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HOT MIX PAVEMENT**

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METHODS OF SAMPLING AND TESTING
MT 302-14
SAMPLING AND TESTING BITUMINOUS MATERIAL
(Montana Method)

1 Scope

- 1.1 This method covers the procedure for sampling and testing bituminous materials, submitting samples, retaining samples, precautions to be used during sampling, designating who is to take the sample and the recording of information pertinent to the acceptance of bituminous materials.

2 Referenced Documents

AASHTO

R 66 Sampling Bituminous Materials

ASTM

D140 Standard Practice for Sampling Bituminous Materials

MT Materials Manual

MT 601 Material Sampling, Testing and Acceptance Guide

MT 610 Numbering Subgrade Material, Surfacing Material, Bituminous Treated Material, and Liquid Asphalt

3 Inspection

- 3.1 The Department will witness the taking of any or all acceptance samples by the Contractor or designated personnel.

4 Sampling Procedure

- 4.1 *Importance of proper sampling* - Sampling is equally as important as testing. Take every precaution to obtain samples that show the true nature and condition of the materials they represent. Test results are valuable only when the tests are performed on representative samples. Take samples in accordance with the following procedures, so there will be no question as to validity. This is very important in case of a test failure, which may be the basis for rejection of the material.
- 4.2 Refer to [MT 601](#) for sample size and container type. Use containers furnished by the Department. Do not use second-hand containers, any containers washed or rinsed with solvents, or any containers provided by the contractor. (*Note 1*)

Note 1 – Use metal containers for cut-back asphalt and asphalt cement. Use plastic containers for asphalt emulsions only.

- 4.2.1 Per Specification, all truck tanks, trailer tanks, or other conveyances containing bituminous materials must be equipped with a sampling valve not less than $\frac{3}{8}$ -inch or more than $\frac{3}{4}$ -inch in diameter. These valves may be installed either through the tank's bulkhead at centerline or on the discharge line between the truck unloading pipe and the hose. Sample the contents of railroad tank cars and truck transports, not equipped with a sampling valve, from the pressure side of the unloading pump.
- 4.2.2 Discharge one gallon or sufficient volume of material to clear the sampling device prior to taking the samples. This step is important to ensure a representative and uniform sample is taken.
- 4.2.3 Take the duplicate samples consecutively with a minimum lapse of time from the same tank or trailer.

Note 2 – Sample all emulsion shipments, regardless of the size of the shipment, within a reasonable time as to not compromise the sample. If emulsion sample has been diluted, note this on the sample record. Protect the emulsions samples from freezing. Re-sample when the material is stored without agitation for three or more days before use.

- 4.2.4 Leave the screw caps loose until the contents cool so the contraction of the asphalt will not collapse the containers. Remove any spillage on the outside of the container with a clean, dry cloth, cotton waste or paper towels. Do not use solvents (diesel fuel, gasoline, etc.) for this purpose.

Note 3 – For other sampling methods, refer to AASHTO R 66 and ASTM D140.

5 Submitting, Reporting and Testing of Samples

5.1 Submitting

- 5.1.1 After samples are taken, immediately forward to the Materials Bureau for testing.

5.2 Reporting

- 5.2.1 Create a SiteManager Sample Record to submit samples; for Performance Graded Asphalt Binder (PGAB) Sampling, use form [MDT-MAT-057, PG Binder Samples](#); for Emulsion and Cutback Sampling, use form [F101-C, Emulsion Samples](#).

- 5.2.2 Refer to [MT 610](#) for numbering the bituminous material samples.

5.3 Testing

- 5.3.1 The Materials Bureau will perform tests for all specification requirements on samples selected at random for each project.
- 5.3.2 The Materials Bureau will immediately notify the Project Manager, who in turn will notify the Prime Contractor, when the result of a series of tests is not within the specification limits.
- 5.3.3 In the event of a failure, refer to applicable Specification.

6 Certification of Shipments

- 6.1 Ensure suppliers of bituminous materials furnish the Project Manager or their representative, one copy of the original bill of lading or invoice and a Certificate of Compliance. Ensure this documentation accompanies each tank car, truck-trailer tank, or other individual conveyance of bituminous materials shipped, or hauled to the project. This certificate, signed by a supplier's responsible representative, attests to the fact that the bituminous material complies with Department specifications for the type and grade of material represented and the conveyance was inspected and found to be free of contaminating material.
- 6.2 The Certificate of Compliance is the basis for tentative acceptance and use of the material. Do not allow the shipment to be tentatively accepted or incorporated in the work without the receipt of the certification. It may be included on the bill of lading or invoice or it may be a separate document attached to the bill of lading. The Project Manager will retain the certificate and bill of lading in the project files and digital files for record purposes.

MT 303-14
SAMPLING BITUMINOUS PAVING MIXTURES
(Modified AASHTO T 168)

1 Scope

- 1.1 These methods cover sampling of bituminous paving mixtures at points of manufacturer, storage, delivery, or in place.

2 Referenced Documents

AASHTO Standards

T 168 Sampling Bituminous Paving Mixtures

ASTM Standards

D979 Sampling Bituminous Paving Mixtures

MT Materials Manual

MT 309 Splitting Samples of Plant Mix Surfacing to Testing Size

MT 601 Materials Sampling, Testing and Acceptance Guide Index

Alberta Transportation ATT Test Procedures

ATT 37 Sampling, Mixes

3 Inspection

- 3.1 Inspect the material to determine discernible variations. Ensure the contractor provides equipment needed for safe and appropriate inspection and sampling.

4 Sampling Procedure

- 4.1 *Importance of proper sampling* - Sampling is equally as important as testing. Take every precaution to obtain samples that show the true nature and condition of the materials they represent. Test results are valuable only when the tests are performed on representative samples. Take samples in accordance with the following procedures, so there will be no question as to validity. This is very important in case of a test failure, which may be the basis for rejection of the material.
- 4.2 *Sampling from Truck Transports* - Select the units to be sampled from the production of materials delivered. Obtain a minimum of three approximately equal increments as shown in Figure 1 and combine to form a field sample. Obtain the sample by collecting the increments with a scoop or shovel. Avoid sampling the extreme top surface.

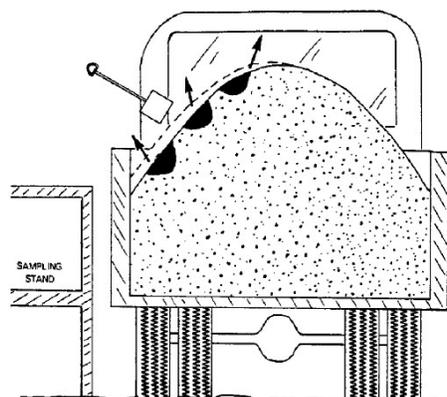


Figure 1. Sampling from Truck Transports

- 4.3 *Sampling from a Paver Auger* – Obtain samples from the end of the auger using a square head shovel. Place the shovel in front of the auger extension, with the blade flat upon the surface to be paved over. Allow the front face of the auger stream to cover the shovel, and remove the shovel before the auger reaches the shovel by lifting it upward as vertically as possible. Obtain sample from a minimum of three equal increments of material.
- 4.4 *Sampling from a Windrow* - Obtain a representative sample from the windrow of one transport unit. Combine a minimum of three approximately equal increments as shown in Figure 2.
1. Use the shovel to flatten a sufficient length of the windrow, discarding the material to either side.
 2. Dig into the windrow's top at three or more equally distributed points along its flattened portion. Do not include material from the subgrade or base. The sample is the total mix from three or more holes.

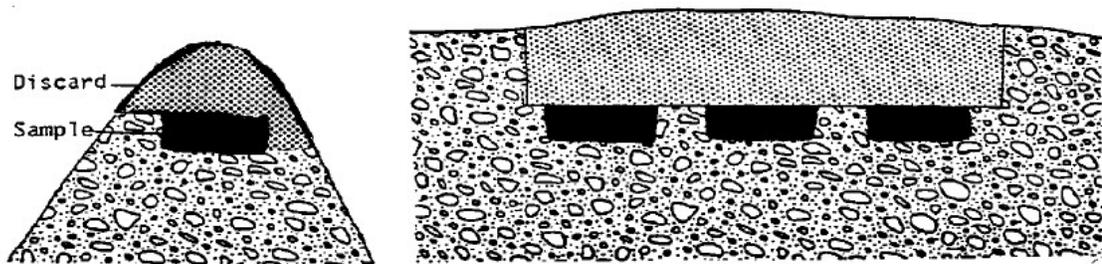


Figure 2. Sampling from a Windrow

- 4.5 *Sampling from Bituminous Cold Mix or Recycled Asphalt Pavement (RAP) Stockpiles* – Cold mixes that are in a stockpile for some time may develop a crust on the surface of the pile. Remove this crust to a depth of 4 inches, over an area of one square yard, to expose the unweathered mix as shown in Figure 3. Stir the exposed stockpile and obtain three approximately equal samples selected at random, and combine to form a field sample.

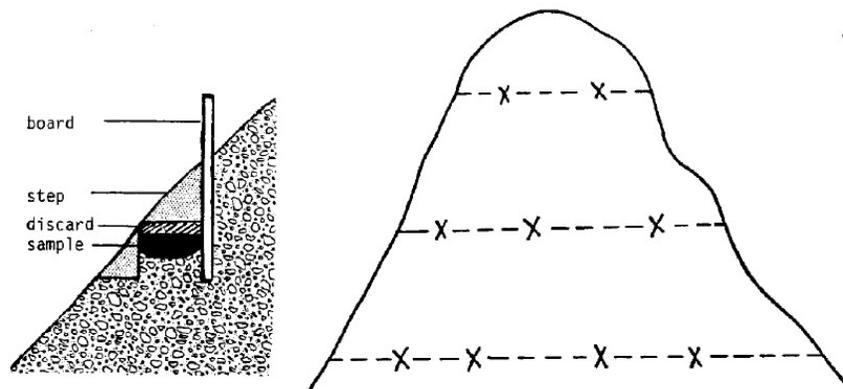


Figure 3. Sampling from a Stockpile

5 Number and Quantities of Field Samples

- 5.1 Designate each unit from which a field sample is to be obtained prior to sampling.
- 5.2 Refer to [MT 601](#) for sample size. The quantities depend on the type and number of tests to which the material is to be subjected. Obtain sufficient material to provide for the proper execution of standard control and acceptance tests.

6 Securing or Submitting Samples

- 6.1 Transport samples in containers constructed to minimize heat loss, contamination, or damage to the sample from mishandling during shipment.
- 6.2 Record pertinent information in the Quality Assurance Suite (QA Suite) Plant Mix section.
- 6.3 Using the [Hamburg Sampling Guideline](#), attach identification to each Hamburg sample sent to a district or headquarter lab.
- 6.4 Create a SiteManager Sample Record and attach to any plant mix sample sent to a district or headquarter lab.
- 6.5 Use tamper resistant container(s) when sample(s) leave Department custody.

MT 304-14
MOISTURE TEST ON PLANT MIX
BITUMINOUS SURFACING AGGREGATES
(Montana Method)

1 Scope

- 1.1 This test method covers the determination of the moisture content of bituminous surfacing aggregates by various drying methods.

2 Referenced Documents**AASHTO Standards**

M 231 Weighing Devices Used in the Testing of Materials

MT Materials Manual

MT 201 Sampling Roadway Materials

3 Terminology

- 3.1 *Constant mass* – the state at which a mass does not change more than 0.10 percent, after additional drying for the defined time interval in Table 3.1.

Table 3.1
Methods of Drying

Heat Source	Specific Instructions	Drying increments (minutes)
Controlled: Forced draft (preferred), ventilated, or convection oven	110 ±5°C (230 ±9°F)	30
Uncontrolled: Hot plate, Heat Lamp, etc.	Stir frequently	20
Microwave	Heap sample and cover with ventilated lid	10

4 Apparatus

Ensure equipment used meets the following requirements;

- 4.1 *Drying Apparatus* - any suitable device capable of drying samples.
- 4.2 *Balance* – balance or scale with a capacity larger than the size of the sample being tested. The balance or scale must have a sensitivity of 0.1 gram and conform to the requirements of AASHTO M 231.
- 4.3 *Sample container* – not affected by heat and of sufficient size to contain a test sample of at least 4,000 g without danger of spilling.

5 Sampling

- 5.1 Obtain a representative sample of at least 3 pounds from each bin, stockpile, or cold feed belt per [MT 201](#). Immediately place the material, from each separate bin, stockpile, or cold feed belt, into a weighed container and seal.

6 Procedure

- 6.1 After weighing the container with aggregate, transfer the material to drying pans and dry to constant mass in an approved manner. Stir the sample occasionally to facilitate drying.
- 6.2 Reweigh sample and container when the sample has been dried to constant mass.

Note 1 – Perform moisture testing on mixes showing the following properties:

- Foaming on the surface of the coarse aggregate particles
- Excessive slumping of the mix in the truck
- Condensed water dripping from the truck box
- Bubbles or blisters forming on the surface immediately behind the paver

Ordinarily these conditions will not develop if the moisture content is below approximately 2 percent.

7 Calculations

- 7.1 Compute the **moisture content** of each sample of the aggregate using the following formula:

$$M = \left(\frac{W-D}{D-C} \right) \times 100$$

where:

M = percent of moisture

W = wt. of wet sample and container

D = wt. of dry sample and container

C = wt. of container

- 7.2 Compute the **composite moisture content** of the total aggregate according to the following example:

Aggregate Size	Fraction of Job Mix	x	Moisture Content, Percent
3/4" to 3/8"	0.20	x	2.00 = 0.40
3/8" to No. 10	0.40	x	1.00 = 0.40
Passing No. 10	0.40	x	0.50 = 0.20
Composite Moisture Content			= 1.00

8 Reporting

- 8.1 Report the moisture content to the nearest 0.10 percent.

METHODS OF SAMPLING AND TESTING
MT 305-09
METHOD OF TEST FOR VOLUME SWELL OF BITUMINOUS MIXTURES
(Montana Test Method)

1 Scope:

- 1.1 This test method provides for the determination of the maximum volume swell of compacted aggregates, soil, sand, or combination of mixtures passing the 10 Mesh (2.0 mm) sieve and stabilized with bituminous material.

2 Apparatus:

2.1 Compaction Apparatus:

- 2.1.1 *Forming mold* - This forming mold shall be a steel cylinder 2.50 inches (63.5 mm) or greater in outside diameter, 2.000 - 2.001 inches (50.80 - 50.8254 mm) inside diameter, and approximately 2.75 inches (69.85 mm) high. One end shall be recessed 0.245 - 0.250 inches (6.223 - 6.350 mm) with an inside diameter of 2.250 - 2.252 inches (57.1500 - 57.2008 mm) to fit the 2.247 - 2.249 inch (57.0738 - 57.1246 mm) base if the base plate method is used.

- 2.1.2 *Plungers* - Cylindrical steel plungers, fitted to the molding cylinders, 1.997 ± 0.001 inch (50.7238 ± 0.0254 mm) in diameter and 3 inches (76.2 mm) high.

- 2.1.3 *Base* - Solid steel, circular plate 1 inch (25.4 mm) thick and 3 inches (76.2 mm) in diameter, beveled and machined to a 2.247 - 2.249 inch (57.0738 - 57.1246 mm) top diameter above the mold seat.

- 2.2 *Compression Testing Machine or Press* - A compression machine or press capable of applying loads of 10,000 pounds (4535.9 kg.) or greater and indicating the applied load with a sensitivity of 50 pounds (22.7 kg.) or less.

2.3 Mixing Apparatus:

- 2.3.1 *Mixing pans* - shall be smooth and conform to the following dimensions:

Bottom inside diameter = approximately 4-3/4" (120.65 mm)

Top inside diameter = approximately 6-1/4 in. (158.75 mm)

Height = approximately 3 in. (76.2 mm)

- 2.3.2 *Spatula* - approximately 7 in. (177.8 mm) long and 1/2 in. (12.7 mm) wide.

- 2.3.3 *Putty knife* - approximately 1-1/2 in. (38.1 mm) wide with a rounded tip.

- 2.3.4 Large metal scoop with handle (24 to 48 oz.).

- 2.3.5 Anti-slip, flexible rubber gloves (nitrile or vinyl).

- 2.4 *Heater* - An electric thermostatically controlled hot plate for warming pans of bituminous mix.

- 2.5 *Vacuum Desiccator* - of convenient size with a vacuum gauge incorporated on the lid. The gauge shall be calibrated in inches or centimeters of Hg (mercury) vacuum.

- 2.6 Hand or motor driven vacuum pump with approximately two feet of plastic vacuum hose.

- 2.7 Stop-cock grease for desiccator seal.

2 Apparatus: (continued)

- 2.8 Screw clamp.
- 2.9 Measuring and weighing apparatus.
 - 2.9.1 A balance with a capacity of 500 grams and sensitive to 0.1g..
 - 2.9.2 A measuring device that is accurately calibrated and equipped to determine heights and diameters of test specimens to the nearest 0.01 cm.
 - 2.9.3 *Mercury Displacement Cup* - A glass or plastic cup with flat ground edge of convenient size to contain test specimens for mercury displacement measurement.
 - 2.9.4 Glass dish approximately 10 x 6 x 2 in. (254 x 152.4 x 50.8 mm)
 - 2.9.5 Porcelain pan approximately 15 x 10 x 2-1/2 in. (381 x 254 x 63.5 mm)
- 2.10 Drying Oven - A thermostatically controlled drying oven capable of maintaining a temperature of $140 \pm 5^{\circ}\text{F}$ ($60 \pm 3^{\circ}\text{C}$)
- 2.11 A 4 mesh (4.75 mm) and a 10 mesh (2.0 mm) sieve.
- 2.12 Thermometers, beakers, and a 100 ml, glass, graduated cylinder with intervals of 1.0 mm.
- 2.13 Pulverizing Apparatus - Either a mortar and rubber covered pestle or a mechanical device consisting of a power-driven rubber covered mallet suitable for breaking up the aggregations of soil particles without reducing the size of the individual grains.

3 Materials:

- 3.1 Distilled water with a pH of approximately 7. (Tap water is satisfactory if it does not interfere chemically with the test.)
- 3.2 Bituminous material - 200/300 Pen A.C.
 - 3.2.1 200/300 Pen A.C. should be replaced with new asphalt at the beginning of each construction season.
- 3.3 Mercury.
 - 3.3.1 Mercury (Hg) is a poison and can be absorbed through the respiratory tract, the intestinal tract or through unbroken skin. Mercury is a cumulative poison and is a very volatile element. Dangerous levels are readily attained in the air at 77°F (25°C). Tests involving the use of Mercury should be performed under conditions of adequate ventilation. A fume hood is recommended for large numbers of samples or where the test is to be carried out frequently over extended periods of time. Protective gloves should be worn under conditions here skin contact with mercury may occur.
 - 3.3.2 This test procedure does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this test procedure to establish appropriate safety and health practices and determine the applicability of regulatory limitation prior to use.

