approved, MDOT shall notify the Supplier that the Supplier's application for ASC status has been granted. The notification shall include a list of the PGAB

covered. When an application has been denied, MDOT shall provide such notification to the Supplier with reasons for denial.

(3) MDOT shall determine approval status of the Supplier's testing laboratory.

(4) MDOT may perform split sample testing in accordance with Section 2.1.2.12.

(5) MDOT shall perform quality assurance sampling and testing in accordance with Section 2.1.2.13.

(6) MDOT shall authorize shipment of each listed PGAB under the ASC system only after all ASC requirements have been satisfied.

(7) MDOT may inspect the operations of the Supplier's facility related to the PGAB shipments when necessary.

(8) MDOT shall notify the Supplier when either split sample data versus Supplier sample data does not compare within the limits established in Sections 2.1.2.12 and 2.1.2.13.

NOTE 4—The Supplier and/or the HMA producer may take a split sample of the quality assurance samples for verification of MDOT's results. If a split sample is taken, a third sample shall be taken as a referee. The referee sample shall be retained either by MDOT or by the HMA producer until the quality assurance sample test results are available. If the test results are not disputed, the referee sample may be discarded. However, if the test results are disputed, MDOT shall test the referee sample, and if requested the Supplier shall be allowed to witness the referee testing. The results of the referee sample testing shall be binding.

(9) MDOT representative at the HMA plant shall develop temperature-viscosity curve on samples taken at random at a minimum frequency of one sample per 100,000 gallons of PGAB incorporated in the work. The temperature-viscosity curve shall be compared to the applicable Supplier's curve for determination of uniformity. If the viscosity range at compaction and/or mixing temperature varies by more than 10ºF, a sample shall be submitted to the Materials Division for complete analysis for determination of compliance to specifications**.**

2.1.2.11 Requirements for Shipping PGAB by an ASC Supplier

(1) The Supplier's quality control plan as approved by MDOT (see Section 2.1.2.8) shall be implemented.

(2) The Supplier shall make PGAB shipments covered by the certification as dictated by shipping schedules. A certificate "A" or "B" as required in Section 2.1.1.2, Bituminous Materials shall be furnished with each shipment.

(3) If the specification compliance test results do not conform to PGAB specifications, the Supplier shall remove the noncompliant material from the shipping queue as outlined in Section 2.1.2.8.2

(4) Based on MDOT assurance testing or the referee sample testing compromise (see NOTE 4), penalties shall be assessed for material that does not comply with the specified PGAB requirements. The penalty shall be determined by MDOT. If problems with the PGAB recur at the HMA plant, MDOT may suspend use of the PGAB until the cause for noncompliance with specifications can be identified and corrected.

2.1.2.12 Split Sample Testing Requirements

MDOT shall test split samples that are obtained at random from the Supplier's facility at a minimum frequency of one sample each ninety (90) days.

NOTE 5--Split samples shall be obtained from the same general points in the Supplier's shipping process that the Supplier's samples are taken; for example, from a storage tank at the refinery, from a holding tank at a terminal, or from a loading line down from the blending operation of an in-line blending process.

If the split sample data and the Supplier test data are not within the test tolerance specified in the applicable test standards, an immediate investigation shall be conducted to determine the reason for the difference between the data. Unless available facts indicate otherwise, the investigation shall include a review of sampling and testing procedures of both Supplier and MDOT.

2.1.2.13 Field Sampling Requirements

MDOT shall obtain samples from the field facility on a random basis for the purpose of quality assurance at a minimum frequency of one sample per 200,000 gallons of PGAB. Additional samples may be obtained by either MDOT or the HMA producer.

NOTE 6—Field samples may be taken for several purposes: To determine the type and magnitude of any changes in the properties of the PGAB during transportation and storage; to determine that the material received in the field is the material ordered; or to verify that the quality control/quality assurance system is performing as intended.

If the field test data are not within tolerance, MDOT shall immediately notify the HMA producer. Unless available facts indicate otherwise, an investigation shall be conducted that shall include a review of quality control and sampling and testing procedures for field sampling and split sampling. When the differences are not readily resolved, all facts available to identify the problem shall be used to decide on an appropriate course of corrective action.

If the PGAB fails to comply with the specifications, the HMA producer and Supplier shall be notified immediately. The HMA producer shall suspend operations immediately. The HMA producer and Supplier shall immediately investigate the possibility of contamination in transport vehicles, field storage tanks, pumps, lines and at handling facilities or other causes, and take appropriate action to correct the problem. When it is determined that the PGAB is back in compliance with specifications, operations may resume. Any mixture placed containing noncompliant PGAB shall be accepted in accordance with Section 105.03 of the Mississippi Standard Specifications for Road and Bridge Construction.

2.1.2.14 Reports and Data Sheets

2.1.2.14.1 Supplier Reports - The Supplier shall prepare the reports described in Sections 2.1.2.7.1, 2.1.2.7.3, 2.1.2.7.6, 2.1.2.8.2, 2.1.2.8.5, 2.1.2.8.6, 2.1.2.11.2, and 2.1.2.11.3.

2.1.2.14.2 MDOT Reports

(1) The Supplier may request copies of the split sample test results and field test data.

(2) MDOT Project Engineers shall maintain a log of Certificates ("A" or "B") on an Asphalt Certificate Summary. A copy of an example form may be obtained from the MDOT intranet website or the www.goMDOT.com website. A SiteManager Sample Record shall be completed with all applicable information and the appropriate template (FFO-617--"Report of Asphalt Shipped by Certificate"). The sample record and template should represent the total amount of certified Asphalt listed on the asphalt summary. A copy of the Summary Log shall be maintained by the project engineer.

(3) County or LPA Project Engineers shall submit a Pretested Materials Shipment Report Request Form to the Central Lab for each project listing each Certificate "A" or Certificate "B" that was received from the Asphalt Binder Source. The form shall include:

The binder's source name
The terminal location
The type material
The certificate number
The total number of gallons from the certification that were received during the requested reporting period.

The form may be forwarded as the project progresses, or at the end of construction. A copy of the form may be obtained from the www.goMDOT.com website under the *Business Section*, or by request to the Materials Division. Upon receipt of the form, the Materials Division will issue a SiteManager Report of the applicable material(s).

Excerpt from *Materials Division Inspection, Certification Manual*

V 1.0, October 2005

Section 1.3.3 MDOT Hot Mix Asphalt Technician Certification Program

(Replaced TMD-22-10-00-000)

1.3.3 MDOT Hot Mix Asphalt Technician Certification Program

1.3.3.1 Scope

The goals of this program are to provide a group of experienced technicians to design, test and monitor hot mix asphalt (HMA) mixtures used as part of the Mississippi Quality Management Program (QMP). The intent of this program is to improve the quality and performance of hot mix asphalt pavements through knowledge and understanding of the product. The program will provide for the certification for three levels of technicians. These levels include CAT-I Testing Technician, CAT-II Quality Management Technician and CMDT Mixture Design Technician.

1.3.3.2 Program Administration

(1) Board of Directors

The Certification Program will be administered by a board of directors appointed by the Joint MDOT/MAPA Specification Committee. The Board shall consist of four members. At least one member shall be a contractor representative of MAPA and at least one member shall be from the MDOT staff.

(2) Meetings

The Board shall schedule meetings as required to manage the program. Advanced notice of the meetings, agenda and minutes of previous meetings shall be distributed to the Board members as appropriate. Copies of all meeting minutes shall be provided to the Specification Committee.

(3) Responsibilities

The Board will be responsible for all operations with regards to the HMA technician certification program to include, but not be limited to, such items as: the establishment and modification of all class, laboratory training and examination programs; selection of the trainers; review of candidates' background; recertification; and to hear and decide on all complaints about the certification program.

1.3.3.3 Certification Standards

(1) Certified Asphalt Technician - I (CAT-I)

The CAT-I will be responsible for the daily sampling, testing, data calculations, charting and process monitoring at the HMA plant. Prospective candidates will be required to have basic math skills, the ability to use a calculator and meet one of the following experience requirements:

a. A minimum of six months of hands on experience under the supervision of a current CAT-I.

b. A minimum of two years of current experience in the HMA industry doing Quality Control testing.

Certification will be based on the successful completion of a written examination and demonstrated competence in the required field sampling and testing program before an approved CMDT proctor. The hands-on demonstration shall be with a proctor who usually works in a district outside the employee's normal working area.

(2) Certified Asphalt Technician - II (CAT-II)

The CAT-II will be responsible for the successful operations of the quality control program at the HMA plant and the necessary adjustments to the process to maintain the mixture within the required control limits. Prospective candidates shall have successfully completed the CAT-I program. The training will consist of a 2-4 day program of class sessions. Certification will be based on the successful completion of a written examination taken under the supervision of MDOT and/or MAPA.

(3) Certified Mixture Design Technician (CMDT)

The CMDT will be responsible for testing according to MDOT design procedures for the development of a job mix formula for HMA mixtures. Prospective candidates will be required to have basic math skills, the ability to use a calculator and meet one of the following experience requirements:

a. A minimum of three months experience as a CAT-I.

b. A minimum of three months experience under the supervision of a current CMDT.

c. A minimum of two years of current experience in the HMA industry doing Quality Control or Mixture Design testing

The training will consist of a 4 day program of class and laboratory sessions conducted under directive of MDOT or MAPA. Certification will be based on the successful completion of a written examination and the submittal of a mixture design conducted according to MDOT design procedures. Completion of the CMDT certification process will also satisfy the requirements for CAT-I certification.

(4) Master Mixture Design Technician (MMDT)

The MMDT will be responsible for testing according to MDOT design procedures for the development of a job mix formula for HMA mixtures. Prospective candidates will be required achieve the level of CMDT and meet the following criteria:

Professional Engineers: Successfully recertify as a CMDT 5 years after initial certification. Maintain Continuing Education Credits by attending 2 MQACs (Mississippi Quality Asphalt Conferences) in a 5-year period upon achieving the title of MMDT.

Non-Professional Engineers: Successfully recertify as a CMDT 5 and 10 years after initial certification. Maintain Continuing Education Credits by attending 2 MQACs (Mississippi Quality Asphalt Conferences) in a 5-year period upon achieving the title of MMDT.

1.3.3.4 Certification Process

Prospective candidates shall submit a request for certification to the HMA Technician Certification Board of Directors in care of the Mississippi Asphalt Pavement Association. The request must contain the certification level sought and information about the successful completion of the required prerequisites for the requested level. Students will be allowed one retest if they do not pass the written examination portion of the certification process. If they do not pass the second examination, they must retake the entire training program. Students not meeting the demonstration requirements for certification will be allowed to retest after further documented experience under the supervision of a certified technician.

1.3.3.5 Recertification

Certification shall be valid at all levels for a period of five years. Recertification for technicians shall consist of attendance at a one-half day review class and passing a written examination. Mix design submittal will also be required for recertification as a CMDT. Recertification will only be required for the highest level of certification obtained. MMDT recertification examination will not be required as long as continuing education credits are maintained according to Section 1.3.3.3.

1.3.3.6 Certified Technician Responsibilities

Certified Technicians will be required to sign an acknowledgement form before their certificate will be issued. When the technicians sign the form, they acknowledge that they will conduct themselves, in regards to HMA responsibilities, in a professional and honest manner at all times. This means that they will conduct all sampling and testing according to the procedures required for the materials being tested and the specifications for the specific project being constructed. All test results will be calculated and reported accurately according to the required procedures. Failure to comply with these responsibilities may result in the suspension or revocation of certification.

Approved by: ***D.B. McCaa***

S.O.P. No.: **CSD-50-70-54-000** **Mississippi Department of Transportation - Standard Operating Procedures**

Subject: **RANDOM SAMPLING**

Effective Date:	**June 1, 1970**	**Supersedes S.O.P.**	**Dated**
Issued Date:	**June 1, 1970**	**CSD-50-70-54-000**	**June 1, 1970**

Approval Required: ☐ MDOT Legal Division ☐ Federal Highway Administration ☐ Secretary of State

PURPOSE: To Establish Procedures for the Use of Random Numbers for Sampling.

REFERENCE: Subsection 700.04.

As stipulated in the reference Subsection, samples in each lot to be evaluated for acceptance under the statistically based acceptance plan are to be taken by a pre-determined random sampling pattern.

Page 2 of 2 consists of two hundred an eighty (280) pairs of random numbers which are to be used in determining location of samples. Each number is to be considered as a decimal fraction of 1,000. For any lot consisting of an area of work, the random numbers are to be taken from the table in pairs.

The two numbers of each pair are to be used to determine coordinates of the sample within the area, measured from a reference point located at one corner of the area. The first, left, number is to be used as the fraction of the length and the second number is to be used as the fraction of the width.

For example, a section of a course twenty-eight (28) feet wide and nine hundred, seventy-five (975) feet long, extending from Station 450 +00 to Station 459 + 75 is to be tested by the random sampling method. A pair of random decimal numbers are selected without bias from any block, such as the second pair in the block at the intersection of column 2 and brace 5. By multiplying by the decimal fractions as indicated above, the coordinates, in feet, of the sample location would be 176 for length, and 17 for width. Assuming the construction to be progressing from the beginning of project toward the end of project, the sampling location would then be Station 451 + 76, 17 feet from the left edge.

The sampling points should always be located from the left edge of construction regardless of the direction of construction with reference to station numbers. For the purpose of practicality, all computations involving relatively large areas should be rounded off to the nearest foot.

It is understood that the location of the test may be moved for good cause within the square yard, the center of which is the coordinate location, such as in the case of edges, boundary line, joints and surface texture affecting testing equipment seating, etc. In the event it is necessary to move the location of the test site outside of the square yard indicated above, the reason for such location should be documented.

The set of random numbers may also be used for lineal random sampling such as in distance, time, number of trucks, etc.. where width or depth is not involved. In such case, merely use the first decimal fraction of the pair and disregard the second decimal fraction. Likewise, the set of random numbers may be used for random sampling in three (3) dimensions merely by using the first decimal fraction for the first dimension, the second decimal fraction for the second dimension and the first decimal fraction of the next pair for the third dimension.