4 Preparation of Aggregate:

- 4.1 A representative sample of the 10 mesh (2.00 mm) material as described in MT-200 (Dry Preparation of Aggregate) shall be prepared. The sample shall be large enough to produce

4 Preparation of Aggregate: (continued)

approximately 400 grams of minus 10 mesh (2.00 mm) material at the conclusion of the pulverizing procedure.

- 5 Volume Swell Procedure:** The caliper method will be used to test all volume swell samples. If the caliper method yields a volume swell of 8.0 or greater then a sample will be submitted to either the Helena Materials Lab or the Billings District Lab for testing using the mercury method. The mercury method will only be performed in the Helena Materials Lab or the Billings District Lab Porous briquettes that may entrap mercury shall be measured with calipers only.

5.1 Volume Swell Procedure – Caliper Method:

- 5.1.1** Warm the 200/300 pen asphalt cement for mixing to approximately $250 \pm 15^{\circ}\text{F}$ ($121 \pm 8^{\circ}\text{C}$).
- 5.1.2** Stabilize the hot plate at 425°F to 475°F (218°C to 246°C).
- 5.1.3** Stir the sample prepared in paragraph 4 with a spatula and transfer a 100 gram sample to the weighing scoop. Use the spatula to obtain a uniform discharge and to pull material from the bottom of the sample container when transferring the material. If desired, the material may be preheated in an oven $230 \pm 9^{\circ}\text{F}$ ($110 \pm 5^{\circ}\text{C}$).
- 5.1.4** Transfer the 100 gram sample from the weighing scoop to the mixing pan, stir with a putty knife and shake the material to one side of the mixing pan.
- 5.1.5** Place the mixing pan and sample on the balance and add 6.5 grams of 200/300 Pen A.C., do not pour asphalt on material; place the pan back on the hot plate.
- 5.1.6** When asphalt starts to flow into the sample, start mixing rapidly with a putty knife while shaking the mixing pan close to the hot plate. Avoid overheating the mix, as evidenced by smoking asphalt. Mix and shake until a thorough mixture is obtained. See Note 1.

Note 1 - In the case of material having poor adhesion, the larger particles will only be slightly coated. Do not add more asphalt. Mix and shake until maximum coverage is obtained.

- 5.1.7** Pour the mixture from the mixing pan into a small scoop. Pour the mixture from the scoop into the assembled mold using the spatula to assist in obtaining a uniform discharge from the scoop. Insert the top plunger with a twist and a light tamp to seat firmly. Place the mold in the compression machine and at a uniform rate increase the load to a total of 6280 pounds in no less than 15 seconds. Maintain the maximum load for one minute and release. Remove the base plate with a twisting motion and mark the briquette in the mold with a wax crayon, applying light pressure.
- 5.1.8** After removing the base plate with a twisting motion and marking the briquette, turn the assembly upside down. Place the sleeve on top of the forming mold and using the jack apply, pressure to the sleeve and top plunger. This will push the briquette and top plunger up into the sleeve. See Note 2. Cool and cure the briquette for three hours at room temperature.

Note 2 -If the briquettes tend to stick to the mold or plungers, preheat mold to 140°F (60°C).

- 5.1.9** Wipe the forming mold, base plate and plungers clean with a suitable solvent and dry with a cloth before forming each briquette.
- 5.1.10** Measure and record the height and radius of the cured briquette. To obtain the height of the specimen, measure and record the height (flats of the specimen) in four locations. Measurements should be taken at 90 degree intervals. Average the four measurements and use the average height for the calculations. To obtain the radius of the specimen, measure and record the

5.1 Volume Swell Procedure – Caliper Method: (continued)

diameter of the specimen (sides) in four locations. Measurements should be taken at 45 degree intervals. Average the four measurements and divide by 2 to obtain the average radius. Use the average radius for the calculations. Refer to Paragraph 6.1.2 (calculations) to determine the volume of the cured briquette.

5.1.11 Check the vacuum equipment for leaks before any briquettes are put into the desiccator.

5.1.12 Fill the vacuum desiccator with distilled water and allow to stabilize at room temperature. Completely submerge the briquette in the distilled water and seal the top. See Note 3.

Note 3 -A perforated tray is supplied for a second layer of briquettes.

5.1.13 Subject the briquette to 8 inches (20.3 cm) of mercury vacuum for one hour. The 8 inches of vacuum will be applied within the desiccator in not less than one minute. The vacuum is maintained for one hour and released gradually to avoid pressure shock to the briquettes.

5.1.14 Keep the briquette completely submerged in the distilled water at room temperature for an additional 23 hours. If necessary to transfer to another container of distilled water, wait 15 minutes after releasing pressure before effecting transfer.

5.1.15 Remove the briquette, blot the excess water and weigh. Measure and record the height and radius of the swollen briquette. To obtain the height of the specimen, measure and record the height (flats of the specimen) in four locations. Measurements should be taken at 90 degree intervals. Average the four measurements and use the average height for the calculations. To obtain the radius of the specimen, measure and record the diameter of the specimen (sides) in four locations. Measurements should be taken at 45 degree intervals. Average the four measurements and divide by 2 to obtain the average radius. Use the average radius for the calculations. Refer to Paragraph 6.1.2 (calculations) to determine the volume of the cured briquette and the percent of volume swell. In no event will the briquette be allowed to set for more than ten minutes before measuring is completed. The sides of the briquette will be squeezed for recording condition of the briquette such as hard, firm, soft, soft and cracked, or disintegrated. Refer to paragraph 6.1.1 (calculations) to determine the percent of volume swell. (See Note 4)

NOTE 4 - The test specimen shall be measured immediately after excess water is blotted off the specimen. When measuring with calipers, take four measurements on the sides of the specimen and four measurements on the flats of the specimen at 90 degree intervals and record. The average of the recordings will be used for the calculation.

5.2 Volume Swell Procedure – Mercury Method: The Helena Materials Lab and the Billings District Lab are the only labs that will be performing volume swell testing using Mercury. A designated set of testing apparatus will be used to test using mercury (such as a Vacuum Desiccator designated for mercury method samples). The mercury method briquettes will be stored in a labeled container with a lid. The desiccator disposal water will also be stored in a labeled container with a lid. The waste products will be stored near the mercury method equipment and when a container of approximately five gallons is collected, Environmental Services will be contacted for disposal.

5.2.1 Warm the 200/300 Pen Asphalt Cement for mixing to approximately 250□ 1°F (121± 8°C).

5.2.2 Stabilize the hot plate at 425 to 475°F (218 to 246°C).

5.2.3 Stir the sample prepared in paragraph 4 with a spatula and transfer a 100 gram sample to the weighing scoop. Use the spatula to obtain a uniform discharge and to pull material from the bottom of the sample container when transferring the material. If desired, the material may be preheated in an oven 230± 9°F (110± 5°C).

5.2 Volume Swell Procedure – Mercury Method: (continued)

- 5.2.4** Transfer the 100 gram sample from the weighing scoop to the mixing pan, stir with a putty knife and shake the material to one side of the mixing pan.
- 5.2.5** Place the mixing pan and sample on the balance and add 6.5 grams of 200/300 Pen A.C., do not pour asphalt on material; place the pan back on the hot plate.
- 5.2.6** When asphalt starts to flow into the sample, start mixing rapidly with a putty knife while shaking the mixing pan close to the hot plate. Avoid overheating the mix, as evidenced by smoking asphalt. Mix and shake until a thorough mixture is obtained. See Note 1.
- 5.2.7** Pour the mixture from the mixing pan into a small scoop. Pour the mixture from the scoop into the assembled mold using the spatula to assist in obtaining a uniform discharge from the scoop. Insert the top plunger with a twist and a light tamp to seat firmly. Place the mold in the compression machine and at a uniform rate increase the load to a total of 6280 pounds in no less than 15 seconds. Maintain the maximum load for one minute and release. Remove the base plate with a twisting motion and mark the briquette in the mold with a wax crayon, applying light pressure.
- 5.2.8** After removing the base plate with a twisting motion and marking the briquette, turn the assembly upside down. Place the sleeve on top of the forming mold and using the jack apply, pressure to the sleeve and top plunger. This will push the briquette and top plunger up into the sleeve. See Note 2. Cool and cure the briquette for three hours at room temperature.
- 5.2.9** Wipe the forming mold, base plate and plungers clean with a suitable solvent and dry with a cloth before forming each briquette.
- 5.2.10** Weigh the cup filled with mercury and record the weight (W_1). Place the cured briquette in the cup and allow the mercury to displace by pressing the plastic plate flatly, squarely and firmly down on the specimen's top surface until the plate is seated on the top rim on the cup and the excess mercury is fully displaced. Remove the cured briquette. Weigh and record the weight of the mercury and the cup minus the weight of the mercury lost due to immersion of the cured briquette (W_2). Wear Rubber exam gloves at all times when while testing with mercury.
- 5.2.11** Check the vacuum equipment for leaks before any briquettes are put into the desiccator.
- 5.2.12** Fill the vacuum desiccator with distilled water and allow to stabilize at room temperature. Completely submerge the briquette in the distilled water and seal the top. See Note 3.
- 5.2.13** Subject the briquette to 8 inches (20.3 cm) of mercury vacuum for one hour. The 8 inches of vacuum will be applied within the desiccator in not less than 1 minute. The vacuum is maintained for one hour and released gradually to avoid pressure shock to the briquettes.
- 5.2.14** Keep the briquette completely submerged in the distilled water at room temperature for an additional 23 hours. If necessary to transfer to another container of distilled water, wait 15 minutes after releasing pressure before transfer.
- 5.2.15** Remove the briquette and blot the excess water. Place the swollen briquette in the mercury cup and allow the briquette to displace the mercury by pressing the plastic plate flatly, squarely and firmly down on the specimen's top surface until the plate is seated on the top rim on the cup and the excess mercury is fully displaced. Weigh and record the weight of the mercury and the cup minus the weight of the mercury lost due to immersion of the swollen briquette (W_3). In no event will the briquette be allowed to set for more than ten minutes before weighing is completed. The sides of the briquette will be squeezed for recording condition of the briquette such as hard, firm, soft, soft and cracked, or disintegrated. Refer to paragraph 6.1.2 (calculations) to determine the percent of volume swell. See Note 5.

5.2 Volume Swell Procedure – Mercury Method: (continued)

Note 5 – The test specimen shall be weighed immediately after excess water is blotted off the specimen. If the specimen is allowed to set for any amount of time, the specimen will dry out and shrink giving erroneous swell results.

6 Calculation:

6.1 The volume swell, expressed as a percentage can be calculated by either of the two following methods.

6.1.1 Percent Volume Swell by Caliper Method

$$V = \pi r^2 h$$

where:

V = volume of specimen

π = 3.1416

r = radius of specimen

h = height of specimen

and

$$S = \frac{V_2 - V_1}{V_1} \times 100$$

where:

S = volume swell, percent,

V_1 = volume of specimen before immersion, by caliper

V_2 = volume of specimen after immersion.

6.1.2 Percent Volume Swell by Mercury Method

$$S = \frac{W_2 - W_3}{W_1 - W_2} \times 100$$

where:

S = volume swell, percent,

W_1 = weight of cup filled with mercury,

W_2 = weight of mercury and cup minus mercury lost because of immersion of cured briquette,

W_3 = weight of mercury and cup minus mercury lost because of immersion of swollen briquette.

7 Report:

7.1 The report shall consist of the following:

7.1.1 Percent of Volume Swell,

7.1.2 Condition of specimen.

METHODS OF SAMPLING AND TESTING
MT 309-15
SPLITTING SAMPLES OF PLANT MIX SURFACING
TO TESTING SIZE
(MONTANA METHOD)

1 Scope

- 1.1 This test method covers the procedure for splitting samples of Plant Mix Surfacing (PMS). Take samples in accordance with [MT 303](#). Place sampled materials in Department provided containers. The sample is to be representative of the PMS being produced. Take a field sample of sufficient mass, such that after splitting, each quarter of the field sample meets the testing requirements. Split the field sample as close as possible to the point of testing, to avoid excessive cooling of the sample.

2 Referenced Documents

MT Materials Manual

MT 303 Sampling Bituminous Paving Mixtures

3 Apparatus

- 3.1 *Oven* – oven capable of maintaining compaction temperature range according to mix design.
- 3.2 *Splitting Surface* – a non-stick surface such as metal, paper, canvas blanket or heat-resistant plastic.
- 3.3 *Miscellaneous Equipment* – flat-bottomed scoop, broom or brush, large spatulas, trowels, metal straight edge or 12 inch dry wall taping knife, sheet metal quartering splitter, hot plate, heat resistant gloves or mittens, pans, buckets and cans.

4 Sample Preparation

- 4.1 Ensure the sample is warm enough to separate. If not, warm in an oven until it is sufficiently soft to mix and separate easily.

5 Procedure for Splitting Samples to Test Size

- 5.1 Heat the trowel(s), spatula(s), and splitting apparatus to 110°C (230°F) minimum.
- 5.2 Remove the sample from the container(s) by dumping into a conical pile. Place the sample on a hard, clean, non-stick, level surface where there will be neither loss of material nor the accidental addition of foreign material.
- 5.3 Mix the material thoroughly by turning the entire sample over four times. With the last turning, form the entire sample into a conical pile.

Note 1 – Accomplish mixing by turning the pile with a heated spatula or by rolling the material over with paper or other material used for the rolling surface. Do not re-mix samples of lean mixes or mixes with aggregate larger than ¾" (19mm).

- 5.4 Flatten the conical pile to a uniform thickness and diameter by pressing down with a hot spatula or trowel. The diameter should be four to eight times the thickness.
- 5.5 Divide the flattened pile into four approximately equal quarters with a heated spatula, trowel, flat metal plate, or sheet metal quartering splitter.
- 5.6 With the quartering apparatus in place, using a straightedge (taping knife), slice through the quarter of the PMS from the apex of the quarter to the outer edge. Pull or drag the material from the quarter holding one edge of the straightedge (taping knife) in contact with the quartering apparatus.
- 5.7 Slide or scoop the material into a sample pan. Repeat step 5.6 removing a similar amount of material from the opposite corner and repeat until all the samples for testing have been obtained.

Note 2 – When reducing the sample to test size it is advisable to take several small increments determining the mass each time until the proper minimum size is achieved. Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size use the sample as reduced for the test.

MT 312-14
DETERMINING MOISTURE CONTENT
OF BITUMINOUS MIXTURES
(Modified AASHTO T 329)

1 Scope

- 1.1 This test method covers the determination of the moisture content of bituminous mixtures by drying in an oven.

2 Referenced Documents**AASHTO**

T 329 Moisture Content of Hot Mix Asphalt (HMA) by Oven Method

MT Materials Manual

MT 303 Sampling Bituminous Paving Mixtures

MT 309 Splitting Samples of Plant Mix Surfacing to Testing Size

3 Terminology

- 3.1 *Constant mass* – the state at which a mass does not change more than 0.05 percent.
- 3.1.2 Determine the mass after initially dried for 90 ± 5 minutes. Continue drying the sample at 30 ± 5 minute intervals, at a temperature not to exceed mix design compaction temperature range. After each interval, determine the mass and use the calculation in Section 7.2 until the sample has achieved constant mass.

4 Apparatus

Ensure equipment used meets the following requirements:

- 4.1 *Forced Air, Ventilated, or Convection Oven* – capable of maintaining mix design compaction temperature range.
- 4.2 *Thermometer* – with a temperature range from 50°F to 400°F (10°C to 204.4°C).
- 4.3 *Balance or scale* – with a capacity of at least 2 Kg., readable to 0.1 gram.
- 4.4 *Sample container* – not affected by heat and of sufficient size to contain a test sample of at least 1,000 g without danger of spilling.

5 Sample

- 5.1 Obtain the test sample in accordance with [MT 303](#), and reduce in accordance with [MT 309](#). Ensure the test sample is at least 1000 g.

6 Procedure

- 6.1 Determine and record the temperature and mass of the sample container to the nearest 0.1 g.
- 6.2 Place the test sample in the sample container and evenly distribute. Determine and record the total mass of the sample container and the test sample to the nearest 0.1 g.
- 6.3 Calculate the initial, moist mass of the test sample by subtracting the mass of the sample container determined in section 6.1 from the total mass of the sample container and the test sample determined in section 6.2.
- 6.4 Dry the test sample to a constant mass in the sample container.

- 6.5 After drying, determine and record the total mass of the sample container and test sample to the nearest 0.1 g.

Note 1 – Do not remove the test sample from the sample container for the purposes of determining mass.

- 6.6 Ensure the final sample temperature is within $\pm 15^{\circ}\text{F}$ of the temperature recorded in Section 6.1.
- 6.7 Calculate the final, dry mass of the test sample by subtracting the mass of the sample container determined in section 6.1 from the total mass of the sample container and the test sample determined in section 6.5.

Note 2 – Moisture content and the number of samples in the oven will affect the rate of drying. Placing wet samples in the oven with nearly dry samples will affect the drying process.

7 Calculations

- 7.1 Calculate the **moisture content**, as a percentage of the total mix, using the following formula:

$$\text{Moisture Content, \%} = \left(\frac{M_i - M_f}{M_i} \right) \times 100$$

where:

M_i = mass of the initial, moist test sample

M_f = mass of the final, dry test sample

Example: $M_i = 1001.3\text{g}$

$M_f = 991.7\text{g}$

$$\text{Moisture Content, \%} = \left(\frac{1001.3 - 991.7}{1001.3} \right) \times 100 = 0.9587, \text{ round to } 0.96\%$$

- 7.2 Calculate the **change in mass**, as a percentage, using the following formula:

$$\% \text{ Change} = \left(\frac{M_p - M_n}{M_n} \right) \times 100$$

Where:

M_p = previous mass measurement

M_n = new mass measurement

8 Reporting

- 8.1 Report the moisture content to the nearest 0.01 percent.

MT 314-14
BULK SPECIFIC GRAVITY OF
COMPACTED BITUMINOUS MIXTURES
(MODIFIED AASHTO T 166)

1 Scope:

- 1.1** This test method covers the determination of bulk specific gravity (G_{mb}) of specimens of compacted plant mix surfacing (PMS).
- 1.2** Do not use this method with samples that contain open or interconnecting voids or absorb more than 2 percent of water by volume, as calculated in section 7.2. If sample absorbs more than 2 percent of water by volume, refer to AASHTO T 275.
- 1.3** The bulk specific gravity (G_{mb}) of the compacted bituminous mixtures may be used in calculating the unit mass of the mixture.
- 1.4** The values stated in SI units are to be regarded as the standard.

2 Referenced Documents:**AASHTO:**

M 231 Weighing Devices Used in the Testing of Materials

T 166 Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Saturated Surface-Dry SpecimensT 275 Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens**ASTM:**

D7227 Rapid Drying of Compacted Asphalt Specimens Using Vacuum Drying Apparatus

3 Terminology:

- 3.1** *Bulk Specific Gravity (of Solids) (G_{mb})* – The ratio of the mass in air of a unit volume of a permeable material (including both permeable and impermeable voids normal to the material) at a stated temperature to the mass in air of equal density of an equal volume of water at a stated temperature. Express G_{mb} as follows:

$$\text{Bulk specific gravity } (G_{mb}) \text{ at } \frac{x}{y}^{\circ}C$$

where:

x = temperature of the material; and

y = temperature of the water.