Approved by: ***D.B. McCaa***

Random Numbers														
	1		2		3		4		5		6		7	
	815	722	048	964	248	826	665	147	767	147	133	870	796	957
	296	205	680	264	469	208	897	815	866	126	922	571	804	252
1	007	573	390	664	846	400	328	613	989	960	647	645	960	982
	053	042	256	264	444	440	379	639	457	661	754	665	346	904
	919	264	641	943	267	259	399	222	715	645	914	424	078	696
	005	047	879	773	422	351	740	995	818	426	438	766	620	766
	007	698	627	561	863	880	762	360	846	931	760	658	779	880
2	690	657	958	552	189	273	265	086	408	599	298	801	127	485
	259	579	298	886	679	487	189	822	654	697	336	542	859	035
	097	834	735	129	308	183	282	357	059	416	349	378	389	880
	915	425	279	301	040	863	298	997	555	848	290	092	796	732
	179	563	909	491	200	599	061	205	180	020	737	835	361	427
3	465	185	188	496	023	510	206	587	281	154	569	533	205	873
	921	896	948	781	846	828	099	254	441	484	255	212	355	204
	145	627	356	812	396	473	568	563	616	495	896	201	774	180
	984	075	333	642	016	924	669	984	048	455	465	041	468	457
	349	639	887	827	344	170	875	408	324	700	706	888	777	693
4	700	282	394	464	232	534	949	258	699	948	196	728	001	667
	539	549	069	672	683	829	113	428	802	882	473	466	065	978
	760	295	409	073	587	257	229	800	399	961	411	142	606	595
	907	522	839	299	658	388	504	837	556	143	317	573	562	415
	643	674	333	319	148	244	597	923	974	892	359	041	237	519
5	089	003	316	253	616	340	812	356	568	693	483	455	785	817
	950	683	935	707	105	045	764	543	023	172	288	147	627	922
	156	104	204	383	911	219	595	816	271	482	467	229	322	856
	164	818	041	533	794	214	830	923	366	312	596	917	727	023
	186	819	055	919	047	130	976	248	947	064	350	048	867	982
6	731	351	474	876	990	710	888	710	187	202	231	729	351	430
	574	167	231	493	450	331	125	410	807	453	448	125	989	912
	304	839	237	144	150	457	227	197	099	743	686	304	707	254
	166	350	859	982	323	523	168	692	827	384	738	325	419	444
	967	202	425	789	053	221	243	542	350	196	110	914	603	197
7	389	642	143	826	665	441	006	355	359	191	633	296	033	598
	316	763	174	533	441	644	647	753	765	316	126	330	603	923
	789	194	236	278	479	025	376	208	721	393	348	089	850	878
	039	333	570	742	634	173	628	399	056	912	688	255	388	469
	744	332	439	101	899	156	528	738	731	886	889	744	518	993
8	090	009	207	954	926	454	095	888	165	511	793	975	162	660
	422	124	870	142	209	045	645	313	860	294	476	059	524	168
	161	080	265	417	819	656	742	563	000	671	775	706	287	341

APPENDIX 2

FORMS

MISSISSIPPI DEPARTMENT OF TRANSPORTATION

QMP HMA

Asphalt Paving Inspectors Daily Report

TMD-004
Rev 3/03

Project No.: _____ County: _____ Contractor: _____ Date: _____

MDOT JMF No. _____ Mix Type: _____ Temperature: AM

PM

Beginning Station No. / Lane

Ending Station No. / Lane

Total Paving Length, ft.

Total Tons Today:

Theor. Tons Today:

Over/Under Today:

INSTRUCTIONS:

Use Table 1 first production day, or bias update day, for density and bias determination.

Fill in Table 2 on bias update days. Use Table 3 on normal production days.

Req. No. Lots

Lot Length, ft.

Table 1

Lot	1	2	3	4	5	6	7	Average
Beginning Station								
Test Location, Sta.								
Offset to rt., ft.								
Core Density, pcf								
Nuclear Density, pcf								
Gauge Bias, pcf								
Max. Den. (Note 1), pcf								
Compaction (Cores), %								
Pay Factor								

Table 2

Prev. Gauge Biases:	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	New Gauge Bias

Table 3

Lot	1	2	3	4	5	6	7
Nuclear Density, pcf							
Location 1							
Location 2							
Location 3							
Location 4							
Location 5							
Average							
Bias							
Corr. Density, pcf							
Max. Den. (Note 1), pcf							
Compaction, %							
Pay Factor (Note 2)							

Lot Compaction

1	2	3	4	5	6	7
Core Density, pcf							

Note 1: Max. Den. = Average Gmm for the day x 62.24

Note 2: Any pay factor < 1.0 must be verified by core density.

Average Daily Compaction: _____

REMARKS: _____

Signed: _____
Paving Inspector

DISTRIBUTION:

Original to State Materials Engineer
Copy to State Construction Engineer
Copy to District Materials Engineer
Copy to Project Engineer

QMP HOT-MIX ASPHALT

Q.A. Mixture Report

TMD-005

Project Number _____

Contractor Report No.'s		M.D.O.T. Dist. Report No.'s	
Day No.	Test No.	Q.A. No.	Lab No.

MDOT Mix No. _____ Type Mix _____ A.C. Source _____ Placed As _____

Contractor _____ Sub-Contr. _____ Agg. BSG. _____ Job Mix AC _____

J. M. VMA _____ J. M. Voids _____ J.M. % Cr. Mat'l. _____ J.M. % L. S. Ret. _____

Producer of Mix _____ % Crush Count _____ % L. S. Ret. _____

Date Produced _____ Date Comparison Made _____

Extraction					Max. Sp. Gr. (Gmm)		
						# 1	# 2
Sample Mass, g					Sam. Mass		
Dry Mass, g					Cali. Mass		
Extr. Mass, g		MDOT	MDOT	Diff. from	Mass in Water		
Job Mix	Sieve Size	Mass Ret.	% Passing	Contr. QC	SSD Mass		
	37.5 mm				Dryback Factor		
	25.0 mm				Max Sp. Gr.		
	19.0 mm				MRCF		
	12.5 mm				Corr. Max. SG		
	9.5 mm					Avg. MSG.	
	4.75 mm						
	2.36 mm						
	1.18 mm						
	600 um						
	300 um						
	75 um						

AC Content / Moisture Corr.	
% AC	
Sample Mass	
Dry Mass	
% Moisture	
% Corr. AC	

Laboratory Compaction / Void Analysis					
Specimen No.	1	2	3	4	Average
Comp. Temp.					**********
Mass in Air					**********
Mass in Water					**********
Mass SSD					**********
Volume					
Bulk Gr.					
Height (N-MAX)					**********
Height (N-DES)					**********
Bulk Gr.(N-DES)					
EQ. Corr. Factor					**********
BRCF					**********
Corr. Bulk Gr.					
Total Voids %					
VMA %					

DESIGN # GYRATIONS

N (ini) = _____

N(des)= _____

N(max)= _____

Core Density (Evaluation Section or Bias Update)								
Lot No.	1	2	3	4	5	6	7	Average
Station No.								**********
Location								**********
Thickness cm.								**********
Mass in Air								**********
Mass in Water								**********
Mass SSD								**********
Volume								
Bulk Sp. Gr.								
Max. Sp. Gr.								
% Density								
Absorption								

Remarks _____

DISTRIBUTION:

Original to State Materials Engineer
Copy to State Construction Engineer
Copy to District Testing Engineer
Copy to Project Engineer
Copy to Producer Lab File

Signed _____

TMD-006

MISSISSIPPI DEPARTMENT OF TRANSPORTATION
QMP HMA
Summary Report of QC Mixture Properties

Project No.: _____ Contractor: _____ Mix: _____

MDOT JMF No. _____ ACsg _____

Date	Tons	Test	AC	AC AVG-4	Gmm	Gmm AVG-4	Gmb	Gmb AVG-4	VOIDS	Voids AVG-4	VMA	VMA AVG-4	Gsb Blend	Crush
		Design												
		1												
		2												
		3												
		4												
		5												
		6												
		7												
		8												
		9												
		10												
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		36												
		37												
		38												
		39												
		40												

TMD-008

MISSISSIPPI DEPARTMENT OF TRANSPORTATION
QMP HMA
Summary Report of QC Gradation Properties

Project No.: _____ Contractor: _____ Mix: _____

MDOT JMF No. _____

Date	Tons	Test	1/2"	1/2" AVG-4	3/8"	3/8" AVG-4	No.8	No.8 AVG-4	No.30	No.30 AVG-4	No.200	No.200 AVG-4
		JMF										
		1										
		2										
		3										
		4										
		5										
		6										
		7										
		8										
		9										
		10										
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		38										
		39										
		40										

HMA DAILY PLANT SAMPLES RANDOM NUMBERS

TMD-020

DATE _____
PROJECT NO. _____
LOT NO. _____
TYPE OF MIX _____

REQUIRED SAMPLE FREQUENCY

TOTAL ESTIMATED PRODUCTION, tons	NUMBER OF TESTS
50-800	1
801-1700	2
1701-2700	3
2701 +	4

TONNAGE PRODUCED PREVIOUS DAY _____

ESTIMATED TONNAGE FOR DAY (A): _____

NUMBER OF SAMPLES REQUIRED (B): _____

ESTIMATED TONNAGE / SAMPLES (A/B) = C: _____

SELECT 4 RANDOM NUMBERS AND ENTER BELOW (4 random numbers should be selected regardless of the number of tests required. Use additional random numbers if production exceeds the estimated tonnage.

RANDOM NO. 1 (R1) _____ SAMPLE TONS 1 = (C x R1) _____

RANDOM NO. 2 (R2) _____ SAMPLE TONS 2 = (C+(C x R2) _____

RANDOM NO. 3 (R3) _____ SAMPLE TONS 3 = (2 x C)+(C x R3) _____

RANDOM NO. 4 (R4) _____ SAMPLE TONS 4 = (3 x C)+(C x RS4) _____

COLD FEED RATES (%)
AGG # 1 _____
AGG # 2 _____
AGG # 3 _____
AGG # 4 _____
AGG # 5 _____
AGG # 6 _____
AGG # 7 _____

IF THE COLD FEED RATES ARE CHANGED MORE THAN 5% FROM THE JMF, RECALCULATE THE COMBINED AGGREGATE BSG AND NOTE THAT CHANGE ON YOUR ASPHALT REPORT

SIGNED _____

TMD-042
Rev. 10/98

MISSISSIPPI DEPARTMENT OF TRANSPORTATION

Bituminous Mix Design for _____ Course
(SIZE - TYPE)

Date: _____

Project No._____ County _____ Contractor _____ Sub-Contr. _____

TEST DATA: ___Original Design ___Revised Design ___Transfer: From Proj. No. _____

MDOT Lab No. _____

Sample No.						Agg. Blend % Passing	Job Mix % Passing	Spec. Design Range
Type Material								
Aggregate Source								
Percent of Material Used in Blend								
Sieve Size	Gradation (Percent by Weight Passing)							
1-1/2"								
1"								
3/4"								
1/2"								
3/8"								
No. 4								
No. 8								
No. 16								
No. 30								
No. 50								
No. 100								
No. 200								
% Clay						Comb. Aggr. Blend Properties		
PI -40 Material							% Total Clay	
% Crushed, + #4							Dust/Binder Ratio	
Apparent SG, Gsa							% Crushed, + #4	
Bulk SG, Gsb							Apparent SG, Gsa	
% Abs. Moisture							Effective SG, Gse	

Gyratory Compaction

Revolutions: Nini = _____ Ndes = _____ Nmax = _____

Compaction Temp. _____ Bulk Spec. Grav. @ Ndes (Gmb) = _____
(ATTACH VISCOSITY CHART)

	Bulk SG, Gsb
	% Abs. Moisture
	Thin & Elong. Pcs., %
	Sand Ratio
Mix Properties @ Ndes	
	Mix Temp.
	Air Voids, Pa, %
	VMA, %
	Absorbed AC by wt. of Total Mix, %
	Effective AC, %
	Max. SG, Gmm (Dry Back)

Analysis of Stripping

TSR = % Visual Stripping = %

Antistrip Addition: ——— Rate = _____ % by wt. of AC Source: _____

Asphalt Cement

Source _____ Grade _____ Spec. Grav. _____

AC (RAP) _____% AC (New) _____% Total AC _%

The percentage of Asphalt Cement of the grade specified above to be used with the above blend of mineral aggregates for the _____Course is _____% by weight of the total mixture.

Remarks: _____

_____

_____
SIGNATURE

QMP INSPECTOR'S CHECKLIST

Contractor_____ Date Inspected _____

Project Number _____ Previous Date Inspected _____

Procedure	Frequency	Compliance (YES/NO)
Bituminous Material (Sampling)	One/100,000 gallons min. (viscosity)	
Mechanically Fractured Face Count	One test/day of production	
Random Number Chart TMD-020	FAXed to QA lab before 9:00 AM each production day	
Daily QA Mixture Tests 1. Mixture Gradation 2. Voids and VMA 3. Asphalt Content	According to Daily Sample Frequency Chart Below	
Stripping Tests (TSR) Boil Test (Visual Stripping)	One at beginning of production, then One/Two weeks production One/Production day	
Stockpile Gradations, RAP Gradations, and Fine Aggregate Angularity Tests	One on first day's production, then One/Eight samples Minimum One/Production week	
QC Charts	Up to date and printed once/day	
Equipment Check	Calibrated and in tolerance	
QC Technicians Present 1. Level I 2. Level II 3. Level III	1. To perform tests 2. To make mix adjustments 3. To make design adjustments	

Daily Sample Frequency Chart

Total Estimated Production (Tons)	Number Tests Required
50 – 800	1
801 – 1700	2
1701 – 2700	3
2701 +	4

Remarks_____
_____
_____
_____
_____
_____

Signed _____ _____

MDOT's QA Inspector Contractor's QC Technician

MISSISSIPPI DEPARTMENT OF TRANSPORTATION
ASPHALT ROADWAY INSPECTION CHECKLIST

Project Number_____ County_____ Date_____

Contractor_____MDOT Inspector(s)_____

Are trucks clean, tight, tarped and with no fluid leaks?	Yes_____	No_____
Are enough trucks provided for a continuous operation?	Yes_____	No_____
Is the holding or prolonged dumping of trucks occurring?	Yes_____	No_____
Is the paver moving at a constant speed?	Yes_____	No_____
Is the temperature being checked at regular intervals?	Yes_____	No_____
Is the inspector visually checking the condition of the mix in the trucks, paver hopper, behind the screed, and behind the rollers?	Yes_____	No_____
Is the mix being compacted while in the tender zone?	Yes_____	No_____
Are the flow gates on the paver set so that the augers run nearly 100% of the time and that the mix stays in the upper quarter of the auger plane?	Yes_____	No_____
Are the paver hopper wings being dumped between trucks?	Yes_____	No_____
Are the flight chains in the paver hopper being exposed at the end of each load?	Yes_____	No_____
Does the paver screed extend full width of the section being paved?	Yes_____	No_____
Is the paver capable of using automatic grade control?	Yes_____	No_____
Is the contractor using an approved profile averaging device?	Yes_____	No_____
Are regular width, depth, slope and quantity checks being made?	Yes_____	No_____
Has all of the roadway equipment been checked for fluid leaks?	Yes_____	No_____
Are the rollers properly equipped with watering devices, scrapers, and pads?	Yes_____	No_____
Are the tires on the pneumatic rollers satisfactory?	Yes_____	No_____
Is diesel fuel being used on rollers to clean or lubricate?	Yes_____	No_____

Has a test strip and an evaluation section been constructed and is the contractor using the rolling pattern established? Yes_____ No_____

Are the following compaction testing procedures in accordance with Chapter 7 of the MDOT Field Manual for Hot Mix Asphalt and latest Special Provision No. 907-401?