- 3.2** *Constant mass* – the state at which a mass does not change more than 0.05 percent.
- 3.2.1** Determine the mass after each cycle (Core Dry Method) or after an initial dry time of 90 ± 5 minutes (Suspension Method). Continue drying the sample at 30 ± 5 minute intervals, at a temperature not to exceed mix design compaction temperature range. Determine the mass at each cycle or interval until the sample has achieved constant mass.

Note 1 - Recently molded laboratory samples, which have not been exposed to moisture, do not require drying. Core samples may be air dried in lieu of oven drying if results are proven not to differ from the oven drying method. The oven drying method is the standard and shall be used in case of dispute.

4 Test Specimens:

- 4.1 Test specimens may be either laboratory-compacted Plant Mix Surfacing (PMS) or sampled from PMS pavements.
- 4.2 *Size of Specimens* – It is recommended that: (1) the diameter of cylindrically molded or cored specimens, or the length of the sides of sawed specimens, be at least equal to four times the maximum size of the aggregate; and (2) the thickness of specimens be at least 1.5 times the maximum size of the aggregate.
- 4.3 Take specimens from pavements with a core drill, diamond or carborundum saw, or by other suitable means.
- 4.4 Avoid distortion, bending, or cracking of specimens during and after the removal from the pavement or mold. Store specimens in a safe, cool place.
- 4.5 Ensure specimens are free from foreign materials such as seal coat, tack coat, foundation material, soil, paper, or foil.
- 4.6 Separate specimens from other pavement layers, if necessary, by sawing or other suitable means. Ensure sawing does not damage the specimens.
- 4.7 Once a testing method has been selected, all core samples for the project must be evaluated using the selected method.

5 CoreDry (InstroTek® Inc.) Drying Method:

- 5.1 Follow the manufacturer's recommendations for warm up and self-test procedures.
- 5.2 *Daily Test:* Every day before starting the testing operation, dry the cold trap and the specimen chamber. Run the unit without any specimens. Ensure the pressure reading on the display is 6 mm Hg or less. If the indicated pressure is higher than 6 mm Hg, refer to the manufacturer's trouble shooting instructions for obtaining a proper pressure reading in the chamber.
- 5.3 *Drying Specimens:* Use a handheld infrared thermometer to ensure that the surface temperature of the specimen is between 15°C and 30°C (59 °F and 86 °F). If the specimen is below 15°C or above 30°C (59 °F and 86 °F), place the specimen in a room temperature environment until the surface temperature approaches the required testing temperature of 15°C to 30°C (59 °F and 86 °F).
- 5.4 Place a specimen (on its side) on top of the specimen support plate inside the chamber.
- 5.5 Place the lid on the vacuum chamber and press the lid down to ensure contact between the lid and the chamber, and start the drying process. The unit will automatically stop when it determines the specimen is dry.
- 5.6 Remove the specimen, determine and record the mass.
- 5.7 Repeat sections 5.4, 5.5 and 5.6, as needed, until the specimen is dried to a constant mass per section 3.2.
- 5.8 Cool the specimen to room temperature at $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$), and record the dry mass as A.
- 5.9 Immerse each specimen in water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) for 4 minutes \pm 1 minute and record the immersed mass as C.

5 CoreDry (InstroTek® Inc.) Drying Method: (continued)

- 5.10 Remove the specimen from the water. Damp-dry the specimen (*Note 1*) by blotting with a damp terry cloth towel and determine the Saturated Surface Dry (SSD) mass as *B* as quickly as possible (*the entire operation is not to exceed 15 s*). Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen. Immerse and weight each specimen individually.

Note 1 - Damp is considered to be when no water can be wrung from the towel that has been completely submerged in water.

- 5.11 Calculate the bulk specific gravity as given in section 7.1.

6 Suspension Method:

6.1 Apparatus:

Ensure equipment used meets the following requirements;

- 6.1.1 *Forced Air, Ventilated, or Convection Oven* – capable of maintaining mix design compaction temperature range.
- 6.1.2 *Weighing Device* –weighing device of sufficient capacity, readable to 0.1 percent of the sample mass, or better, and conforms to the requirements of AASHTO M 231. Use a device equipped with suitable suspension apparatus and holder to permit weighing the specimen while suspended from center of the scale pan of the weighing device.
- 6.1.3 *Suspension Apparatus* – the wire suspending the container must be the smallest practical size to minimize any possible effects of a variable immersed length. The suspension apparatus must enable the container to be immersed to a depth sufficient to cover it and the test sample during weighing. Ensure no trapped air bubbles exist under the specimen.
- 6.1.4 *Water Bath* - for immersing the specimen in water while suspended under the balance, equipped with an overflow outlet for maintaining a constant water level.

6.2 Procedure:

- 6.2.1 Dry the specimen to a constant mass at a temperature of $125 \pm 5^{\circ}\text{F}$ ($52 \pm 3^{\circ}\text{C}$).
- 6.2.2 Cool the specimen to room temperature at $25 \pm 5^{\circ}\text{C}$ ($77 \pm 9^{\circ}\text{F}$), and record the dry mass as *A*.
- 6.2.3 Immerse each specimen in water at $25 \pm 1^{\circ}\text{C}$ ($77 \pm 1.8^{\circ}\text{F}$) for 4 minutes \pm 1 minute and record the immersed mass as *C*.
- 6.2.4 Remove the specimen from the water. Damp-dry the specimen (*see Note 1 in section 5.10*) by blotting with a damp terry cloth towel, and determine the Saturated Surface Dry (SSD) mass as *B* as quickly as possible, (*the entire operation is not to exceed 15 s*). Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen. Immerse and weight each specimen individually.

7 Calculation:

7.1 Calculate the bulk specific gravity of the specimen as follows:

$$G_{mb} = \frac{A}{(B-C)}$$

where:

G_{mb} = Bulk Specific Gravity

A = mass in grams of the specimen in air

B = mass in grams of the surface-dry specimen in air

C = mass in grams of the specimen in water

7.2 Calculate the percent of water absorbed by the specimen (on a volume basis) as follows:

$$\text{Percent of Water Absorbed by Volume} = \frac{(B-A)}{(B-C)} \times 100$$

8 Report:

8.1 Include the following:

8.1.1 The method used (CoreDry or Suspension).

8.1.2 Bulk Specific Gravity reported to the nearest thousandth, 0.001.

8.1.3 Absorption reported to the nearest hundredth 0.01%.

**METHOD OF SAMPLING AND TESTING
MT 316-04
METHOD OF SAMPLING RECYCLED PAVEMENT
AND FIELD CONTROL OF RECYCLE PAVING**

1 General:

1.1 This method is divided into four sections which are as follows:

1.2 **Section A:** Sampling pavement for Cold Recycling

1.3 **Section B:** Field Control of Cold Recycle Paving

1.4 **Section C:** Sampling Pavement for Hot Recycling

1.5 **Section D:** Field Control of Hot Recycle Paving

Each section of this method is to be used specifically for its respective purpose related to recycle paving.

SECTION A:

2 Sampling Pavement for Cold Recycling

2.1 Scope:

2.2 This section describes the procedure for sampling roadways for cold mix recycling. The first portion describes sampling procedures for design information to determine if recycling is possible. The second portion describes sampling procedures for mix design purposes.

3 Procedure:

3.1 Preliminary Sampling for Proposed Recycled Pavement

3.1.1 The project should be divided into at least three areas from which milled or cored samples are obtained. A minimum of three representative sample locations should be visually selected in each area. Samples weighing approximately sixty pounds and representative of the lifts to be recycled should be obtained from each location. If maintenance patches or other intermittent treatments occur within the area, the locations that samples were taken should be recorded and the samples properly labeled. The proposed depth for recycling the pavement should be recorded.

3.1.2 Sampling a Cold Recycled Pavement for Mix Design: Milled Sampling

3.1.2.1 The project should be divided into at least three areas from which samples are obtained. A minimum of three locations should be used for each area of sampling. Submit approximately one hundred pounds of milled plant mix from each location. Three core samples should be taken to correspond with each milled area. The core samples should be placed into sealed containers at the job site so that in-place moisture contents may be determined.

3.1.3 Submitting Samples:

3.1.3.1 Samples from different locations are to be kept separate and submitted to the Materials Bureau for testing. Pertinent information such as locations at which samples were taken and depth to which milling was performed should be submitted with the samples.

SECTION B:**4 Field Control of Cold Recycle Paving:****4.1 Scope:**

- 4.1.1** This section describes the procedure for field control of cold recycle paving. The test procedure utilizes standard 50 blow Marshall specimens. The Marshall specimens will be fabricated at the job site and then transported to the Materials bureau for compression testing.
- 4.1.2** Material should be secured from either the feed hopper of the laydown machine or the windrow, depending on the paving operation. Enough material (at least 25 lbs.) should be obtained for both the molding of briquettes and moisture determination.

5 Procedure:**5.1 Determination of Moisture Content:**

- 5.1.1** For moisture determination, a representative sample of 2000 grams shall be weighed and placed in a 140°F oven.
- 5.1.2** The sample shall be weighed at intervals with weight losses recorded until a stabilized condition is achieved. A moisture loss of less than 1.0 gram in one hour should be considered a stabilized condition. Moisture content may be determined by:

$$\text{Moisture Content}(\%) = \frac{WT(\text{Initial}) - WT(\text{final})(100\%)}{WT(\text{final})}$$

5.2 Briquette Fabrication:**5.2.1 Apparatus:**

5.2.1.1 Scoops

5.2.1.2 Thermometer, - 50° to 150°F

5.2.1.3 Balance - 2 kg. Capacity for weighing batch samples and briquettes

5.2.1.4 Mixing spoons

5.2.1.5 Spatulas

5.2.1.6 Standard Marshall compaction pedestal - with molds and compaction hammer

5.2.1.7 Extrusion jack

5.2.1.8 Gloves and marking crayons

5.2.1.9 Pans for holding and warming specimens

5.2.1.10 Oven - capable of maintaining 140°F ±5°F

6 Preparation of Test Specimens:

- 6.1** Prepare three specimens for each test.
- 6.2** Thoroughly clean molds and hammer face. Place paper disk in bottom of molds. Warm molds and hammer to remove chill.
- 6.3** Weigh out individual briquette samples. It is recommended that a trial briquette, approximately 1140 grams, be molded initially to determine height. Weight of material should then be adjusted to produce 2-1/2" ±0.05" specimens.

6 Preparation of Test Specimens:

- 6.4 Warm individual specimens in 140°F oven for two hours. Note: This process has been found to develop a density of mix equal to the roller compaction on the roadway.
- 6.5 Mold briquettes using standard Marshall procedures (i.e., 50 blows applied to each face).
- 6.6 Curing specimens in molds for up to 24 hours before extruding may be necessary if distortion occurs at an earlier extrusion time. Molds should be placed on their sides to permit equal ventilation of both ends (remove paper disks).
- 6.7 Carefully extrude specimens from molds.
- 6.8 If, when extruded, briquettes are sufficiently strong to enable handling, proceed to weigh in air, weigh in water and weigh saturated surface dry.
- 6.9 If, when extruded, briquettes are too tender to handle, curing will be required until they can be handled. The bulk specific gravities may then be determined.

Bulk specific gravity is calculated as follows:

$$\text{BulkSpecificGravity}(BSG) = \frac{WT_{inAir}}{WT(SSD) - WT_{inWater}}$$

- 6.9 Once bulk specific gravities have been determined, carefully transport the specimens to the Materials Lab for compression testing.
- 6.10 Report the specific gravities that were measured and the location represented by the samples. The samples must be protectively wrapped for shipping and they must be numbered sequentially to maintain control of their origin and history.

7 Utilization of Final Record Samples:

- 7.1 The final record pavement core samples taken in accordance with MT 602 are designated for research. As soon as possible, these should be sent to the Materials Bureau, accompanied by Form No. 31. The location and sample number are to be entered on the form and the wrapped cores are to be sequentially numbered.

SECTION C:**8 Sampling Pavement for Hot Mix recycling:****8.1 Scope:**

- 8.1.2 This section describes the procedure for sampling roadways for hot mix recycling. The first portion describes sampling procedures for design information to determine if recycling is possible. The second portion describes sampling procedures for mix design purposes.

9 Procedure:**9.1 Preliminary Sampling for Proposed Recycled Pavement:**

- 9.1.2 The project should be divided into at least three areas from which milled or cored samples are obtained. A minimum of three representative sample locations should be visually selected in each area. Samples weighing approximately sixty pounds and representative of the lifts to be recycled should be obtained from each location. If maintenance patches or other intermittent treatments occur within the area, the locations that samples were taken from should be recorded and the samples properly labeled. The proposed depth for recycling the pavement should be recorded.

9.1 Preliminary Sampling for Proposed Recycled Pavement: (continued)

To complete assessment of a potentially recyclable pavement, submit information about sources of aggregate used on the original project. In addition, send a minimum of 350 pounds of material to the Materials Bureau from a source which may be used as a virgin aggregate in the recycle mix.

10 Sampling a Hot Recycled Pavement for Mix Design:**10.1 Milled Sampling:**

10.1.1 The project should be divided into at least three areas from which samples are obtained. A minimum of three locations should be used for each area of sampling. Submit approximately one hundred pounds of milled plant mix from each location. Three core samples should be taken to correspond with each milled area.

11 Stockpile Sampling:

11.1 Stockpiles of crushed reclaimed plant mix shall be sampled in accordance with MT 201, paragraph 10.

Note - Stockpile sampling requires particular care to avoid segregation. Samples should be taken from a near vertical face and should be secured by reducing the sample to 300-pounds by the quartering method or with a sample splitter. Due to the time required to extract and analyze the reclaimed plant mix, samples should be submitted as soon as one-third of the reclaimed mat stockpile has been produced.

11.2 To complete the mix design, 350 pounds of aggregate from the stockpiles of virgin aggregate, along with the appropriate forms, are required. The samples and documentation may be submitted when, in the judgment of the Project Manager, they are representative of the material to be incorporated into the recycled plant mix.

SECTION D:**12 Field Control of Hot Recycle Paving:****12.1 Scope:**

12.1.2 This section describes the procedure for field control of hot recycle paving.

13 Procedure:

13.1 The crushed reclaimed mate shall be sampled in accordance with MT 201, paragraph 11: "Production sample shall be taken not less than every four hours. The sample shall be sieved and the percentage of oversize recorded. One sample of approximately 15 pounds shall be taken and submitted to the Materials Bureau every three days."

13.2 The aggregate incorporated into the mix shall be subject to all of the controls of a normal plant mix operation. The output of the plant will be subjected to field control Marshall testing with the same frequency as a conventional mix.

13.3 Monitors of established production of recycled plant mix shall be taken the first three days and the first day of every week thereafter or until otherwise informed by the Materials Bureau.

13.4 The samples shall be placed in a new double paper bag with completed form No 98 inserted between the sacks to keep it clean. The bag should be securely tied and marked as to sample number, stationing, lane and lift. This same information shall be placed on each Daily Plant Mix Report. Several of these paper bags can be packed into a sample sack for transmittal to the laboratory. Care should be taken to see that no movement is possible, or broken bags and mixed samples will result.

14 Utilization of Final Record Samples:

- 14.1** The final record pavement core samples taken in accordance with MT 602 are designated for research. As soon as possible, these should be sent to the Materials Bureau, accompanied by Form No. 31. The location and sample number are to be entered on the form and the wrapped cores are to be sequentially numbered.

METHODS OF SAMPLING AND TESTING
MT 319-14
DETERMINING THE ASPHALT BINDER CONTENT
OF PLANT MIX SURFACING (PMS) BY THE IGNITION METHOD
(Modified AASHTO T 308)

1 Scope

- 1.1 This test method covers the determination of asphalt binder content of Plant Mix Surfacing (PMS) mixtures by ignition at temperatures that reach the flashpoint of the binder in a furnace. The means of specimen heating may be the convection method or the direct infrared (IR) irradiation method.
- 1.2 The values in metric units are to be regarded as the standard.
- 1.3 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2 Referenced Documents**AASHTO**

M 231 Weighing Devices Used in the Testing of Materials

T 308 Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

MT Materials Manual

MT 202 Sieve Analysis of Fine and Coarse Aggregates

MT 303 Sampling Bituminous Paving Mixtures

MT 309 Splitting Samples of Plant Mix Surfacing to Testing Size

MT 312 Determining Moisture Content of Bituminous Mixtures

MT 320 Mechanical Analysis of Aggregate Recovered from Ignition Oven Burn

MT 325 Determining Moisture Content of Bituminous Mixtures or Aggregate Using Microwave Ovens

3 Summary of Test Method

- 3.1 The asphalt binder in the paving mixture is ignited using the furnace equipment applicable to the particular method. The asphalt binder content is calculated as the difference between the initial mass of the PMS and the mass of the residual aggregate. The asphalt content is expressed as mass percent of moisture-free mixture. This method may be affected by the type of aggregate in the mixture. Accordingly, to optimize accuracy, establish correction factors for asphalt binder and aggregate by testing a set of correction factor specimens for each type of PMS.

4 Significance and Use

- 4.1 This method can be used for quantitative determinations of asphalt binder content and gradation in PMS mixtures and pavement specimens for quality control, specification acceptance, and mixture evaluation studies. This method does not require the use of solvents. Use aggregate obtained by this test method for gradation analysis according to [MT 320](#).

5 Apparatus

Ensure equipment used meets the following requirements:

- 5.1 *Ignition furnace* - A forced air ignition furnace that heats the specimen by either convection method or direct IR irradiation method. Use a convection-type furnace capable of maintaining a temperature at 578°C (1072°F). Use a furnace containing an internal balance thermally isolated from the furnace chamber and accurate to 0.1 g. The balance must be capable of weighing a 3500 gram specimen in addition to the specimen baskets. A data collection system is included so

that the weight can be automatically determined and displayed during the test. The furnace has a built in computer program to calculate change in mass of the specimen and provide for the input of a correction factor. The furnace chamber and basket dimensions must be adequate to accommodate a specimen size of up to 3500 grams. The furnace provides an audible alarm and indicator light when the specimen mass loss does not exceed 0.01 percent of the total specimen mass for three consecutive minutes. The furnace door is equipped so that the door cannot be opened during the ignition test. The furnace must be vented into a hood or to the outside. The furnace is equipped with a fan capable to pull air through the furnace to expedite the test and to reduce the escape of smoke into the laboratory.

- 5.2 *Specimen basket(s)* - of appropriate size that allows the specimens to be thinly spread and allows air to flow through and around the specimen particles. Ensure sets with 2 or more baskets are nested. Completely enclose the specimen with screen mesh, perforated stainless steel plate, or other suitable material.

Note 1 – Screen mesh or other suitable material with maximum and minimum opening of 2.36 mm (No. 8) and 600 microns (No. 30), respectively, has been found to perform well.