Bias determination:	Yes____	Bias	No_____
Updates:	Yes____	Allowable	No_____
bias variations:	Yes_____	Number of	No_____
lots:	Yes_____	Number of	No_____
density test sites:	Yes_____	Removal of	No_____
lots:	Yes_____	Re-evaluating	No_____
corrected lots:	Yes_____		No_____

Are density tests kept current? Yes_____ No_____

Are density tests being made using an approved random number procedure and are the numbers being recorded? Yes_____ No_____

Are cores used only for bias and bias determination for the nuclear gauge? Yes_____ No_____

In case of removal, is the corrected lot retested for approval and determination of a new lot density in accordance with Chapter 7 of the MDOT field manual for Hot Mix Asphalt? Yes_____ No_____

Are the edge joints being tamped? Yes_____ No_____

Where grade stakes are used, has the inspector visually inspected the vertical and horizontal placement of the string? Yes_____ No_____

Is the fresh mix being string-lined for irregularities and surface tolerances? Yes_____ No_____

Are contractor's tickets being properly completed? Yes_____ No_____

Has the roadway been cleaned properly in front of the paving operation? Yes_____ No_____

Is the scrap material from the trucks being cleared from the roadway in front of the paver? Yes_____ No_____

Is the profilograph being run according to the specifications and in the presence of the inspector? Yes_____ No_____

Is the profilograph machine being calibrated on the job site and in the presence of an MDOT representative for each move in? Yes_____ No_____

Is the tack coat being applied in a manner that meets section 401.03.1.2? Yes_____ No_____

REMARKS:

Signed: _____

HMA Field Inspector

MISSISSIPPI DEPARTMENT OF TRANSPORTATION
ASPHALT PLANT INSPECTION CHECKLIST

Plant_____ Project Number_____ County_____
Date_____

1. STOCKPILES

Are stockpiles on a clean, dry, stable foundation?	Yes_____	No_____
Are stockpiles properly separated?	Yes_____	No_____
Is material segregated?	Yes_____	No_____

2. GENERAL REQUIREMENTS FOR PLANTS

Are storage tanks and material properly heated?	Yes_____ Are	No_____
all pipe links and fittings steamed, oil jacketed and	Yes_____ otherwise	No_____
properly insulated to prevent heat loss?		
Is storage tank capacity such as to insure continous operation	Yes_____	No_____
of the plant and uniform temperature of the AC when mixed		
with the aggregates?		
Are liquid AC lines equipped with meter to measure output?	Yes_____ Is	No_____
meter operating properly?	Yes_____	No_____

3. COLD FEED SYSTEM

Are cold feed bins working properly?	Yes_____ Are	No_____
cold feed bins being loaded with no overflow to adjacent	Yes_____ bins?	No_____
Does all reclaimed material pass through a properly located	Yes_____	
two-inch sieve?		No_____
Is feeder for mineral filler furnished with the feeder drive	Yes_____	
positively interlocked and synchronized with aggregate feeds?		No_____
Is lime silo working properly?	Yes_____ Does	
the asphalt material delivery interlock with aggregate	Yes_____ weight	No_____
control?		No_____

4. DUST COLLECTORS AND EMISSION CONTROL STOCKPILES

Is dust collector working properly?	Yes_____ Has	
contractor received permit to operate from EPA?	Yes_____	No_____
		No_____

5. PLANT SCALE AREA

Is plant scale area kept clean?	Yes_____ Are	No_____
scale sections reading in tolerance range?	Yes_____ Are	No_____
batch and platform scale weight tolerance checks made?	Yes_____ Are	No_____
the truck scales checked and certified, or if an electronic	Yes_____ weighing	No_____
system is used, are random loads checked on certified		
platform scales?		
Are ten, fifty (50) pound weights available on site for checking	Yes_____	No_____
scales? (Batch Plants)		

6. ASPHALT TRUCKS

Do the truck beds have holes on both sides for temperature	Yes_____	No_____
checks?		
Are the truck beds clean and in good condition?	Yes_____ Is	No_____
diesel fuel being used to clean and lubricate truck beds?	Yes_____ Is	No_____
a releasing agent being used in the truck beds?	Yes_____ Is	No_____
excess releasing agent being drained from trucks prior to	Yes_____	No_____

loading?
Do trucks have covers to protect asphalt? Yes_____ Is No_____
the temperature of the mix being checked by the contractor? Yes_____ Is No_____
the temperature of the mix being checked by MDOT personnel? Yes_____ No_____

7. SILO/SEMI-BATCH PLANTS
Is a minimum of 20 tons of asphalt kept in the storage bin during normal operations? Yes_____ No_____
Is the storage bin equipped with a material level indicator? Yes_____ Is No_____
the indicator visible from the plant operator's station? Yes_____ Is No_____
the plant equipped with a horn or buzzer to alert the operator insufficient material is in the bin for discharge? Yes_____ that No_____
Are gears, pulleys, chains, sprockets, and other dangerous moving parts thoroughly protected? Yes_____ No_____
Do the doors open and shut smoothly and quickly? Yes_____ Is No_____
the batcher at the top of the silo being used properly (timer or system being used to open/close gates)? Yes_____ weigh No_____
Are trucks being loaded properly? Yes_____ Are No_____
trucks moving during loading? Yes_____ Is No_____
asphalt being dribbled into trucks during loading to obtain maximum weight? Yes No_____
Is mix segregated in truck? Yes_____ No_____

Truck Temperatures _____

WAS PLANT FOREMAN INFORMED OF ANY DEFICIENCIES? Yes_____ No_____

REMARKS:

Signed:_____ _____
Contractor Representative MDOT Plant Inspector

APPENDIX 3

EXAMPLE PROBLEMS

TMD-006

MISSISSIPPI DEPARTMENT OF TRANSPORTATION
QMP HMA
Summary Report of QC Mixture Properties

Project No.: Example No. 1 Contractor: ABC Asphalt, Jackson Mix: ST - 12.5mm

MDOT JMF No. JMF1234 ACsg 1.034

Date	Tons	Test	AC	AC AVE-4	Gmm	Gmm AVE-4	Gmb	Gmb AVE-4	VOIDS	Voids AVE-4	VMA	VMA AVE-4	Gsb Blend	Crush
		Design	5.6		2.480		2.380		4.0		14.6		2.630	95
2/23	432	1	5.72		2.468	2.468	2.384		3.4		14.5		2.630	
2/23	721	2	5.74		2.463	2.466	2.378		3.5		14.8		2.630	96
2/23	1457	3	5.68		2.472	2.468	2.391		3.3		14.3		2.630	
2/24	590	4	5.74	5.72	2.466	2.467	2.385	2.385	3.3	3.4	14.5	14.5	2.630	97
2/24	1323	5	5.62	5.70	2.475	2.469	2.392	2.387	3.4	3.3	14.2	14.4	2.630	
2/25	149	6	5.78	5.71	2.460	2.468	2.393	2.390	2.7	3.2	14.3	14.3	2.630	
2/25	1046	7	5.80	5.74	2.462	2.466	2.395	2.391	2.7	3.0	14.2	14.3	2.630	
2/25	1590	8	5.76	5.74	2.468	2.466	2.394	2.394	3.0	2.9	14.2	14.2	2.630	91
2/26*	683	9	5.82	5.79	2.461	2.463	2.389	2.393	2.9	2.8	14.5	14.3	2.630	
2/26	1234	10	5.62	5.75	2.474	2.466	2.381	2.390	3.8		14.6	14.4	2.630	94
2/27	420	11	5.58	5.70	2.478	2.470	2.386	2.388	3.7		14.3	14.4	2.630	
2/27	1096	12	5.63	5.66	2.472	2.471	2.388	2.386	3.4		14.3	14.4	2.630	96
2/27	1784	13	5.60	5.61	2.470	2.474	2.384	2.385	3.5	3.6	14.4	14.4	2.630	
2/28	349	14	5.64	5.61	2.466	2.472	2.389	2.387	3.1	3.4	14.3	14.3	2.630	91
2/28	1420	15	5.63	5.63	2.470	2.470	2.390	2.388	3.2	3.3	14.2	14.3	2.630	
		16												
		17												
		18												
		19												
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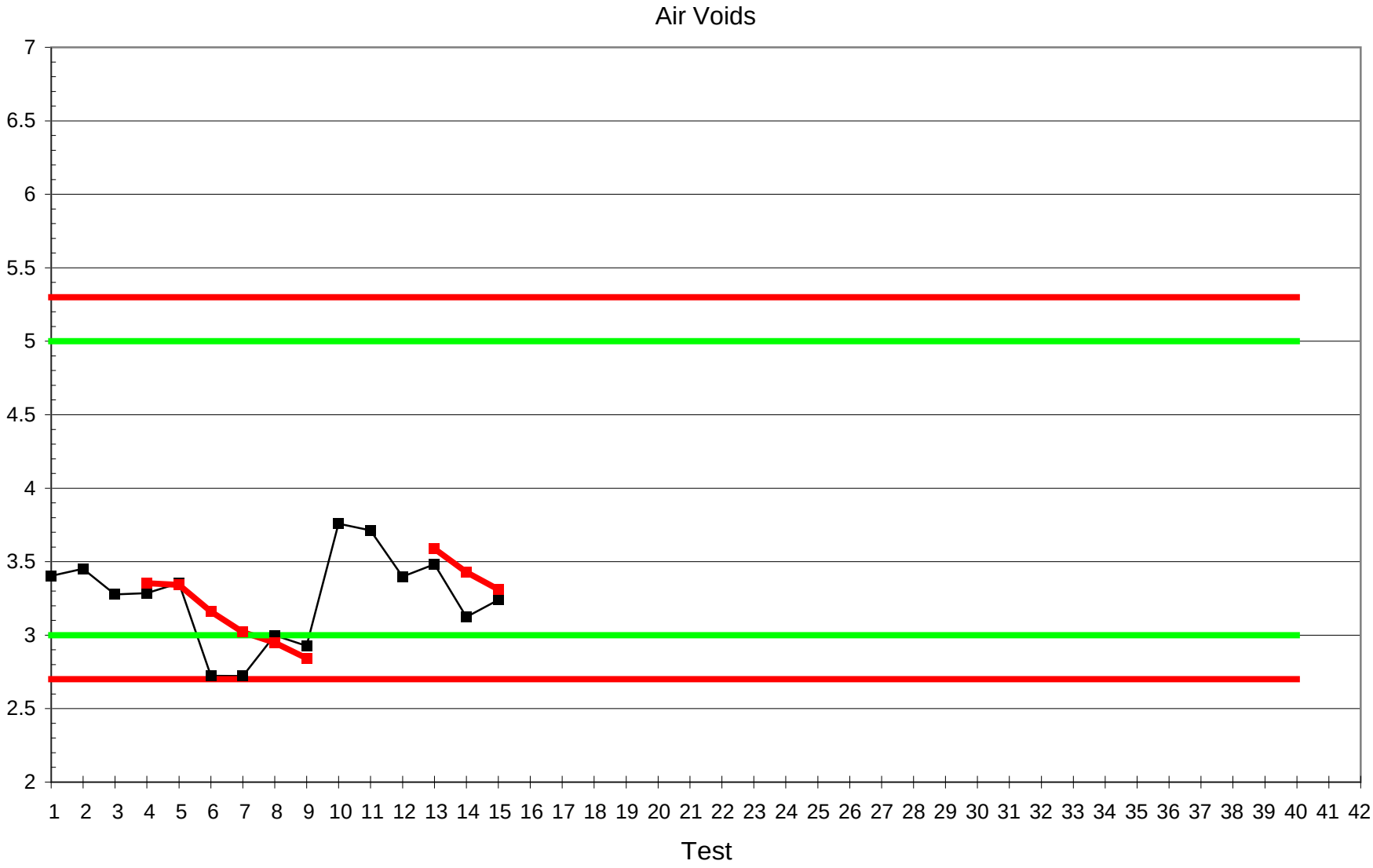
		33												
		34												
		35												

* Contractor notifies MDOT that second air void running average in warning bands.
The contractor reduces the asphalt binder content by 0.2 percent.

Example No. 1


Air Voids
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
Test

TMD-006

MISSISSIPPI DEPARTMENT OF TRANSPORTATION
QMP HMA
Summary Report of QC Mixture Properties

Project No.: Example No. 2 Contractor: ABC Asphalt, Jackson Mix: ST - 12.5mm

MDOT JMF No. JMF1234 ACsg 1.034

Date	Tons	Test	AC	AC AVE-4	Gmm	Gmm AVE-4	Gmb	Gmb AVE-4	VOIDS	Voids AVE-4	VMA	VMA AVE-4	Gsb Blend	Crush
		Design	5.6		2.480		2.380		4.0		14.6		2.630	95
2/23	432	1	5.72		2.468		2.384		3.4		14.5		2.630	
2/23	721	2	5.74		2.463		2.378		3.5		14.8		2.630	96
2/23	1457	3	5.68		2.471		2.391		3.2		14.3		2.630	
2/24	590	4	5.74	5.72	2.464	2.467	2.385	2.385	3.2	3.3	14.5	14.5	2.630	97
2/24	1323	5	5.76	5.73	2.463	2.465	2.392	2.387	2.9	3.2	14.3	14.5	2.630	
2/25	149	6	5.84	5.76	2.456	2.464	2.393	2.390	2.6	3.0	14.3	14.3	2.630	
2/25	1046	7	5.80	5.79	2.462	2.461	2.395	2.391	2.7	2.8	14.2	14.3	2.630	
2/25*	1590	8	5.76	5.79	2.468	2.462	2.394	2.394	3.0	2.8	14.2	14.3	2.630	91
2/26	683	9	5.82	5.81	2.461	2.462	2.389	2.393	2.9		14.5	14.3	2.630	
2/26	1234	10	5.82	5.80	2.460	2.463	2.390	2.392	2.8		14.4	14.3	2.630	94
2/27	420	11	5.86	5.82	2.458	2.462	2.391	2.391	2.7		14.4	14.4	2.630	
2/27	1096	12	5.79	5.82	2.464	2.461	2.388	2.390	3.1	2.9	14.5	14.4	2.630	96
2/27	1784	13	5.82	5.82	2.460	2.461	2.390	2.390	2.8	2.9	14.4	14.4	2.630	
2/28	349	14	5.64	5.78	2.466	2.462	2.378	2.387	3.6	3.1	14.7	14.5	2.630	91
2/28	1420	15	5.63	5.72	2.470	2.465	2.381	2.384	3.6	3.3	14.6	14.5	2.630	
		16												
		17												
		18												
		19												
		20												
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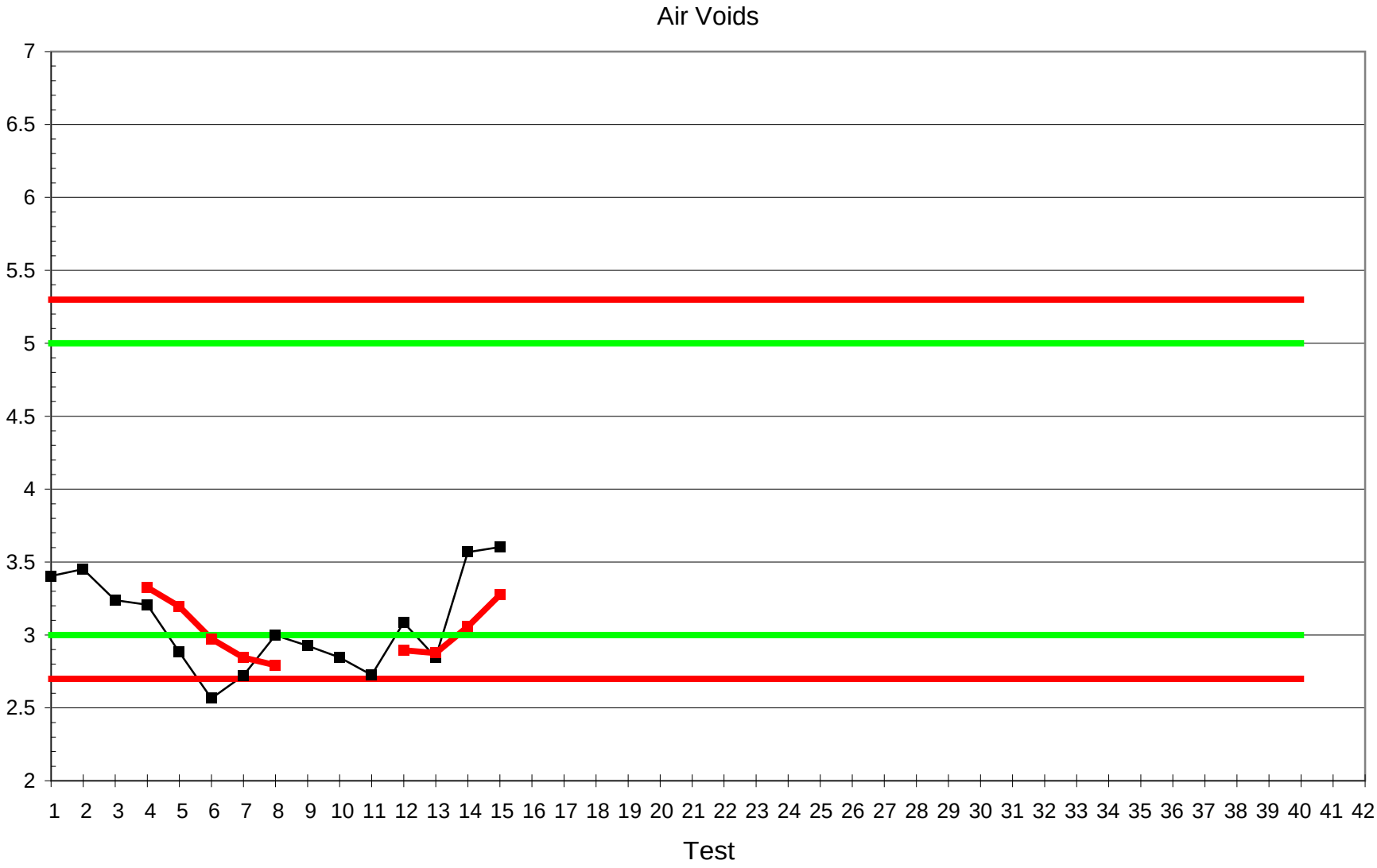
* Contractor notified MDOT of problem and made a aggregate blend change.