- 5.3 *Catch Pan* - of sufficient size to hold the specimen basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught.
- 5.4 *Oven* - capable of maintaining mix design compaction temperature.
- 5.5 *Balance* - of sufficient capacity and conforming to the requirements of AASHTO M 231, Class G 2, for weighing specimen in basket(s).
- 5.6 *Safety Equipment* - face shield, high temperature gloves, a heat resistant surface capable of withstanding 650°C (1202°F) and a protective cage capable of surrounding the specimen baskets during the cooling period.
- 5.7 *Miscellaneous Equipment* - a pan larger than the specimen basket(s) for transferring specimen after ignition; spatulas, bowls, wire brushes, and other manufacturer's equipment.

6 Sampling

- 6.1 Obtain samples of freshly produced PMS in accordance with [MT 303](#).
- 6.2 Obtain the test specimen by splitting a sample taken in accordance with [MT 309](#).
- 6.3 If the mixture is not sufficiently soft to separate with a spatula or trowel, place it in a large flat pan or glass dish in an oven (conventional or microwave). Heat the specimen to separate. Excessive heat may cause asphalt drain down or oxidation to occur, altering the results.
- 6.4 The size of the test specimen is governed by the nominal-maximum aggregate size of the PMS and must conform to the mass requirement shown in Table 1. Ensure the specimen is no more than 400 grams greater than the minimum recommended specimen mass.

Note 2 – Large specimens of fine mixes tend to result in incomplete ignition of asphalt.

Table 1—Mass Requirements

Nominal Max Agg Size, mm	Sieve Size	Min Mass of Specimen, g
4.75	No. 4	1200
9.5	3/8 in.	1200
12.5	1/2 in.	2000
19.0	3/4 in.	2000
25.0	1 in.	3000
37.5	1 1/2 in.	4000

7 Test Procedure

7.1 Test Initiation:

- 7.1.1 For the convection-type furnace, preheat the ignition furnace to 538°C (1000°F) or as determined in ANNEX A1.9.1. Manually record the furnace temperature (set point) prior to the initiation of the test if the furnace does not record automatically.
- 7.1.2 For the direct IR irradiation-type furnace, preheat furnace to 420°C (788°F) or manufacturer's recommendation. Use the same burn profile as used during the correction factor determination.
- 7.2 Determine the moisture content of the specimen according to [MT 312](#) or [MT 325](#) at the beginning and middle of each production day and as needed.
- 7.3 Apply the correction factor for the specific mix to be tested as determined in ANNEX A1 in the ignition furnace.
- 7.4 Weigh and record the mass of the specimen basket(s) and catch pan (with guards in place) to the nearest 0.1 gram.
- 7.5 Prepare the specimen as described in Section 6. Place the specimen basket(s) in the catch pan. Evenly distribute the specimen in the specimen basket(s), taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.
- 7.6 Weigh and record the total mass of the specimen, basket(s), catch pan, and basket guards. Calculate and record the initial mass of the specimen (total mass minus the mass of the specimen basket assembly).
- 7.7 Input the initial mass of the specimen to 0.1 gram for direct IR irradiation-type furnace or 1 gram for convection-type furnace into the ignition furnace controller. Verify that the correct mass has been entered.
- 7.8 Open the chamber door and place the specimen basket assembly in the furnace, carefully positioning the specimen basket assembly so it is not in contact with the furnace walls. Close the chamber door, and verify that the specimen mass (including the basket assembly) displayed on the furnace scale equals the total mass recorded in Section 7.6 within ± 5 grams. (Note 4) An indication that the specimen basket assembly is contacting the furnace wall is a difference greater than 5 g or failure of the furnace scale to stabilize.

Initiate the test by pressing the start/stop button. This operation will lock the specimen chamber and start the combustion blower.

Note 3 – The furnace temperature will drop below the set point when the door is opened, but will recover with the door closed and when ignition occurs. Specimen ignition typically increases the temperature well above the set point, depending on specimen size and asphalt binder content.

Note 4 – The weights obtained from external weighing take precedence over those obtained from the internal balance.

- 7.9 Allow the test to continue until the stable light and audible alarm indicate the test is complete (the change in mass does not exceed 0.01 percent for three consecutive minutes). Press the start/stop button. This will unlock the specimen chamber door.
- 7.10 Open the chamber door, remove the specimen basket assembly, allow specimen to cool to room temperature and weigh. During cooling, ensure specimen basket assembly is protected from contaminants.
- 7.11 Calculate the corrected asphalt binder content (percent) from the external weighing according to the following equation:

$$Pb, \% = \left[\frac{(M_i - M_f)}{M_i} \times 100 \right] \pm Cf - MC$$

Pb = the measured (corrected) asphalt binder content, percent
M_i = the total mass of the PMS specimen prior to ignition, g
M_f = the total mass of aggregate remaining after the ignition, g
Cf = the correction factor, percent by mass of PMS specimen
MC = the moisture content of the PMS

8 Extraction of Residual Aggregate for Gradation

- 8.1 Cool the contents of the specimen baskets to room temperature prior to performing the gradation analysis. Empty the contents of the baskets into a flat pan, being careful to capture all the material. Use a small wire sieve brush to ensure that any residual fines are removed from the baskets and catch pan.
- 8.2 Weigh the specimen and perform the gradation analysis according to [MT 320](#).

9 Report

- 9.1 Report the corrected asphalt binder content to the nearest 0.01%, correction factor, temperature compensation factor (if applicable), total percent loss, specimen mass and moisture content (if determined).

ANNEX**A1 Correction Factors**

- A1.1 Asphalt binder content results may be affected by the type of aggregate in the mixture and the ignition furnace. Accordingly, to optimize accuracy, establish a correction factor by testing a set of correction factor specimens for each type of PMS. Perform this procedure before any acceptance testing is completed. Repeat the process for determining a correction factor each time there is a new or transferred PMS design. Determine a unique correction factor for each ignition furnace in the location where testing is to be performed.
- A1.2 *Asphalt binder correction factor* – Certain aggregate types may result in unusually high correction factors (greater than 1.0 percent). Such mixes must be corrected and tested at a lower temperature, as described below. Determine a unique asphalt binder correction factor for each ignition furnace in the location where testing will be performed.
- A1.3 *Aggregate correction factor* – Due to potential aggregate breakdown during the ignition process, determine a unique aggregate correction factor for each ignition furnace in the location where testing will be performed when the following conditions occur: aggregates that have a proven history of excessive breakdown; or aggregates are from an unknown source.

A2 Correction Factor Procedure

- A2.1 According to the requirements of Section 6, prepare a minimum of four correction specimens at the job mix formula design asphalt content and gradation using only virgin material in a buttered bowl. Sample aggregate used for the correction factor specimens from stockpiled material produced and designated for use on the candidate project. An additional “blank” (aggregate only) specimen is provided for aggregate gradation comparison according to [MT 320](#). The washed gradation must fall within the mix design tolerances. (*Note 5*)

Note 5 – Helena Mix Design Laboratory will prepare all correction specimens. MDT Materials Bureau personnel will notify project personnel if aggregate degradation is apparent and to proceed according to Sections Annex A3 and A5.

- A2.2 Place the freshly mixed specimens directly in the specimen baskets assembly. If allowed to cool, heat the specimens in a conventional oven to compaction temperature. Do not preheat the specimen baskets assembly.
- A2.3 Test the specimens in accordance with Sections 7 and 8.
- A2.4 **After burning the appropriate number of calibration specimens**, determine the measured asphalt binder contents for each specimen by calculation or from the printed tickets.
- A2.5 If the difference between the measured asphalt binder contents of the 2 specimens exceeds 0.15 percent, repeat the 2 tests and, from the 4 tests, discard the high and low results. Determine the correction factor from the 2 remaining results. Calculate the difference between the actual and measured asphalt binder contents for each specimen. The correction factor is the average of the differences expressed in percent by weight of the asphalt mixture.

A3 Correction Factor Ignition Oven Temperature Adjustment

- A3.1 For the convection-type furnace, if the correction factor exceeds 1.0 percent, lower the test temperature to $482 \pm 5^{\circ}\text{C}$ ($900 \pm 8^{\circ}\text{F}$) and repeat test. Use the correction factor obtained at 482°C ($900 \pm 8^{\circ}\text{F}$) even if it exceeds 1.0 percent.
- A3.2 For the direct irradiation-type furnace, use Option 2 burn profile for most materials. Option 1 is designed for very soft aggregate (such as dolomites) that typically require a large aggregate correction factor (greater than 1%). Option 2 is designed for specimens that may not burn completely using the DEFAULT burn profile and is appropriate for most of Montana aggregates.

A4 Procedure Temperature

- A4.1 For the convection-type furnace, the temperature for testing PMS specimens in Section 7.1.1 is the same temperature selected for testing mixture correction specimens.
- A4.2 For the direct IR irradiation-type furnace, the burn profile for testing PMS specimens in Section 7.1.2 is the same burn profile selected for testing mixture correction specimens.

A5 Aggregate Correction Factor

- A5.1 Perform a gradation analysis on the residual aggregate in accordance with [MT 320](#), if required. Utilize the results to develop an aggregate correction factor. Calculate and report to the nearest 0.1 percent.
- A5.2 From the gradation results, subtract the percent passing for each sieve for each specimen from the percent passing each sieve of the “blank” specimen gradation results from Section A2.1.
- A5.3 Determine the average difference for the 2 values. If the difference for a single sieve exceeds the allowable difference for that sieve as listed in Table A1, apply aggregate gradation correction factors (equal to the resultant average differences) for all sieves, to all acceptance gradation test results determined by [MT 320](#), prior to final rounding and reporting. If the 0.075-mm (No. 200) sieve is the only sieve outside the limits in Table A1, apply the aggregate correction factor to only the 0.075-mm (No. 200) sieve.

Table A1 – Permitted Sieving Difference

Sieve Size	Allowable Difference
Sizes larger or equal to 2.36 mm (No. 8)	±5.0%
Sizes larger than 0.075 mm (No. 200) and smaller than 2.36 mm (No. 8)	±3.0%
Sizes 0.075 mm (No. 200) and smaller	±0.5%

A6 [Burn Oven Worksheet](#)

METHODS OF SAMPLING AND TESTING
MT 320-14
MECHANICAL ANALYSIS OF AGGREGATE
RECOVERED FROM IGNITION OVEN BURN

1 Scope

- 1.1 This test method is a procedure for the determination of the particle size distribution using square mesh sieves of fine and coarse aggregates recovered from bituminous mixtures by MT319.

2 Referenced Documents**AASHTO Standards**

M 231 Weighing Devices Used in the Testing of Materials

MT Materials Manual

MT 319 Determining the Asphalt Binder Content of Plant Mix Surfacing (PMS) by the Ignition Method

MT 405 Wire Cloth Sieves for Testing Purposes

MT 607 Reducing Field Samples of Aggregate to Testing Size

3 Terminology

- 3.1 *Constant mass* – the state at which a mass does not change more than 0.10 percent, after additional drying for a defined time interval in Table 3.1

Table 3.1
Methods of Drying

Heat Source	Specific Instructions	Drying increments (minutes)
Controlled: Forced draft (preferred), ventilated, or convection oven	110 ±5°C (230 ±9°F)	30
Uncontrolled: Hot plate, Heat Lamp, etc.	Stir frequently	20
Microwave	Heap sample and cover with ventilated lid	10

4 Significance and Use

Use this method to determine the grading of aggregates extracted from bituminous mixtures. Use the results to determine compliance of the particle-size distribution with applicable specification requirements.

5 Apparatus

Ensure equipment used meets the following requirements:

- 5.1 *Balance* – balance or scale with a capacity larger than the size of the sample being tested. Use a balance or scale with sensitivity of 0.1 gram and in accordance with AASHTO M 231.
- 5.2 *Sieves* – square mesh sieves mounted on substantial frames constructed to prevent loss of material during sieving. Select suitable sieve sizes to furnish the information required by the specifications covering the material being tested. Ensure the sieves conform to the requirements of [MT 405](#) Wire Cloth Sieves for Testing Purposes.

- 5.3 *Mechanical Sieve Shaker* - A mechanical sieving device creating a motion of the sieves that causes the particles to bounce, tumble, or otherwise turn so as to present different orientations to the sieving surface. Excessive time (more than 10 minutes) to achieve adequate sieving may result in degradation of the sample.
- 5.4 *Heat Source* - Oven, Hot Plate or alternate heating source.
- 5.5 *Wetting Agent* – Any dispersing agent, such as dishwashing detergent, or a soap that promotes separation of the fine materials.
- 5.6 *Container and utensils* - A container sufficient to contain the sample covered with water and to permit vigorous agitation without inadvertent loss of any part of the sample or water.
- 5.7 *Mechanical Washing Apparatus (Optional)* – A mechanical washing apparatus, if used, must provide results that are consistent with those obtained by use of manual operations.

6 Sample

- 6.1 Ensure the sample consists of the entire sample of aggregate obtained in accordance with [MT 319](#).

Note 1 – If the sample is overloading screens, split or quarter the sample in accordance with [MT 607](#), Procedure for Reducing Field Samples of Aggregate to Testing Size. Grade each part of the sample separately and combine the weights to obtain a representative gradation. Use the following table to determine if screens are overloaded.

MAXIMUM WEIGHT RETAINED				
Screen Size	8-inch (203 mm) Diameter Screen		12-inch (304.8 mm) Diameter Screen	
	Maximum Grams	Maximum Pounds	Maximum Grams	Maximum Pounds
1 ¼-inch (31.75 mm)			3821.9	8.4
1-inch (25.0 mm)			3057.5	6.7
¾-inch (19.0 mm)			2598.9	5.7
⅝-inch (16.0 mm)			2293.2	5.1
½-inch (12.5 mm)			1987.4	4.4
⅜-inch (9.5 mm)			223.0	2.7
No. 4 (4.75 mm)			318	0.7
No. 8 (2.36 mm)	194	0.4	436.5	0.9
No. 10 (2.00 mm)	194	0.4	436.5	0.9
No. 16 (1.18 mm)	194	0.4	436.5	0.9
No. 30 (0.600 mm)	194	0.4	436.5	0.9
No. 40 (0.425 mm)	194	0.4	436.5	0.9
No. 50 (0.300 mm)	194	0.4	436.5	0.9
No. 80 (0.180 mm)	194	0.4	436.5	0.9
No. 100 (0.150 mm)	194	0.4	436.5	0.9
No. 200 (0.075 mm)	194	0.4	436.5	0.9

7 Procedure

- 7.1 Dry the sample to constant mass. The total mass of aggregate in the bituminous mixture being tested is the sum of the mass of the dried aggregates and the mineral matter contained in the extracted asphalt.

- 7.2 Place the test sample in a container and cover with water. Add a detergent, dispersing agent, or other wetting solution to the water to ensure a thorough separation of the material passing the No. 200 sieve from the coarser particles. Add just enough wetting agent to produce a small amount of suds when the sample is agitated. The quantity depends on the hardness of the water and the quality of the detergent. Excessive suds may overflow the sieves and carry some material with them. Agitate the contents of the container vigorously and immediately pour the wash water over a nest of 2 sieves consisting of a No. 10 or 16 sieve superimposed on a No. 200 sieve. Use a large metal spoon to stir and agitate the aggregate in the wash water.
- 7.3 Ensure the agitation is sufficiently vigorous to result in the complete separation of the coarse particles from all particles finer than the No. 200 sieve and bring them into suspension in order that they may be removed by decantation of the wash water. Take care to avoid, as much as possible, the decantation of the coarse particles of the sample. Repeat the operation until the wash water is clear. Do not overflow or overload the No. 200 sieve.
- 7.4 Return all material retained on the nested sieves to a drying container. Dry the washed aggregate in the container to constant mass in an oven or alternate heating source. Weigh the sample and record to the nearest 0.1 gram.
- 7.5 Cool the aggregate and mechanically sieve over sieves of the various sizes required by the specification, for approximately 10 minutes. Record the weight of material passing each sieve and the amount passing the No. 200 sieve.

8 Calculations

- 8.1 Convert the individual weights retained to total weight passing each of the various sieves. Divide the total weight passing by the total weight of the sample, multiply by 100, which will result in the percent passing.
- 8.2 Ensure the total mass of the material after sieving closely aligns with the original mass of the sample placed on the sieves (dry mass after washing). Confirm the sum of these masses is within 0.2 percent of the mass after wash.
- 8.2.1 Calculate the percent change using the constant mass equation:

$$\frac{M_1 - M_2}{M_1} \times 100 = \% \text{ Change}$$

Where:

M_1 = mass prior to sieving

M_2 = total mass after sieving

9 Report

- 9.1 Report the results of the sieve analysis as the total percentages passing each sieve size and report to the nearest whole number for all material coarser than the 200 mesh. Report the 200 mesh material to one tenth of one percent (0.1). Calculate the percentages on the basis of the total initial weight (before wash) of the sample, including any material finer than the 200 mesh sieve.

GRADATION WORKSHEET EXAMPLE

Date: _____ Project/Termini _____

Contract ID _____ Sample Number _____

Before Wash 2405 After Wash 2352.2 LBW 52.8

Wt. Retained	Wt. Pass.	Percent Passing
<u>0.0</u>	25M <u>2405</u>	<u>100</u>
<u>144.0</u>	19M <u>2261</u>	<u>94</u>
<u>312.0</u>	12.5M <u>2093</u>	<u>87</u>
<u>673.0</u>	9.5M <u>1732</u>	<u>72</u>
<u>1322.0</u>	4.75M <u>1083</u>	<u>45</u>
<u>1538.0</u>	2.36M <u>867</u>	<u>36</u>
<u>1827.1</u>	1.18M <u>577.9</u>	<u>24</u>
<u>2019.1</u>	0.60M <u>385.9</u>	<u>16</u>
<u>2115.1</u>	0.30M <u>289.9</u>	<u>12</u>
<u>2163.1</u>	0.15M <u>241.9</u>	<u>10</u>
<u>2259.1</u>	0.075M <u>145.9</u>	<u>6.1</u>
<u>2352.0</u>	Dry Pan <u>53.0</u>	

Remarks:

All weights are recorded to 0.1 of a gram.

GRADATION WORKSHEET

Date: _____ Project/Termini _____

Contract ID _____ Sample Number _____

Before Wash _____ After Wash _____ LBW _____

Wt. Retained	Wt. Pass.	Percent Passing
_____	25M _____	_____
_____	19M _____	_____
_____	12.5M _____	_____
_____	9.5M _____	_____
_____	4.75M _____	_____
_____	2.36M _____	_____
_____	1.18M _____	_____
_____	0.60M _____	_____
_____	0.30M _____	_____
_____	0.15M _____	_____
_____	0.075M _____	_____
_____	Dry Pan _____	_____

Remarks:

All weights are recorded to 0.1 of a gram.

METHOD OF SAMPLING AND TESTING
MT 321-14
DETERMINING THEORETICAL MAXIMUM SPECIFIC GRAVITY
OF BITUMINOUS PAVING MIXTURES - "RICE GRAVITY"
(Modified AASHTO T 209)

1 Scope

- 1.1 This test method covers the determination of theoretical maximum specific gravity (commonly referred to as Rice Gravity) of un-compacted bituminous paving mixtures.

2 Referenced Documents

AASHTO

T 209 Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt (HMA)

MT Materials Manual

MT 303 Sampling Bituminous Paving Mixtures

MT 309 Splitting Samples of Plant Mix Surfacing to Testing Size

MT 325 Determining Moisture Content of Bituminous Mixtures or Aggregate Using Microwave Ovens

3 Terminology

- 3.1 *Residual pressure, as employed by this test method* – the pressure in a vacuum vessel when vacuum is applied.
- 3.2 *Specific gravity, as determined by this test method* – the ratio of a given mass of material at 25° C (77° F) to the mass of an equal volume of water at the same temperature.

4 Significance and Use

- 4.1 The theoretical maximum specific gravities of bituminous paving mixtures are basic properties whose values are influenced by the composition of the mixtures and types and amounts of aggregates and asphalt materials.
- 4.2 These properties are used to calculate percent air voids in compacted bituminous paving mixtures.
- 4.3 These properties provide target values for the compaction of bituminous paving mixtures.
- 4.4 These properties are essential when calculating the amount of asphalt binder absorbed by the internal porosity of the individual aggregate particles in bituminous paving mixtures.

5 Apparatus

Ensure equipment used meets the following requirements:

- 5.1 *Balance* – Capacity of 16,000 g sensitive to 0.1 g, to allow the maximum specific gravity of the un-compacted mix to be calculated to four significant figures (3 decimal places).
- 5.2 *Container* - 4000 mL volumetric flask. Ensure the flask, with a proper cover, is sufficiently strong to withstand a partial vacuum. Ensure the flask includes a rubber stopper and a hose connection. Confirm the top surfaces of all containers are smooth and substantially plane.
- 5.3 *Vacuum Pump* - Motor driven vacuum pump, capable of maintaining at least 25 mm of Hg of vacuum. The pump is used for removing air from the flask through the vacuum.

- 5.4 *Water Bath* - Water bath capable of maintaining constant temperature of $25 \pm 0.6^\circ \text{C}$ ($77 \pm 1^\circ \text{F}$), to fill the 4000 mL flask.
- 5.5 *Thermometer* – Liquid-in-glass thermometer accurate to 0.5°C (1°F).

6 Sampling

- 6.1 Obtain field samples in accordance with [MT 303](#). Split field samples in accordance with [MT 309](#).
- 6.2 Meet the sample size requirements in Table 1.

Table 1 – Minimum Sample Sizes

Nominal Maximum Aggregate Size	Minimum Sample Size
1" (25 mm)	2500g (5.50 lb.)
3/4" (19 mm)	2000g (4.40 lb.)
1/2" (12.5 mm)	1500g (3.30 lb.)
3/8" (9.5 mm)	1000g (2.20 lb.)
No. 4 (4.75 mm)	500g (1.10 lb.)

7 Standardization of Flasks

- 7.1 Volumetric flask and glass capillary stopper are standardized to accurately determine the mass of water, at $25 \pm 0.5^\circ \text{C}$ ($77 \pm 0.9^\circ \text{F}$), in the flask.
- 7.2 Fill the flask with water. Gently place the stopper in the flask ensuring proper seating. Ensure all air has been removed from the flask. Remove flask from water bath. Carefully towel dry the outside of the flask and stopper area. Weigh the flask with stopper and record the mass. Designate this mass as *E*.
- 7.3 Remove the stopper and decant a portion of the water back into the bath.
- 7.4 Repeat section 7.2 two (2) more times at the beginning of PMS production and periodically thereafter.
- 7.5 Record the average of the flask standardization masses. Designate this average mass as *E*. (See section 9.1)

Note 1 – Check standardization daily and re-standardize as needed or when there is a change in tester. Keep the equipment clean and free from any accumulation that would change the mass if the volume standardization is to remain constant. Do not subject glass vessels to vacuum if they are scratched or damaged.

8 Procedure

- 8.1 Obtain a sample size in accordance with section 6.2, Table 1.
- 8.2 Separate the particles of the sample, taking care not to fracture the mineral particles. The fine aggregate portion is all the material passing the ¼ inch (6 mm) sieve.
- 8.3 The sample may be heated at mix design compaction temperature if necessary to facilitate the breakup of the sample.
- 8.4 Cool the sample to approximately 77°F .

- 8.5 Remove flask (containing enough water at 77° F to cover the sample by approximately 1 inch). Towel dry the outside of the flask, place on scale, and tare the scale.
- 8.6 Add the test sample to the flask (about 2000 ml) at $25 \pm 0.6^\circ\text{C}$ ($77 \pm 2^\circ\text{F}$). Weigh to the nearest 0.1g. Designate the mass of the sample as *D*.
- 8.7 Wet the mouth of the flask and seat the vacuum apparatus in the flask, to ensure a proper seal between the flask vacuum apparatus. Turn on the vacuum pump to remove entrapped air by subjecting the contents to a partial vacuum of 27.5 ± 2.5 Hg mm gauge pressure for 15 ± 2 minutes. (Note 2) Agitate the container and contents either continuously by mechanical device or manually by vigorous shaking at intervals of about 2 minutes.

Note 2 – The time the sample is under vacuum does not begin until the proper gauge pressure has been reached.

- 8.8 Turn off the vacuum pump, slowly open the release valve, and remove the vacuum apparatus.
- 8.9 Fill the flask with water ($77 \pm 2^\circ\text{F}$). Gently place the stopper in the flask ensuring proper seating and taking care not to introduce air into the sample. Bring contents to a temperature of $77 \pm 2^\circ\text{F}$ in the constant temperature bath within 10 ± 1 min after completing the vacuum procedure.
- 8.10 Remove flask from water bath. Carefully towel dry the outside of the flask and stopper area. Determine the mass of the flask filled with contents. Designate the mass of flask with water and sample as *C*.

9 Calculations

- 9.1 Calculate the average of the flask standardization masses as follows:

$$E = \left(\frac{E_1 + E_2 + E_3}{3} \right)$$

Where:

E = average mass of standardized flask

E₁ = 1st flask standardization mass

E₂ = 2nd flask standardization mass

E₃ = 3rd flask standardization mass

- 9.2 Calculate the mass of the sample (dry mass) and mass of standardized flask:

$$F = D + E$$

Where:

F = mass of the sample (dry mass) and mass of standardized flask

D = mass of the sample (dry mass)

- 9.3 Calculate the volume of the sample as follows:

$$G = F - C$$

Where:

G = Volume of sample

C = mass of the standardized flask with contents (water and saturated sample)

- 9.4 Calculate the “Rice Gravity” of the sample as follows:

$$R = \frac{D}{G}$$

Where:

$R = G_{mm}$ = theoretical maximum specific gravity of the mixture, “Rice Gravity”

10 Report

- 10.1 Report the theoretical maximum specific gravity of the mixture, “Rice Gravity”, nearest thousandth, 0.001.

METHODS OF SAMPLING AND TESTING
MT 322-04
METHOD OF DETERMINING THE PERCENT OF ADHESION
OF BITUMINOUS MATERIALS TO AGGREGATE
(Montana Method)

1 Scope

- 1.1 This test is intended to evaluate the resistance of a bituminized mixture to its bituminous film removal by water.

2 Apparatus

- 2.1 *Drying oven* - capable of maintaining a temperature of 248° F (120° C).
- 2.2 Electric hot plate
- 2.3 Various mixing pans
- 2.4 Putty knife
- 2.5 *Balance* - with a capacity of 500 grams
- 2.6 ¼" wire screen
- 2.7 ½ gallon can
- 2.8 Water
- 2.9 "Red Devil" or equal paint shaker

3 Preparation of Sample

- 3.1 The proposed aggregate is mixed with bituminous materials, which may be Asphalt Cement or Liquid Asphalt, or Emulsified Asphalt. The preparation of the sample, depending upon the type of bituminous materials, is as follows:

3.2 Asphalt Cement or Liquid Asphalt

- 3.2.1 Approximately 150 grams of plus ¼" aggregate and a sufficient quantity of the appropriate bituminous material are heated in separate containers in an oven at 248 °F (120 °C).
- 3.2.2 After heating, the aggregate is mixed on a hot plate with just enough bituminous material to thoroughly coat the aggregate surfaces. Avoid overheating the mix, as evidenced by smoking asphalt. A metal pan and putty knife are used to accomplish the mixing. The mixture is oven cured at 250 °F (121 °C) for one hour, then stirred and left to cool at room temperature.

3.3 Emulsified Asphalt

- 3.3.1 The test procedure varies somewhat at the preliminary stage when an emulsified asphalt is used. Add a sufficient quantity of the appropriate emulsion to approximately 150 grams of dry, cool, plus ¼" aggregate and stir until the sample is completely covered. Excess emulsion is drained off on an elevated 4 Mesh wire screen. The mixture is oven cured at 250 °F (121 °C) for a period of one hour. If CRS-2 is used, the aggregate must be pre-wetted.

4 Procedure

- 4.1 After the aggregate-bituminous mixture has cooled or cured for the prescribed time, it is removed from the mixing pan or draining screen with a putty knife.

Note – In order to facilitate removal, the mixture may be removed from the mixing pan or draining screen after the receptacle has been heated on a hot plate for approximately three seconds.

- 4.2 The mixture is then immersed in a half-gallon can containing one quart of water at 49 to 73 °F (15 to 25 °C) for twenty-four hours.
- 4.3 At the end of the soaking period, the mixture is shaken in a "Red Devil" or other approved paint shaker for five minutes, after which it is carefully washed to remove any loose bituminous material, and placed on a doubled layer of paper toweling. The sample is spread evenly over an area approximately five inches in diameter so that the paper is not visible through the sample.

5 Evaluation

- 5.1 Evaluation of adhesion is made only after the aggregate is thoroughly dry. A visual estimate of the proportion of the surfaces remaining coated with bituminous material is made and the results expressed as percent adhesion.

METHODS OF SAMPLING AND TESTING
MT 325-14
DETERMINING MOISTURE CONTENT
OF BITUMINOUS MIXTURES OR AGGREGATE
USING MICROWAVE OVENS

1 Scope

- 1.1 This test method provides a procedure for determining the amount of moisture in either bituminous mixtures or graded aggregates used in bituminous mixtures. Its primary purpose is to provide a rapid field test to permit quality assurance of bituminous mixtures and its use is strictly limited to moisture content determination.

2 Referenced Documents

AASHTO:

M 231 Weighing Devices Used in the Testing of Materials

MT Materials Manual

MT 201 Sampling Roadway Materials

MT 202 Sieve Analysis of Fine and Coarse Aggregates

MT 303 Sampling Bituminous Paving Mixtures

MT 309 Splitting Samples of Plant Mix Surfacing to Testing Size

MT 607 Reducing Field Samples of Aggregate to Testing Size

3 Terminology

- 3.1 *Constant Mass for Bituminous Mixtures* – the state at which a mass does not change more than 0.05 percent. Do not exceed the mix design mixing temperature. Use equation 7.1. If the % change is greater than 0.05 continue drying.
- 3.2 *Constant Mass for Aggregate* – the state at which a mass does not change more than 0.1 percent. Do not exceed the mix design mixing temperature. Use equation 7.2. If the % change is greater than 0.1 continue drying.

4 Apparatus

Ensure equipment used meets the following requirements:

- 4.1 *Microwave* - oven capable of holding 4000 g sample.
- 4.2 *Sample containers* - capable of holding 600 g (must be Pyrex, glass, porcelain, ceramic or paper plates).
- 4.3 *Balance* - with a 16,000 g capacity and sensitive to 0.1 g, conforming to requirements of AASHTO M 231.
- 4.4 *Miscellaneous Equipment* – Spatula, Gloves
- 4.5 *Airtight container* - capable of holding 2500 to 3000 g sample.
- 4.6 *Flat pan* - approximately 25 x 20 x 3 inches.

5 Sample Preparation

- 5.1 Obtain 2500 to 3000 g of bituminous mix (according to [MT 303](#)) or aggregate (according to [MT 201](#)).
- 5.2 Quarter the aggregate into two (2) 500 ± 50 gram samples. Reduce aggregate samples in size, if necessary, according to [MT 607](#).
- 5.3 Reduce bituminous mixtures in size, as necessary, according to [MT 309](#), to obtain two (2) 500 ± 50 g samples.

6 Procedure

- 6.1 Place sample in tared container, and weigh to the nearest 0.1 g.
- 6.2 Record sample temperature.
- 6.3 Put sample in microwave oven and turn oven on.
- 6.4 After two (2) minutes, turn the oven off, remove the container and sample, weigh the sample and container to the nearest 0.1 g, and record the weight and temperature.
- 6.5 Place sample and container back in the oven. Turn oven on and dry sample for two (2) additional minutes.
- 6.6 Remove sample and container from oven, weigh to the nearest 0.1 g, and record weight and temperature.
- 6.7 Repeat steps 6.3 through 6.6 until a constant mass is obtained.
- 6.8 Ensure the final sample temperature, when weighed, is within $\pm 15^\circ\text{F}$ of section 6.2.

Note 1 – Do not exceed mix design mixing temperature.

7 Calculations

- 7.1 After a constant weight has been obtained, calculate the moisture content for bituminous mixtures as follows:

$$\text{Moisture Content of Bituminous Mixtures, \%} = \left(\frac{M_i - M_f}{M_i} \right) \times 100$$

where:

M_i = mass of the initial, moist test sample

M_f = mass of the final, dry test sample

Record the moisture content of bituminous mixtures as the average of the two samples to the nearest 0.01%.

- 7.2 After a constant weight has been obtained, calculate the moisture content aggregate as follows:

$$\text{Moisture Content, \%} = \left(\frac{M_i - M_f}{M_f} \right) \times 100$$

where:

M_i = mass of the initial, moist test sample

M_f = mass of the final, dry test sample

Record the moisture content of aggregate as the average of the two (2) samples to the nearest 0.1%.

- 7.3 If the moisture contents of the two (2) samples differ by more than 0.2%, the test is invalid. In this case new samples must be prepared and the test re-run.

8 Precautions

- 8.1 Use gloves for handling hot mixtures during quartering and when placing in or removing from oven.
- 8.2 Do not use metal containers in oven at any time. Damage to the oven will occur.
- 8.3 Do not delay getting sample into oven after sampling. (If a delay of 15 minutes or more is anticipated, samples must be placed into and kept in sealed containers. For reliable results, all samples should be tested within 1 hour of sampling).
- 8.4 **DO NOT USE** the moisture content sample for additional testing.

METHOD OF SAMPLING AND TESTING
MT 328-14
ESTABLISHING FIELD TARGET DENSITY
FOR PLANT MIX SURFACING DENSITY CONTROL

1 Scope

- 1.1 This test method is the procedure for establishing the field target density for compaction control of bituminous mixtures.

2 Referenced Documents

MT Materials Manual

MT 321 Determining Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures – “Rice Gravity”

3 Procedure

- 3.1 Determine the maximum specific gravity of un-compacted bituminous paving mixtures in accordance with [MT 321](#).
- 3.2 When two (2) maximum specific gravities of field samples have been determined using [MT 321](#), average the results. Use the average for the field target Rice Gravity density. This target is effective retroactive to the start of plant mix production on the project.
- Maintain documentation of the Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures ([MT 321](#)) to determine the target density and all changes during the contract.
- 3.3 When four (4) field Rice Gravities are completed, average the four (4) test values. If a change of 0.5 pound per cubic foot (8.0 kg per cubic meter) or greater is calculated change, to the new average Rice Gravity. This change is effective at the time the last sample was obtained.
- Notify applicable Department personnel (e.g. Project Manager, Lab Supervisor, Lead Inspector) immediately of effective change with day, time and tonnage of the change.
- 3.4 As each additional field Rice Gravity is completed, add the results to the sum of the previous three (3) gravities and compute an average. If a change of 0.5 pound per cubic foot (8.0 kg per cubic meter) or greater is calculated from the last field target density, change to the new average Rice Gravity. This change is effective at the time the last sample was obtained.

METHODS OF SAMPLING AND TESTING
MT 329-04
PROCEDURE FOR EVALUATING PLANT MIX SURFACING FAILURES

1 Scope:

- 1.1 This method covers the step-by step procedure for evaluating a plant mix surfacing failure. The procedure calls for reviewing the types of plant mix failures and method for rating the distressed areas.
- 1.2 After determining the type and extent of the failure, further investigational requirements will include reviewing plant mix production records, visual analysis, deflection analysis, sampling analysis of plant mix, base and subgrade materials and surfacing design analysis. Based upon all the information and data gathered through this procedure, the causes, potential solutions and recommendations to correct the plant mix surfacing failures can be determined.

2 Visual Analysis:

- 2.1 The first step in investigating a pavement failure is to perform a complete and comprehensive visual analysis of the entire project emphasizing the distressed areas in question.
- 2.2 Determine the approximate milepost and/or stationing and length of each of the distressed areas. The following is a list of pavement distress types and a rating system to be used for the distress.

PAVEMENT FAILURE RATING SYSTEM
RATING

<u>FAILURE TYPE</u>	<u>Light</u>	<u>Modera</u>	<u>te</u>	<u>Severe</u>
Rutting				
Rut Depth	0-1/2"		1/2 – 3/4"	3/4" & Greater
Rate of Rutting	0-1/8"/yr.		1/8 – 3/8"/yr.	3/8" yr.& Greater
Lateral Movement Of Rut (Humping)	None Visible			Visible Bulge
Cracking				
	Longitudinal Cracks In wheel paths (Load Associated)		Alligator or Block Cracking Tight	Alligator or Block Cracking Edges spaced – pieces loose or missing
*Stripping	Some asphalt material stripped		**Cores	**Cores
Ravelling	Fines removed from Surface.		1st layer coarse Aggregate removed	Pavement removed through one or more lifts.

*Any stripping should be noted.

**If the investigation requires plant mix cores, advanced stages of stripping will be determined at that time.

NOTE - If dual wheel ruts exist, they should be noted. Measurements should always be taken in both wheelpaths with a stringline stretched from centerline to the shoulder to obtain the measurements.

3 Report of Visual Analysis:

- 3.1 A summary of the visual analysis should be written immediately after the investigation.

3 Report of Visual Analysis: (continued)

- 3.2 The report should include date, reviewer, project termini, and detailed information concerning each distressed area. This information should include but not be limited to approximate milepost or station, length, width, relationship to centerline, lane and type of distress. Also, photographs of the typical distress on the project should be included. In addition to recording the types of pavement distress referenced above, record any other problems that are visible (drainage, terrain, frost problems, dips or swells, etc.). Based upon this visual analysis, the course of action and investigational requirements can be determined.
- 3.3 Copies of the report shall be sent to the District Engineer and the Materials Bureau Chief.

4 Deflection Analysis:

- 4.1 After the visual analysis report has been evaluated, the second step of this procedure will normally require Road Rater testing. The decision to have a Road Rate analysis will be determined based upon the visual analysis. When the decision has been made to use the Road Rater, the following are the steps that will be followed.
- 4.2 The Road Rater shall be used to determine the in-place strengths of each layer. An elastic modulus for each layer will be determined from the roadway deflections.
 - 4.2.1 Deflection tests will be taken at 200-800 foot intervals throughout problem areas to determine the extent of the distress. In addition, the remainder of the project will be tested using the normal testing intervals (six tests per mile).
 - 4.2.2 The deflection analysis will be reviewed for elastic modulus of each layer to determine the nature and extent of the problem. The required design overlay thickness analysis will then be performed.