Example No. 2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2
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Test

TMD-006

MISSISSIPPI DEPARTMENT OF TRANSPORTATION
QMP HMA
Summary Report of QC Mixture Properties

Project No.: Example No. 3 Contractor: ABC Asphalt, Jackson Mix: ST - 12.5mm

MDOT JMF No. JMF1234 ACsg 1.034

Date	Tons	Test	AC	AC AVE-4	Gmm	Gmm AVE-4	Gmb	Gmb AVE-4	VOIDS	Voids AVE-4	VMA	VMA AVE-4	Gsb Blend	Crush
		Design	5.6		2.480		2.380		4.0		14.6		2.630	95
2/23	432	1	5.72		2.468		2.384		3.4		14.5		2.630	
2/23	721	2	5.74		2.463		2.378		3.5		14.8		2.630	96
2/23	1457	3	5.68		2.471		2.391		3.2		14.3		2.630	
2/24	590	4	5.74	5.72	2.464	2.467	2.385	2.385	3.2	3.3	14.5	14.5	2.630	97
2/24	1323	5	5.76	5.73	2.463	2.465	2.392	2.387	2.9	3.2	14.3	14.5	2.630	
2/25	149	6	5.84	5.76	2.456	2.464	2.393	2.390	2.6	3.0	14.3	14.3	2.630	
2/25	1046	7	5.80	5.79	2.462	2.461	2.395	2.391	2.7	2.8	14.2	14.3	2.630	
2/25	1590	8	5.76	5.79	2.468	2.462	2.394	2.394	3.0	2.8	14.2	14.3	2.630	91
2/26	683	9	5.82	5.81	2.461	2.462	2.389	2.393	2.9	2.8	14.5	14.3	2.630	
2/26	1234	10	5.82	5.80	2.460	2.463	2.390	2.392	2.8	2.9	14.4	14.3	2.630	94
2/27	420	11	5.86	5.82	2.458	2.462	2.391	2.391	2.7	2.9	14.4	14.4	2.630	
2/27	1096	12	5.79	5.82	2.464	2.461	2.388	2.390	3.1	2.9	14.5	14.4	2.630	96
2/27	1784	13	5.82	5.82	2.460	2.461	2.390	2.390	2.8	2.9	14.4	14.4	2.630	
2/28	349	14	5.64	5.78	2.466	2.462	2.378	2.387	3.6	3.1	14.7	14.5	2.630	91
2/28	1420	15	5.63	5.72	2.470	2.465	2.381	2.384	3.6	3.3	14.6	14.5	2.630	
		16												
		17												
		18												
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		33												
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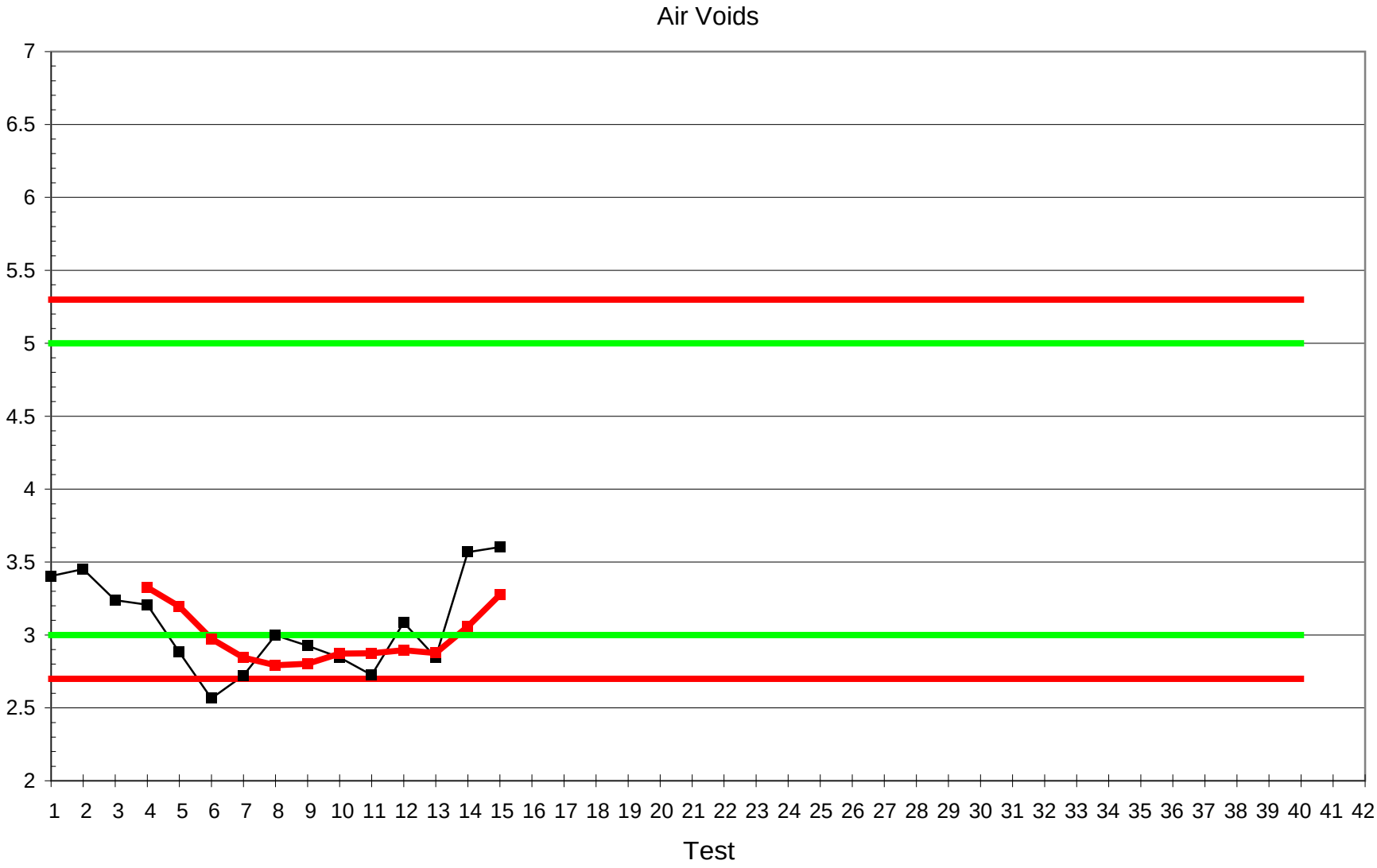
		35												