5 Investigation Requirements:

- 5.1 Determine the investigational requirements depending on the type and extent of the plant mix failure. The following is a list of the distress types and requirements for each:

<u>Distress Type</u>	<u>*Investigation Required</u>
Cracking – Alligator	(1)-(7)
Rutting & Shoving	(1)-(7)
Stripping – Underlying Courses	(1)-(7)
Ravelling – Surface	(1),(3),(4)
Segregation	(1),(3),(4)

6 Investigational Requirements:

- 6.1 **Physical Data:** (information already obtained)
 - Location
 - Weather
 - Extent of Failure
 - Photos
- 6.2 **Deflection Analysis:** (information already obtained)
 - Road Rater testing – evaluate good and bad areas of the project.
- 6.3 **Production Records:** (a review of construction reports)

NOTE - When reviewing the reports listed below, look for any abnormalities.

Example: The production records generated during construction should be reviewed to determine if any problems during construction can be related to the pavement failure. For example there may have been some density problems in the same area of the failure, late paving, etc.

Mix Design
 Plant Reports
 Marshall Tests
 Aggregate Tests
 Compaction Tests
 Monitor Samples
 Project Diaries

6.4 Core Samples: Plant mix core samples shall be obtained and tested as follows:

NOTE - Lifts will be identified and tested separately.

Tests
 Thickness
 Density
 Rice Gravity
 A.C. Content
 Gradation
 HP-GPC
 Absorption Extraction – AC Penetration
 Petrographic – Geology

Other tests to be determined by the Materials Bureau at the time of testing

7 Sampling In-Place Material:

R Value
 Liquid Limit and Plastic Index
 Moisture
 Gradation
 Proctor

8 Traffic Data:

Present ADL
 Accumulative ADL

9 Structural Properties:

Gravel Equivalency – Surfacing Design

10 Samples and Testing Required:

10.1 Samples shall be taken so that the following tests and procedures can be run to evaluate the problem areas. The samples will be submitted to the Materials Bureau for testing unless otherwise specified.

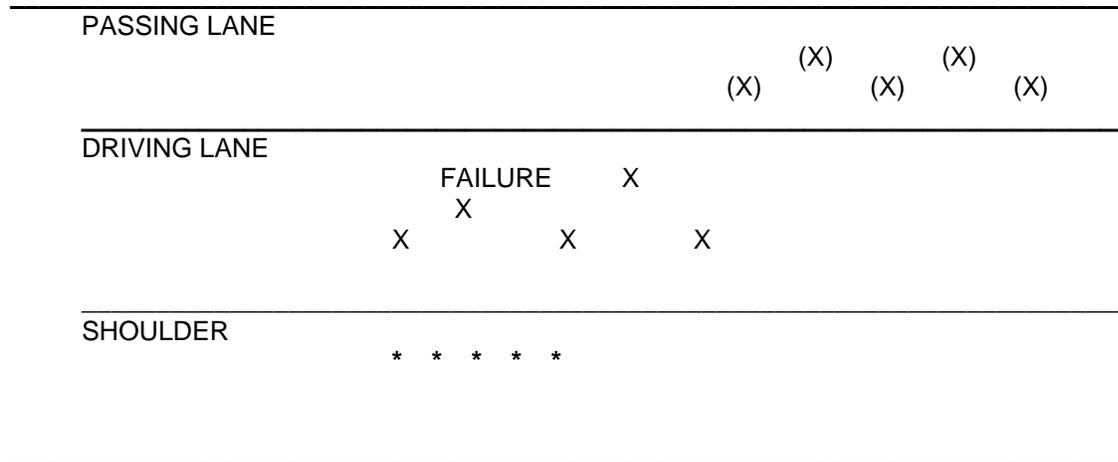
10.2 Plant Mix Surfacing Core Samples:

10.2.1 Samples shall be taken of each plant mix layer with at least five 4” cores from a bad area, a shoulder next to bad area, and good area. (See Figure 1 for sampling diagram.) If more than five distressed areas exist on a project, the minimum number of sample locations will be three if all distressed areas appear to be visually identical. If material or geological conditions change between distressed areas, each various condition shall be sampled. If the lifts are still intact they shall be separated using a coring saw if required. Each lift of plant mix shall be evaluated for:

10.2 **Plant Mix Surfacing Core Samples:** (continued)

- Rice Gravity
- Density
- Thickness – Each core should be measured
- Extracted Gradation (MT-202 or MT-327)
- Extracted Percent Asphalt (MT307)
- Abson Extraction – Asphalt Penetration
- HP-GPC
- Petrographic-Analysis

Figure 1 Typical Coring Scheme



- X** – Samples within area of visible failure
- * - Samples within same paver pass but not visibly failed
- (X)** – Samples from good area

10.3 **Base and Subgrade:**

- 10.3.1 When obtaining samples of the base and subgrade materials, a minimum 3-by-3-foot area of plant mix shall be taken in the wheelpath at each location. This should allow for adequate testing and sampling of each lift of material.
- 10.3.2 In-place densities and moisture shall be obtained for each lift using a nuclear gauge.
- 10.3.3 In-place moisture samples shall be taken of each lift and immediately placed in a sealable plastic sack. The sample size shall be a minimum of 1 lb. (450 grams). These samples shall then be oven dried to obtain a moisture content.
- 10.3.4 A minimum of two “R” value samples shall be taken from both the base and subgrade for a given problem area. In addition, one sample per mile shall be taken for the remainder of the project. The sample size will be determined in accordance with MT-207.
- 10.3.5 Samples and size of each lift shall be taken immediately and placed in a sealable plastic bag for soils classification (MT-214), plastic index and liquid limit (MT-208) in accordance with referenced procedures.
- 10.3.6 Samples of the base and subgrade shall be taken for a proctor test to establish the optimum moisture and density. The sample size shall be determined in accordance with MT-230.

11 Traffic Data:

11.1 Traffic data will be requested from the Planning and Statistics Bureau by the Materials Bureau. This data will be used by the Road Rater and Surfacing Design Sections to determine if any structural deficiencies exist. If the traffic section in the Planning Bureau feels traffic data may not reflect the true 18 Kip axle loads, a site specific investigation should be conducted by them.

12 Structural Analysis - Surfacing Design:

12.1 The surfacing Design personnel will check the design of the problem area based on the new "R" Values and the condition of the pavement structure in place.

13 Report:

13.1 A summary of the sample tests and other investigational requirements will be submitted upon completion of all testing of all testing and analysis.

**METHOD OF SAMPLING AND TESTING
MT 331-14
SAMPLING AND EVALUATING
STRIPPING PAVEMENTS
(Montana Method)**

1 Scope

1.1 This test method describes the procedure for sampling cores. Cores are used to evaluate existing structure, materials, pavement condition, lift thicknesses, and potential milling depth.

2 Sampling Procedure

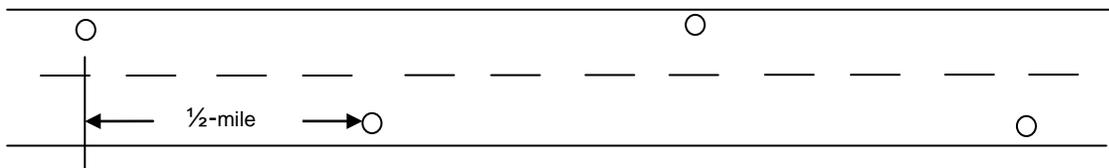
2.1 *4-Lane Roadway*

Take a minimum of one (1) core per ½ mile of roadway in each direction. Alternate cores between the outside wheel path of the driving lane and the outside wheel path of passing lane. Pavement displaying a high extent or severity of cracking or raveling, rutting greater than 1/3 inch, and excessive patches, may require modification to the sampling frequency and location. If available, record the Global Positioning System (GPS) coordinates of core.

2.2 *2-Lane Roadway*

A minimum of one (1) core per ½ mile of roadway, taken in the outside wheel path and in alternating lanes. Pavement displaying a high extent or severity of cracking or raveling, rutting greater than 1/3 inch, and excessive patches, may require modification to the sampling frequency and location. If available, record the GPS coordinates of core.

Example:



3 Sample Containment

3.1 Bag the cores with the bagging system provided by the Department’s Helena Materials Bureau. If possible, bag the core in the orientation it was extracted (directly from drill barrel). Keep field notes describing the appearance, location, and total depth of the core. Take pictures to accompany field notes. If a portion or portions of the core are rubble, describe the thickness of the rubble section and where the rubble portion was within the core. Submit the sample for stripping evaluation. Also describe the roadway condition and any other information that would be helpful in evaluating the cores and the in-place pavement.

4 Sample Identification and Submitting of Samples

4.1 Mark core with specimen number using a marker or grease pencil. Each core sample bag must contain a tag including the Sample Record ID number and specimen number. Ensure the Sample Record contains the Sample ID number, specimen number, uniform project number (UPN), and project name if available, location (route number, station, mile post, lane, offset, and GPS), total depth drilled and total length of the core when bagged. Submit the cores to the Materials Bureau for evaluation. Include observations and comments in the Sample Record Remarks.

5 Evaluation of Cores

5.1 Evaluate the **total** core for stripping using the "control photographs" in Annex A. Split cores by indirect tensile loading in a press and record maximum pressure needed to yield the core. Evaluate each lift or distinct layer of plant mix for stripping using the Core Rating Scale (Section 5.2).

5.2 Core Rating Scale

Core Rating	Description
4 (good core)	Face shiny, black, all aggregate particles coated
3 (moisture damaged)	Loss of sheen, dull appearance, some smaller aggregate is uncoated
2 (stripping)	In addition to moisture damage some large aggregate is not coated
1 (severely stripped)	Most of the aggregate is so clean the colors of the rock are easily seen
0 (no core)	Asphalt is mostly gone from all sizes of aggregate. The core has disintegrated.

6 Reporting Results

6.1 At the completion of the evaluation, test results consisting of the extent of stripping, and other test information are entered into SiteManager by the Materials Bureau. Each lift or layer is evaluated for stripping in the report.

ANNEX: Examples of Evaluated Cores

A1



GOOD CORE (4)
SHINY, BLACK
ALL AGGREGATE PARTICLES
ARE COATED

A2



MOISTURE DAMAGED (3)
LOSS OF SHEEN, DULL APPEARANCE
SOME SMALLER AGGREGATE (-10 M)
IS UNCOATED

A3



STRIPPING (2)
IN ADDITION TO MOISTURE
DAMAGE SOME LARGE AGGREGATE
IS NOT COATED

A4



**SEVERLY STRIPPED (1)
MOST OF THE AGGREGATE IS
SO CLEAN THE COLORS OF THE
ROCKS ARE EASILY SEEN**

A5



METHOD OF SAMPLING AND TESTING
MT 332-14
GYRATORY COMPACTION OF BITUMINOUS MIXTURES
(Montana Method)

1 Scope

- 1.1 This test method describes the procedure for verification of asphalt content and mixture properties of bituminous mixtures by the compaction of cylindrical specimens of Plant Mix Surfacing (PMS) using the Superpave gyratory compactor. The density of bituminous mixtures is determined directly for N_{des} .
- 1.2 Establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.
- 1.3 This test method describes the procedure for placing a sample into a 150 mm diameter mold for an apparatus that compacts bituminous mixture using a combination of pressure and gyration. The apparatus measures the specimen height very precisely as compaction occurs after each gyration. The required compaction effort is defined from tables found in the specifications. This procedure shows how closely the bituminous mixture being produced is to the production requirements.

2 Referenced Documents**AASHTO**

- T 312 Preparing and Determining the Density of the Hot Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor
- M 231 Weighing Devices Used in the Testing of Materials
- T 344 Evaluation of Superpave Gyratory Compactor (SGC) Internal Angle Using Simulated Loading

MT Materials Manual

- MT 314 Bulk Specific Gravity of Compacted Bituminous Mixtures
- MT 319 Determining the Asphalt Binder Concrete of Plant Mix Surfacing (PMS) by the Ignition Method
- MT 320 Mechanical Analysis of Aggregate Recovered from Ignition Oven Burn
- MT 321 Determining Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures – “Rice Gravity”

3 Significance and Use

- 3.1 Use this standard to prepare specimens for determining the mechanical and volumetric properties of PMS. The specimens simulate the density, aggregate orientation, and structural characteristics obtained in the actual roadway when proper construction procedures are used in the placement of the PMS.

4 Apparatus

Ensure equipment used meets the following requirements:

- 4.1 *Superpave Gyratory Compactor* - An electrohydraulic or electromechanical compactor with a ram and ram heads as described in Section 5.3 that are restrained from revolving during compaction. The axis of the ram is perpendicular to the platen of the compactor. The ram applies and maintains a pressure of 600 ± 18 kPa perpendicular to the cylindrical axis of the specimen during compaction. The compactor tilts specimen molds at an average internal angle of 1.16 ± 0.02 degrees, in accordance with AASHTO T 344. The equipment gyrates specimen molds at a rate of 30.0 ± 0.5 gyrations per minute throughout compaction.

- 4.1.1 *Specimen Height Measurement and Recording Device* - When specimen density is to be monitored during compaction, the Superpave Gyrotory Compactor is equipped with means to continuously measure and record the height of the specimen to the nearest 0.1 mm during compaction; once per gyration.
- 4.1.2 The system may include a connected printer capable of printing test information, such as specimen height per gyration. In addition to a printer, the system may include a computer and suitable software for data acquisition and reporting.
- 4.2 *Specimen Molds* - Specimen molds have steel walls that are at least 7.5 mm thick hardened to a minimum Rockwell hardness of C48. The inside of the molds are smooth (Note 1). Ensure molds have an inside diameter of 149.90 to 150.20 mm and are at least 250 mm high at room temperature.
- 4.3 *Ram Heads and End Plates* - Ram heads and end plates are fabricated from steel with a minimum Rockwell hardness of C48. The ram heads stay perpendicular to its axis. The platen side of each end plate is flat and parallel to its face. Ensure all ram and end plate faces (the sides presented to the specimen) are flat to meet smoothness requirements in 4.2 (Note 1) and have a diameter of 149.50 to 149.75 mm.

Note 1 – Smooth is measured in accordance with ANSI B46.1 with rms value of 1.60 μ m or less.

- 4.4 *Thermometers* - Armored, glass, digital probe or dial-type thermometers with metal stems for determining temperature of aggregates, binder and PMS between 10°C to 232°C.
- 4.5 *Balance* - a balance meeting the requirements of AASHTO M 231, Class G5, for determining the mass of aggregates, binder and PMS.
- 4.6 *Oven* - An oven, thermostatically controlled to $\pm 3^\circ\text{C}$, for heating aggregates, binder, PMS and equipment as required. Ensure the oven is capable of maintaining the compaction temperature range.
- 4.7 *Miscellaneous* - Flat bottom metal pans of at least 500 square inches that are square or rectangular for heating plant mix. Ensure pans will accommodate quartering. Scoop to remove mixture quarters for testing. Large spatula for turning and mixing sample prior to quartering. Insulated gloves, a lab apron or coat and other safety equipment as necessary. Lubricating materials recommended by compactor manufacturer and assorted cloth and paper rags for wiping molds and other surfaces. A Gyro Loader (a trough) is optional for adding samples to the mold.

5 Standardization

- 5.1 Items requiring periodic verification of calibration include the ram pressure, the angle of gyration, the gyration frequency, the LVDT (or other means used to continuously record the specimen height) and oven temperature. Verification of the mold and platen dimensions and the inside finish of the mold are also required. When the computer and software options are used, periodically verify the data processing system output using a procedure designed for such purposes. Verification of calibration, system standardization and quality checks may be performed by the manufacturer, other agencies providing such services, or in-house personnel. **Ensure verification is current in accordance with manufacturer's recommendations.**
- 5.2 The angle of gyration refers to the internal angle (tilt of the mold with respect to end plate surface within the gyrotory mold). Verify the calibration of the internal angle of gyration in accordance with AASHTO T 344.

6 Materials

- 6.1 Obtain a sufficient quantity of PMS in accordance with [MT 303](#) and [MT 601](#).

7 Preparation of Apparatus

- 7.1 Turn on the main power for the compactor for the manufacturer's required warm-up period.
- 7.2 Verify machine settings are correct for angle, pressure and number of gyrations.

Note 2 – The required number of gyrations are shown in the contract.

- 7.3 Lubricate any bearing surfaces as needed per the manufacturer's instructions.
- 7.4 When specimen height is to be monitored, the following additional item of preparation is required. Immediately prior to the time when the PMS is ready for placement in the mold, turn on the device for measuring and recording the height of the specimen, and verify the readout is in the proper units (mm), and the recording device is ready. Prepare the computer, if used, to record the height data, and enter the header information for the specimen.

8 Asphalt Specimen Fabrication

- 8.1 Adjust the target specimen mass to result in a final compacted specimen having dimensions of 150 mm in diameter and 115 ± 5 mm in height at the designed number of gyrations based on volumetric properties. PMS that is brought to the test location and is still within the compaction temperature range may be batched for immediate testing. Bring loose PMS below the compaction temperature range to the compaction temperature range by careful uniform heating in an oven immediately prior to molding. Heating proceeds more quickly if the sample is placed in a clean (buttered) flat bottomed pan. Loose PMS that is within the compaction temperature range should not be reheated.

Note 3 – Ensure specimens are fabricated to maintain a consistent height throughout production to provide satisfactory test results.

9 Compaction Procedure

- 9.1 Place a compaction mold and end plates in an oven at the required compaction temperature to pre-heat the mold and end plates to compaction temperature prior to the estimated beginning of the compaction cycle. When the bituminous mixture is within the compaction temperature range, remove the heated mold and end plate from the oven and place a paper disc in the bottom of the mold.

Note 4 – Compact test specimens at a consistent temperature based on the compaction temperature range in the mix design.

- 9.2 Center the mold under the loading ram. Rotate the mold clockwise to the stop, and lock the head down.
- 9.3 Pour the pre-weighed quantity of bituminous mixture into the mold in one lift. Use a gyro loader to facilitate this operation. If you do not have a gyro loader, another method that works is to pour the sample from a paper bag. The bag acts as a container and a funnel when filling the mold. Care should be taken to avoid segregation. Introduce the sample into the mold in a continuous motion to avoid segregation. Level the mix with the stroke of a spatula (if necessary) and place another paper disk on top of the leveled material. Insert the top end plate with the bevel up.
- 9.4 Start the load compaction cycle. The machine will lower the ram until the pressure on the specimen reaches $600 \text{ kPa} \pm 18 \text{ kPa}$, apply a $1.16 \pm 0.02^\circ$ average internal angle to the mold assembly and begin the gyratory compaction. Allow the compaction to proceed until the desired number of gyrations is reached and the ram retracts. Record the specimen height at N_{des} . A printed record may be produced as the compactor operates. Extrude the specimen from the mold. Remove the mold from the compactor.

Note 5 – Normally, extrude the specimens from the mold immediately. For lean, rich or tender mixtures, cool 5 to 10 minutes before extruding the specimen to avoid specimen collapsing.

- 9.5 Immediately remove the paper discs from the top and bottom of the hot specimen. Write the specimen number on the specimen and the gyration worksheet. Cool the specimens by a fan or air conditioner. Handle specimens carefully. Hot specimens are very tender and fragile.

Note 6 – Before reusing the mold, clean thoroughly, place in an oven, and reheat to compaction target temperature. The use of multiple molds will speed up the compaction process.

10 Density Procedure

- 10.1 Determine the maximum specific gravity (G_{mm}) of the loose mix in accordance with [MT 321](#) using a companion sample. Condition the companion sample to the same extent as the compaction sample.
- 10.2 Determine and record the mass of the extruded specimen to the nearest 0.1 gram and determine the bulk specific gravity (G_{mb}) of the extruded specimen in accordance with [MT 314](#). This is the bulk gravity of the specimen at N_{des} . Measure the bulk density of the compacted bituminous mixture after the specimen has cooled sufficiently (to near room temperature) in accordance with [MT 314](#).

11 Calculations

% Air Voids (V_a)

$$V_a = 100 \times \left(\frac{G_{mm} - G_{mb}}{G_{mm}} \right)$$

Where:

G_{mm} = Maximum specific gravity of paving mixture (Rice)

G_{mb} = Bulk specific gravity of compacted mixture

Record and round to the nearest 0.1%

Voids in the Mineral Aggregate (VMA)

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

Where:

G_{mb} = Bulk specific gravity of compacted mixture

P_s = Aggregate content, percent by total mass of mixture

G_{sb} = Bulk specific gravity of aggregate

Record and round to the nearest 0.1%

Voids Filled with Asphalt (VFA)

$$VFA = 100 \times \left(\frac{VMA - V_a}{VMA} \right)$$

Record and round to the nearest 0.1%

Dust/Asphalt Ratio

$$DA = \left(\frac{P_{200} - 1}{P_b} \right)$$

Where:

DA = Dust to Asphalt Ratio,

P_{200} = Aggregate content passing the 0.075mm sieve, the percent by mass of aggregate (MT 320)

P_b = Asphalt Content, percent by total mass of mixture (MT 319)

Record and round to the nearest 0.1%

Note 7 – The Dust/Asphalt ratio is used during mix design and field production.

Dust Proportion

$$DP = \left(\frac{P_{200} - 1}{P_{be}} \right)$$

Where:

DP = Dust Proportion,

P_{200} = Aggregate content passing the 0.075mm sieve, the percent by mass of aggregate (MT 320)

P_{be} = Effective asphalt content, percent by total mass of mixture

Note 8 – The Dust Proportion is used during mix design.

Effective Asphalt Content

$$P_{be} = - (P_s \times G_b) \times \left(\frac{G_{se} - G_{sb}}{G_{se} \times G_{sb}} \right) + P_b$$

Where:

P_{be} = Effective asphalt content, percent by total mass of mixture

P_s = Aggregate content, percent by total mass of mixture

G_b = Specific gravity of asphalt

G_{se} = Effective specific gravity of aggregate

G_{sb} = Bulk specific gravity of aggregate

P_b = Asphalt Content, percent by total mass of mixture

Record and round to the nearest 0.1%.

12 Report

12.1 Record pertinent information in the QA Suite Plant Mix section.

13 Forms

13.1 **Gyratory Data Entry Form**

METHODS OF SAMPLING AND TESTING
MT 333-04
METHOD OF TEST FOR THE TORSIONAL RECOVERY OF
LATEX MODIFIED ASPHALT EMULSION RESIDUE

1 Scope

- 1.1 This test method provides an indication of the amount of elasticity that has been imparted to asphalt by the addition of latex. The asphalt used in this test has been recovered from an emulsion.

2 Apparatus

- 2.1 *Sample container* – A flat-bottomed, cylindrical, seamless tin 55mm (2.17 inch) in diameter and 35 mm (1.38 inch) in depth. The container is commonly known as a 3-ounce ointment tin.
- 2.2 *Disc and spider assembly* – This assembly is shown in Figure 1. The disc is made of aluminum. The spider assembly, bolt, and pointer are made of steel.
- 2.3 *Wrench* – A 9/16 inch open-end or box wrench.
- 2.4 *Timer* – A stopwatch, clock, or other timing device graduated in divisions of one second or less.
- 2.5 *Scale* – A paper scale, graduated in millimeters, at least 180 mm in length.

3 Procedure

- 3.1 Place the spider assembly on the container and adjust it so that it is centered, using the small nuts on the arms of the spider to maintain the adjustment. Adjust the depth of the disc in the container so that the top of the disc will not be below the surface of the asphalt. Remove the spider assembly from the container. Construct two, centered spider assemblies and containers per test.
- 3.2 Obtain a latex modified asphalt residue sample by following the procedure outlined in AASHTO T 59, Residue By Evaporation, sections 21 – 27.
- 3.3 Transfer a sufficient quantity of the hot residue into the sample container to fill it to within ½ to ¼ inch from the top of the container. Immediately place the previously centered spider assembly on the container and adjust the depth of the disc to bring the top of the disc level with the surface of the asphalt.
- 3.4 Place the two test assemblies in a 138°C (280°F) oven for ten minutes to allow air bubbles to escape and the break the surface tension around the disc. Remove the assembly from the oven and allow cooling to room temperature for two hours.
- 3.5 Tape a paper scale around the container and mark the location of the pointer. Make another mark 180° from the pointer (halfway around the container).
- 3.6 Holding the container and spider assembly rigidly, place the wrench on the bolt head and turn the bolt to the 180° reference mark and release immediately. The rotation should be done at a steady rate and be accomplished in approximately 5 seconds. Start the stopwatch when the bolt is released. Mark the location of the pointer on the scale when 30 seconds have elapsed, and again when 30 minutes have elapsed. Repeat the procedure with the second test assembly.

4 Calculation and Report

4.1 The percent of recovery following deformation is calculated as follows:

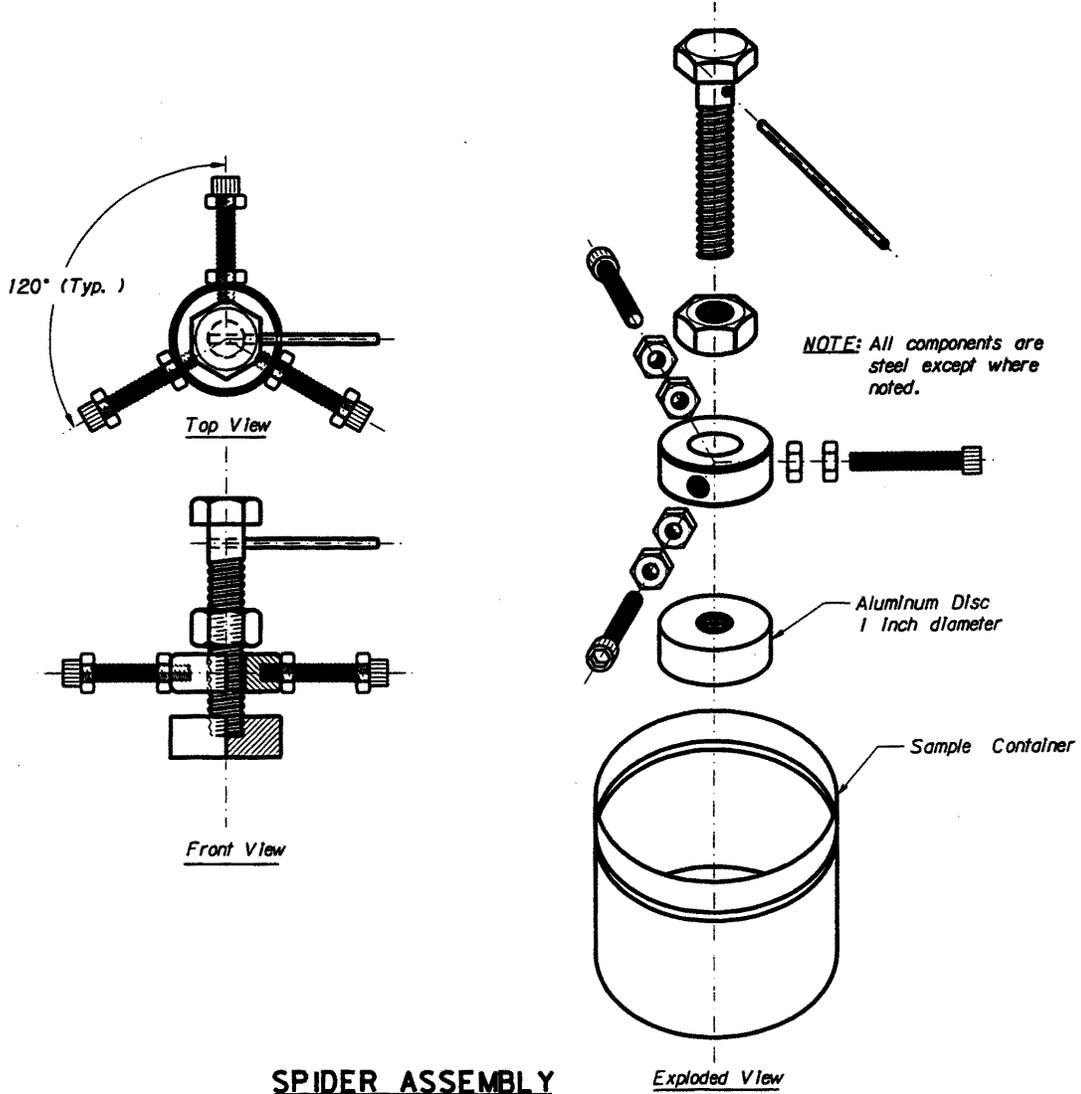
$$\text{Percent Recovery} = 100[A/(B/2)]$$

where:

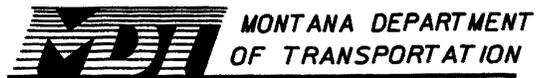
A = The arc on the container, measured in millimeters, between the mark made after 30 seconds has elapsed, and the mark made after 30 minutes has elapsed.

B = The circumference of the can, measured in millimeters.

4.2 Report the percent recovery as an average of the two tests.



SPIDER ASSEMBLY
Scale ~ N. T. S.



FILENAME: Motorist.dgn

Sheet 5-3-00 D.S.C.

METHOD OF SAMPLING AND TESTING
MT 334-14
HAMBURG WHEEL-TRACK TESTING
OF COMPACTED BITUMINOUS MIXTURES
(Modified AASHTO T 324)

1 Scope

- 1.1 This test method describes a procedure for testing the rutting and moisture-susceptibility of plant mix surfacing (PMS) samples in the Hamburg Wheel-Track Testing Device.
- 1.2 The method describes the testing of submerged, compacted PMS in a reciprocating rolling-wheel device. This test provides information about the rate of permanent deformation from a moving, concentrated load. This procedure utilizes laboratory compacted specimens or field cores.
- 1.3 The test method is used to determine the premature failure susceptibility of PMS due to weakness in the aggregate structure, inadequate binder stiffness, or moisture damage. This test method measures the rut depth and number of passes to failure.
- 1.4 The potential for moisture damage effects are evaluated because the specimens are submerged in temperature-controlled water during loading.

2 Reference Documents***AASHTO***

T 324 Hamburg Wheel-Track Testing of Compacted Hot Mix Asphalt (HMA)

MT Materials Manual

MT 303 Sampling Bituminous Paving Mixtures

MT 314 Bulk Specific Gravity of Compacted Bituminous Mixtures

MT 321 Determining Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures – “Rice Gravity”

MT 332 Gyrotory Compaction of Bituminous Mixtures

MT 335 Linear Kneading Compaction of Plant Mix Surfacing (PMS)

Manufacturer’s Operation Manual

For equipment used

3 Summary of Method

- 3.1 A laboratory-compacted specimen of PMS, a saw-cut slab specimen, or a core taken from a compacted pavement is repetitively loaded using a reciprocating steel wheel. The specimen is submerged in a temperature-controlled water bath at a temperature specified for the binder being used. The deformation of the specimen, caused by the wheel loading, is measured.
- 3.2 The impression is plotted as a function of the number of wheel passes. An abrupt increase in the rate of deformation coincides with stripping of the asphalt binder from the aggregate in the PMS specimen.

4 Apparatus

Ensure equipment used meets the following requirements:

- 4.1 *Hamburg Wheel-Track Testing Device* - Electrically powered device capable of moving a steel wheel with a diameter of 203.6 mm and width of 47 mm over a test specimen. The load applied by the wheel is 705 N. The wheel load is maintained at + 5% for the duration of the test excluding the cycles that are interrupted by stopping the process. The wheel reciprocates over the specimen, with the position varying sinusoidally over time. The wheel makes 52 +2 passes across the specimen per minute.

- 4.2 *Temperature Control System* - Water bath capable of controlling the temperature within + 2.0°C over a range of 25 to 70°C. This bath has a mechanical circulating system to stabilize the water temperature.
- 4.3 *Impression Measurement System* - Linear Variable Differential Transducer (LVDT) device capable of measuring the depth of the impression of the wheel within 0.5 mm, over a range of at least 0 to 20 mm. The system is mounted to measure the depth of the impression at several points, including the midpoint, in the wheel's path on the specimen. The impression is measured at least every 400 passes of the wheel without stopping the wheel.
- 4.4 *Wheel Pass Counter* - Device that counts each wheel pass over the specimen. The signal from this counter is coupled to the wheel impression measurement, allowing for the depth to be correlated with the number of wheel passes.
- 4.5 *Sample Mounting System* - Tray is mounted to the machine so that movement of the specimen is restricted to less than 0.5 mm during testing. The system supports the specimen, allowing for free circulation of water in the bath on all sides of the specimen and tray.
- 4.6 *Balance* – Balance with a minimum capacity of 15,000 grams, accurate to 0.1 g.
- 4.7 *Oven* - Forced draft or convection oven.
- 4.8 *Mixing apparatus* – Bowls, spoon, spatula, etc.
- 4.9 *Diamond Bladed Saw* – Capable of cutting PMS.

5 Specimen Preparation

- 5.1 Slabs – Compact and prepare PMS into slabs in accordance with [MT 335](#). Slab thicknesses within a range of 38 to 100 mm can be used. Ensure the slab thickness is at least twice maximum aggregate size.
- 5.1.1 The formula for the volume of a slab is as follows: length x width x thickness. The amount of material to batch for each slab with 7% + 1% air voids is determined by multiplying the sample length x width x thickness in cubic centimeters by the sample's maximum specific gravity (Gmm) x 0.93. Mass for sample = sample volume x 1 gm/cm³ x Gmm x 0.93
- 5.2 Gyratory Specimens – Two gyratory specimens produced to the same requirements are cut to height, paired, and tested or a single specimen may be cut in half to yield two specimens. Each sample is cut on a chord that is 35 to 45 mm longer than the width of the test wheel and parallel to the vertical axis of the specimen. The two specimens are mounted so that the chords are together and the wheel rolls on the uncut faces of the specimens (see Note 1). The wheel path follows the diameter of each half of the sample through the center of the chords. A tolerance of + 5 mm offset from the center is allowed. Using a diamond saw, cut two specimens the same height.

Note 1 – Take care when loading the sample so it is level to the surface of the mold. Trim the sample if it is too tall or shim it up if it is too short (support with plaster if needed).

- 5.3 Ten Inch Cores – Use a nominal 10-inch diameter bit to cut field cores. Complete the preparation of the cores for testing by removing the bottom lift(s) of PMS to achieve the desired height between 38 to 100 mm. Cut the core with a diamond saw at the desired point, taking care to orient the cut parallel to the surface being tested.
- 5.4 Laboratory Produced Mix – Before mixing bituminous mixtures for testing, “butter” all of the pans and implements. Heat materials to the mixing temperature range in a forced draft or convection oven. Do not overheat the samples.

6 Procedure

- 6.1 Position the frame holding the sample into the wheel-tracker so that the loading arm of the wheel is approximately horizontal when it rests on the slab. Ensure that the frame is securely fastened. Confirm that the settings of the machine are the same as those required for the specification. These settings include wheel force, water temperature (see note 2), stroke length, speed and any other variables described in the procedure. Enter the number of test passes required by the specification.

Note 2 – Test the PG binder in accordance with the chart below:

GRADE	TEST TEMPERATURE
70 - 28	133°F (56°C)
64-22 and 64 - 28	122°F (50°C)
58 - 28	111°F (44°C)

- 6.2 Lower the wheel onto the slab. Select the “Start” button of the testing device software. When the specimen has been preconditioned in the water at the test temperature, for 30 minutes, ten passes with the loaded wheel occur. This establishes zero. The wheel-tracking device shuts off when the test completes the specified number of passes or when the test has achieved the maximum impression depth established in the specification. The testing device software automatically saves the test data file.
- 6.3 Raise the wheel(s) and photograph the tested specimen. Remove the specimen mounting tray(s) containing the specimen(s). Once specimen(s) have been removed, thoroughly clean the mounting tray(s). Clean the water bath, heating coils, wheels, filter element, spacers, and temperature probe in accordance with manufacturer’s recommendations. If no manufacturer’s recommendation exists, use water and scouring pads. Use a wet-dry vacuum to remove particles that have settled to the bottom of the baths. Lubricate moving parts after every test or in accordance with manufacturer’s recommendations. Do not use solvents to clean the water bath.

7 Report

- 7.1 Ensure the report for the results of testing samples using the wheel-tracking device contains the following information:

7.1.1 Cover Sheet:

Sample, Compaction, and Run Dates
 Project Number
 Project Name
 Binder Content
 Binder Grade
 SiteManager Sample ID
 Sample Type
 Other Comments

7.1.2 Configuration Settings:

Conditioning Time
 Velocity
 Maximum Allowed Passes
 Maximum Allowed Depth
 Sample Frequency
 Data Points
 Wheel Travel

Acceleration
Water Temperature
Force Setting
Average Final Impression
Graph (number of passes on the x-axis and impression depth on the y-axis)

- 7.2 Report the Average Final Impression determined by the software as the Hamburg Wheel-Tracking Device test result. Determine the average impression of each run by averaging the middle seven points from the data given by the software (eliminating the first two data points and the last two data points). A Production test is considered a single specimen. A Mix Design Verification test is the average of two or more specimens. If two Mix Design Verification tests vary by more than 6mm with one passing test result and one failing test result, prepare two more test specimens and re-run. The reported result will be the average of all four or more individual specimen test results.

METHOD OF SAMPLING AND TESTING
MT 335-14
LINEAR KNEADING COMPACTION OF
PLANT MIX SURFACING (PMS)

1 Scope

- 1.1 This test method is used to prepare compacted slabs of PMS for testing with the Hamburg Wheel-Track Testing Devices.