* Asphalt binder content reduced 0.2 percent.

Example No. 3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2.5
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Test

TMD-006

MISSISSIPPI DEPARTMENT OF TRANSPORTATION
QMP HMA
Summary Report of QC Mixture Properties

Project No.: Example No. 4 Contractor: ABC Asphalt, Jackson Mix: ST - 12.5mm

MDOT JMF No. JMF1234 ACsg 1.034

Date	Tons	Test	AC	AC AVE-4	Gmm	Gmm AVE-4	Gmb	Gmb AVE-4	VOIDS	Voids AVE-4	VMA	VMA AVE-4	Gsb Blend	Crush
		Design	5.6		2.480		2.380		4.0		14.6		2.630	95
2/23	432	1	5.72		2.468	2.468	2.384		3.4		14.5		2.630	
2/23	721	2	5.74		2.463	2.466	2.378		3.5		14.8		2.630	96
2/23	1457	3	5.68		2.472	2.468	2.391		3.3		14.3		2.630	
2/24	590	4	5.74	5.72	2.466	2.467	2.385	2.385	3.3	3.4	14.5	14.5	2.630	97
2/24	1323	5	5.62	5.70	2.475	2.469	2.392	2.387	3.4	3.3	14.2	14.4	2.630	
2/25	149	6	5.78	5.71	2.468	2.470	2.393	2.390	3.0	3.2	14.3	14.3	2.630	
2/25	1046	7	5.70	5.71	2.470	2.470	2.395	2.391	3.0	3.2	14.1	14.3	2.630	
2/25	1590	8	5.74	5.71	2.468	2.470	2.385	2.391	3.4	3.2	14.5	14.3	2.630	91
2/26	683	9	5.74	5.74	2.466	2.468	2.389	2.391	3.1	3.1	14.4	14.3	2.630	
2/26	1234	10	6.82	6.00	2.425	2.457	2.395	2.391	1.2	2.7	15.1	14.5	2.630	94
2/27	420	11	5.58	5.97	2.478	2.459	2.386	2.389	3.7	2.9	14.3	14.6	2.630	
2/27	1096	12	5.63	5.94	2.472	2.460	2.388	2.390	3.4	2.9	14.3	14.5	2.630	96
2/27	1784	13	5.60	5.91	2.470	2.461	2.384	2.388	3.5	3.0	14.4	14.6	2.630	
2/28	349	14	5.64	5.61	2.466	2.472	2.389	2.387	3.1	3.4	14.3	14.3	2.630	91
2/28	1420	15	5.63	5.63	2.470	2.470	2.390	2.388	3.2	3.3	14.2	14.3	2.630	
		16												
		17												
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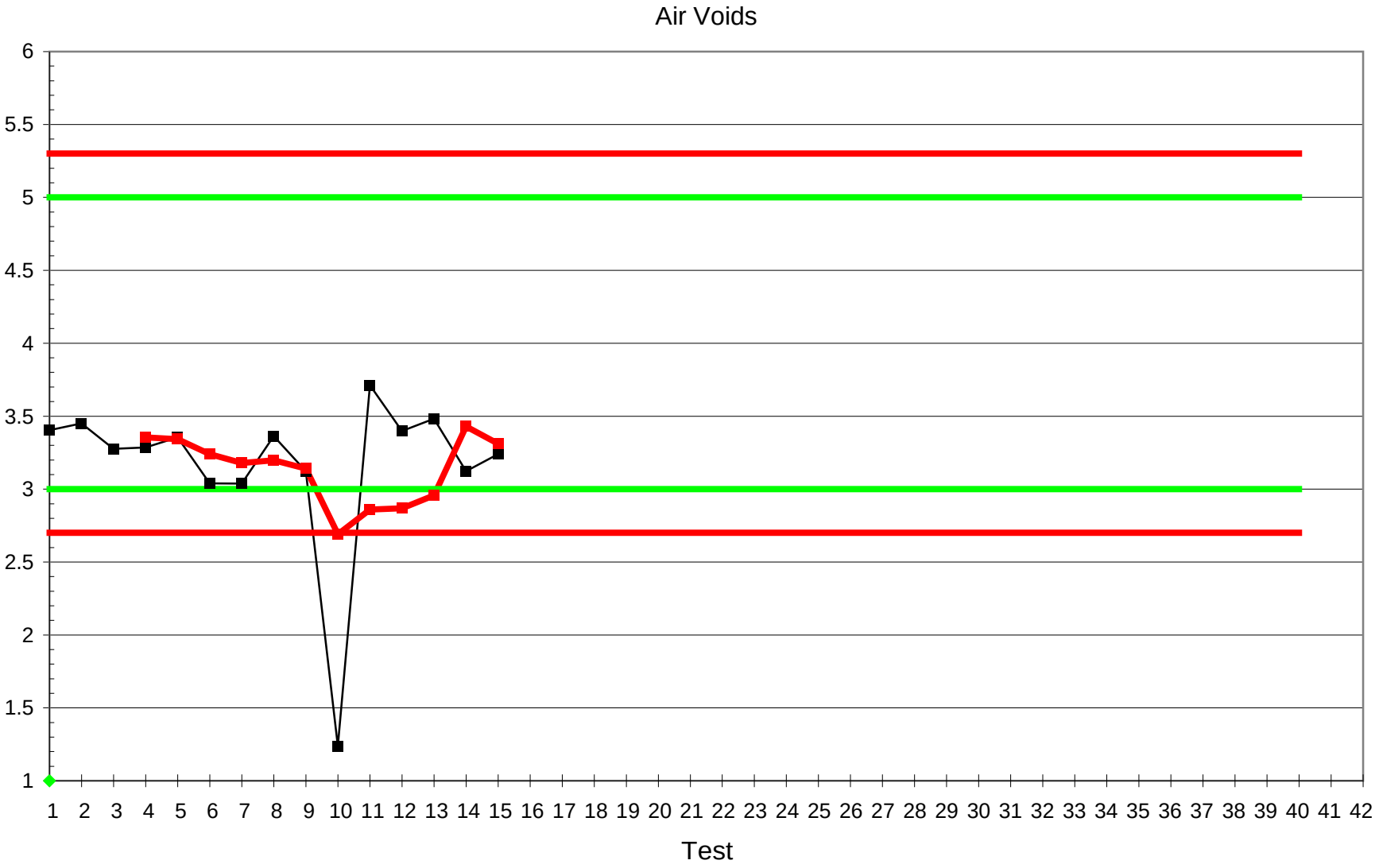
Example No. 4


Air Voids
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3.5
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2.5
2
1.5
1
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42
Test