2 Reference Documents***MT Materials Manual***

MT 303 Sampling Bituminous Paving Mixtures
MT 309 Splitting Samples of Plant Mix Surfacing to Testing Size
MT 314 Bulk Specific Gravity of Compacted Bituminous Mixtures
MT 321 Determining Theoretical Maximum Specific Gravity of Bituminous Paving Mixtures –
“Rice Gravity”
MT 332 Gyration Compaction of Bituminous Mixtures
MT 334 Hamburg Wheel-Track Testing of Compacted Bituminous Mixtures

Manufacturer’s Operation Manual

For equipment used

3 Summary of Method

- 3.1 A slab of plant mix is compacted by applying pressure to the PMS through a series of rectangular parallel plates. The sample is placed in an open top steel box with the desired dimensions. Closely fitting steel plates are placed in a vertical row across the plant mix. A steel roller travels back and forth on the row of plates and successively applies pressure to the plant mix through the plates. This compacting motion continues until the height of the specimen of plant mix is reduced to the height calculated to yield the desired voids.

4 Apparatus

Ensure equipment used meets the following requirements:

- 4.1 *Linear Kneading Compactor* – Hydraulic powered unit, used to compact bituminous mixtures into rectangular slabs using vertically aligned steel plates that compress the bituminous mixture into a flat slab of predetermined thickness and density.
- 4.2 *Steel Wear Plate* – 10.125” wide, 12.6” long, 0.125” high
- 4.3 *Steel Compacting Plates* – 3.6” high
- 4.4 *Steel Compaction Carrier Box* – 10.25” wide, 12.625” long, 6” high
- 4.5 *Temperature Control System* – Oven which can maintain temperatures (250°F to 350°F).
- 4.6 *Shims* – Aluminum or steel plates that vary in thickness to achieve desired specimen height.
- 4.7 *Rubber Mallet*
- 4.8 *Balance* – Balance with a minimum capacity of 15,000 grams, accurate to 0.1 g.

5 Sample

- 5.1 *Field Specimens* – The top lift or lifts of PMS are tested. Ensure specimens for testing have a thickness at least two times the nominal maximum aggregate size.
- 5.1.1 *Slabs* –The formula for the volume of a slab is as follows: length x width x thickness. The amount of material to batch for each slab with $7 \pm 1\%$ air voids is determined by multiplying the specimen length x width x thickness in cubic centimeters by the specimen's maximum specific gravity (G_{mm}) x 0.93. Mass for sample = 5283 cm³ x 1 gm/cm³ x G_{mm} x 0.93
- 5.1.2 *Laboratory Produced Mix* – Before mixing bituminous mixtures for testing, “butter” all of the pans and implements. Heat materials to the mixing temperature range in a forced draft or convection oven. Do not overheat the specimens.

6 Procedure

- 6.1 Preheat wear and compaction plates in an oven to desired compaction temperature. Ensure PMS is heated to desired compaction temperature. If not, place in the oven to heat to compaction temperature.
- 6.2 Mix and reduce the sample in accordance with [MT 309](#) to approximate sample sizes. Individually weigh enough material for each specimen.
- 6.3 Place the wear plate in compaction carrier box.
- 6.4 Load the specimen into compaction carrier box. Place the steel parallel plates vertically on top of the specimen mixture. To level plates on the specimen, use a rubber mallet if needed.
- 6.5 Ensure that all safety mechanisms are in place at Linear Kneading Compaction start-up in accordance with manufacturer's recommendations. Start the Linear Kneading Compactor.
- 6.5 Using a hydraulic jack, pressure will be applied automatically or manually to the specimen. Maintain a constant pressure until specimen reaches desired height. Ensure final compaction is $7 + 1\%$ air voids.
- 6.6 Press the stop button to complete the compaction process. Shut off the Linear Kneading Compactor and disengage safety mechanisms. Remove steel plates and side walls. Remove slab along with the bottom plate and cool to room temperature (to the touch).
- 6.7 Repeat the procedure for any additional specimens.

7 Calculation

- 7.1 Using [MT 314](#) and [MT 321](#), calculate the air void content of the specimen to the nearest tenth of a percent.

% Air Voids (V_a):

$$V_a = 100 \times \left(\frac{G_{mm} - G_{mb}}{G_{mm}} \right)$$

Where:

G_{mm} = Maximum specific gravity of paving mixture (Rice)

G_{mb} = Bulk specific gravity of compacted mixture

Round and record to the nearest 0.1%

METHODS OF SAMPLING AND TESTING
MT 337-10
METHOD OF TEST FOR SOIL STIFFNESS GAUGE

1 Scope

- 1.1 This method covers the in-place evaluation of the stiffness of base course material for use in roadways by means of electro-mechanical stiffness measurements.

2 Reference Documents**ASTM**

D6758 Standard Test Method for Measuring Stiffness and Apparent Modulus of Soil and Soil-Aggregate In-Place by an Electro-Mechanical Device

MT Materials Manual

MT 212 Determination of Moisture and Density of In-Place Materials

Other

H-4140 – Test Method for Using the Humbolt GeoGauge as an In-Place Index of CBR

3 Terminology

- 3.1 *Stiffness* – the ratio of change of force to the corresponding change in translational deflection of an elastic element.
- 3.2 *Young's modulus* – the ratio of the increase in stress on a test specimen to the resulting increase in strain under constant traverse stress limited to materials having a linear stress-strain relationship over a range of loading, also called elastic modulus.
- 3.3 *Poisson's ratio* – the ratio between linear strain changes perpendicular to and in the direction of a given uniaxial stress change.
- 3.4 *Foot* – the part of the gauge which contacts the ground and imparts force to it.
- 3.5 *Footprint* – the annular ring imprint left on the ground by the foot of the gauge.
- 3.6 *Non-destructive testing* – a condition that does not impair future usefulness and serviceability of a layer of soil or soil-aggregate mixture in order to measure, evaluate or assess its physical properties.
- 3.7 *Seating the foot* – the process of placing the gauge on the ground such that the desired footprint is achieved.
- 3.8 *Site* – the general area where measurements are to be made.
- 3.9 *Test location* – a specific location on the ground where a measurement is made.
- 3.10 *Shear modulus (G)*

$$G = \frac{E}{2(1 + \nu)} \quad (1)$$

Where:

G = shear modulus, kpsi (MPa),
 E = Young's modulus, kpsi (MPa),
 ν = Poisson's ratio

4 Significance

- 4.1 This test method is suitable for the in-place determination of a Young's and a shear modulus of soil and soil-aggregate mixtures (3, 4). Stiffness, as measured by this method, is related to modulus (5) from an assumption of Poisson's ratio and from the radius of the foot of the gauge as follows:

$$K_{gr} \approx \frac{1.77RE}{(1-\nu^2)} \approx \frac{3.54RG}{(1-\nu)} \quad (2)$$

Where:

Kgr = stiffness of the ground layer being measured, klf/in (MN/m),

R = outside radius of the gauge' foot, in (m),

ν = Poisson's ratio,

E = Young's modulus, kpsi (MPa),

G = shear modulus, kpsi (MPa).

5 Gauge

- 5.1 Stiffness gauge – an electro-mechanical instrument capable of being seated on the surface of the material under test and which provides a meaningful and measureable stress level and a means of determining force and displacement.
- 5.2 *Seating sand* – a supply of moist, clean, fine sand passing a No. 30 (600 μ m) sieve that is sufficiently moist to clump in the palm of the hand. This is used to assist the seating of the rigid foot on hard and rough surfaces or at anytime when additional assistance in seating is required.
- 5.3 *Principle of Operation* - The force applied by the shaker and transferred to the ground is measured and calculated by differential displacement across the internal flexible plate as follows:

$$F_{dr} = K_{flex}(X_2 - X_1) + \omega^2 m_{int} X_1 \quad (3)$$

Where:

F_{dr} = force applied by the shaker, lbf (N),

K_{flex} = stiffness of the flexible plate, klf/in (MN/m),

X₂ = displacement at the flexible plate, in. (m),

X₁ = displacement at the rigid foot, in. (m),

$\omega = 2\pi f$, where f is frequency, Hz, and,

m_{int} = mass of the internal components attached to the rigid foot and the foot itself, lb (kg).

At the frequencies of operation, the ground-input impedance is dominantly stiffness controlled.

$$K_{gr} = \frac{F_{dr}}{X_1} \quad (4)$$

Where:

Kgr = stiffness of the ground layer being measured, klf/in (MN/m).

By substituting Eq 3 for Fdr in Eq 4, averaging over the operating frequencies and substituting velocity, V, for displacement, X, since the units cancel each other, the ground stiffness is calculated as follows:

$$K_{gr} = K_{flex} \frac{\sum_1^n \left(\frac{X_2 - X_1}{X_1} \right)}{n} + \frac{\sum_1^n \omega^2}{n} m_{int} = K_{flex} \frac{\sum_1^n \left(\frac{V_2 - V_1}{V_1} \right)}{n} + \frac{\sum_1^n \omega^2}{n} m_{int} \quad (5)$$

Where:

n = number of test frequencies used in the gauge,

V2 = velocity at the flexible plate, ft/s (m/s),

V1 = velocity at the rigid foot, ft/s (m/s).

6 Calibration / Equipment Verification

6.1 Follow the recommendation of the gauge manufacturer.

6.2 Field check the calibration whenever any stiffness measurement is in doubt.

Note 1 – Field conditions may not allow the precision of a laboratory calibration and so an appropriate tolerance should be assigned to the field check (for example, ± 5% relative to the value of the stiffness expected).

7 Procedure

7.1 Stiffness measurement

7.1.1 Ensure that the foot is clean and free of soil or other debris.

7.1.2 Turn on the gauge.

7.1.3 Prepare the surface. Lightly brush any loose material away from the test location before seating the foot. If the test location requires leveling, scrape the surface with a square point shovel or with the template provide with the gauge. The surface does not need to be leveled if the gauge can stand on its own.

7.1.4 Lay the template onto the surface being tested and apply a layer of seating sand (1/8 to 1/4 inch thick). (Note 2) Pat down firmly, strike off the sand with a straightedge, place the gauge on top of the sand and rotate 1/4 turn to seat. (Note 3) Ensure that the gauge does not contact any portion of the template.

Note 2 – Use moist or wet, clean and uniform local fines (minus 30 mesh) or commercially available mortar sand for seating the gauge. The moist or wet condition is for cohesiveness of the sand. Dry sand and other cohesionless materials will serve to decouple the gauge from the ground.

Note 3 – Do not apply additional pressure to the gauge when seating and rotating. Follow the manufacturer's recommendation as appropriate.

7.1.5 At least 60% of the foot's annular ring surface must seat or contact the ground to provide consistent stress on the ground for each measurement. Visibly estimate the amount of surface contact from the footprint left by the foot by lifting the gauge off the ground after the measurement is taken. Reseat the gauge and run test again if it is determined that less than 60% of the annular ring made contact with the ground.

7.1.6 Ensure that the external case of the gauge does not come into contact with a trench wall, pipe or any other object.

- 7.1.7 Take the measurement. (Press “Meas” button. SSG will measure site noise and stiffness as a function of frequency. The gauge will display average stiffness, lb/in (MN/m) or modulus, psi (MPa) or percentage of target. If construction noise is present, try to take the test at a distance greater than 25 yards from the operating equipment.) Take a minimum of three measurements and report the average.
- 7.1.8 Remove the gauge from the test location and inspect the footprint. If contact is not adequate, repeat the measurement.

8 Report

- 8.1 The make, model and serial number of the gauge used.
- 8.2 Name of the operator.
- 8.3 Project name and number.
- 8.4 Test locations and average stiffness value rounded to the whole number.
- 8.5 Moisture content to 0.1 %.

Form 337 STAB
Revised 12-30-2009

Montana Department of Transportation CAC Surfacing Stiffness – Summary of Test Data

Soil Stability Gauge No. _____

Type of Surfacing: _____

Make & Model SSG _____

Summary Sheet No. _____

Nuclear Device No. _____

Pit Lab No.: _____

Project No.: _____ Project Name: _____ Tested by: _____

Roadway Section No.	Lane and Station of Roadway Section	Lift ____ of ____	Proctor Results		Average of Tests on this Section		% of Control Density	+ or - Control Moisture	Stiffness Value	Cure Time Hours/Days	Remarks
			Dry Density	Moisture	Dry Density	Moisture					
			Moisture								

Avg. Moisture Value: _____ **Avg. Stiffness Value:** _____

Approved by EPM _____ Checked by District Materials Supervisor _____

REMARKS: _____

_____ Materials Bureau-Helena
_____ Construction Bureau

METHODS OF SAMPLING AND TESTING
MT 338-10
DRAINDOWN CHARACTERISTICS IN UNCOMPACTED ASPHALT MIXTURES
(Modified ASTM D6390)

1 Scope

- 1.1 This method covers the determination of the amount of draindown in an uncompacted asphalt mixture sample when the sample is held at elevated temperatures comparable to those encountered during the production, storage, transport, and placement of the mixture.

2 Referenced Documents**ASTM**

D6390 Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures

MT Materials Manual

MT 303 Sampling Bituminous Paving Mixtures

MT 306 Marshall Method for Bituminous Mix Design

3 Terminology

- 3.1 *Draindown* – draindown is considered to be that portion of material which separates itself from the sample as a whole and is deposited outside the wire basket during the test. The material which drains may be composed of either asphalt binder or a combination of asphalt binder, additives, or fine aggregate.

4 Summary of Test Method

- 4.1 A sample of the asphalt mixture to be tested is prepared in the laboratory or obtained from field production. The sample is placed in a wire basket which is positioned on a plate or other suitable container of known mass. The sample, basket, and plate or container is placed in a forced draft oven for one hour at a pre-selected temperature. At the end of one hour, the basket containing the sample or container is removed from the oven along with the plate or container and the mass of the plate or container containing the drained material, if any, is determined. The percent of draindown is then calculated.

5 Significance and Use

- 5.1 This test method can be used to determine whether the amount of draindown measured for a given asphalt mixture is within specified acceptable levels. The test provides an evaluation of the draindown potential of an asphalt mixture during mixture design and/or during field production. This test is primarily used for mixtures with high coarse aggregate content such as porous asphalt (open graded friction coarse) and stone matrix asphalt (SMA).

6 Apparatus

- 6.1 *Forced Draft Oven* – capable of maintaining a set temperature in a range from 120°C to 175°C to within $\pm 2^\circ\text{C}$.
- 6.2 *Plates* - or other suitable containers of appropriate size. The plates or containers used shall be of appropriate durability to withstand the oven temperatures. Cake pans or pie tins are examples of suitable types of containers.
- 6.3 *Standard basket* – A basket constructed of standard 1/4 inch sieve cloth, 4 1/4 \pm 3/8 inches in diameter, 5 1/2 \pm 3/8 inches in height with a wire sieve cloth bottom installed inside the basket 1 \pm 1/4 inches from the bottom of the basket.
- 6.4 *Balance* – A balance accurate to 0.1 g.

7 Sample Preparation

7.1 Laboratory Prepared Samples

- 7.1.1 Number of Samples –Determine the draindown characteristics for each mixture tested at two different temperatures. The temperatures shall be the anticipated plant production temperature as well as 10°C above (see Note 1). Test duplicate samples for each temperature. Thus for one asphalt mixture, a minimum of four samples will be tested.

Note 1 – When using the test as part of the mixture design procedure, the test should be performed at two temperatures in order to determine the potential effect that plant temperature variation may have on the mixture during production. When the test is used in the field during production, it should be necessary to perform the test at the plant production temperature only.

- 7.1.2 Dry the aggregate to a constant mass and sieve it into appropriate size fractions as indicated in MT 306.
- 7.1.3 Determine the anticipated plant production temperature for the specific mix to be tested based on the specifications, mix design, or recommendations of the binder supplier.
- 7.1.4 Place the amount of each size fraction required to produce completed mixture samples of 1200 ± 200 g into separate pans. Combine the aggregate fractions to produce the same gradation as the job-mix formula. Place the aggregate samples in an oven and heat to a temperature not to exceed the temperatures established in 7.1.1.
- 7.1.5 Heat the asphalt binder to the temperatures established in 7.1.1.
- 7.1.6 Place the heated aggregate in the mixing bowl. Add any stabilizers (see Note 2) and thoroughly mix the dry components. Form a crater in the aggregate blend and add the required amount of asphalt binder. Add the asphalt binder so that the final sample has the same asphalt content as the job-mix formula. At this point, the temperature of the aggregate and asphalt binder shall be at the temperature determined in 7.1.1. Mix the aggregate (and stabilizer if any) and asphalt binder quickly until the aggregate is thoroughly coated.

Note 2 – Some types of stabilizers such as fiber or some polymers are added directly to the aggregate prior to mixing with the asphalt binder. Other types of stabilizers are added directly to the asphalt binder prior to blending with the aggregate.

7.2 Plant Produced Samples

- 7.2.1 Number of samples – Test triplicate samples at the plant production temperature.
- 7.2.2 Obtain the samples in accordance with [MT 303](#) during plant production by sampling the mixture at any appropriate location prior to the mixture leaving the plant. Reduce the samples obtained during actual production to the proper test size.

8 Procedure

- 8.1 Weigh the empty wire basket described in Section 6.3 and designate as A. Transfer the uncompacted mixture sample to the wire basket as soon as possible. Place the entire sample into the basket. Do not consolidate or otherwise disturb the sample after transfer to the basket. Determine the mass of the sample and the basket and designate as B.
- 8.2 Determine and record the mass of a plate or other suitable container to the nearest 0.1 g at ambient temperature and designate as C. Place the basket on the plate or container and place the assembly into the oven at a temperature as determined in 7.1.1 or 7.2.1 for $1 \text{ hr} \pm 5 \text{ min}$.
- 8.3 After the sample has been in the oven for $1 \text{ hr} \pm 5 \text{ min}$, remove the basket and the plate or container from the oven and cool to room temperature. Determine and record the mass of the plate or container plus the drained material to the nearest 0.1g and designate as D.

9 Calculation

- 9.1 Calculate the percent of mixture which drained to the nearest 0.1% as follows:

$$\text{Draindown \%} = (D - C) / (B - A) \times 100$$

Where:

A = mass of empty wire basket,

B = mass of wire basket and sample,

C = mass of empty catch plate or container, and

D = mass of catch plate or container plus drained material.

10 Report

- 10.1 Report the average percent of draindown at each of the test temperatures to the nearest 0.1%.

ASPHALT DRAINDOWN WORKSHEET

Project Number _____

Project Name _____

Tester Name _____ Date ____

Plant Production Temperature _____

Laboratory Prepared Samples
(minimum of 4 samples tested)

	<i>D</i>	<i>C</i>	<i>B</i>	<i>A</i>	
Sample # 1	_____	-	_____ ÷ _____		- _____ x 100 = _____
Sample # 2	_____	-	_____ ÷ _____		- _____ x 100 = _____
					Average = _____
Sample # 3	_____	-	_____ ÷ _____		- _____ x 100 = _____
Sample # 4	_____	-	_____ ÷ _____		- _____ x 100 = _____
					Average = _____

Plant Produced Samples
(minimum of 3 samples tested)

	<i>D</i>	<i>C</i>	<i>B</i>	<i>A</i>	
Sample # 1	_____	-	_____ ÷ _____		- _____ x 100 = _____
Sample # 2	_____	-	_____ ÷ _____		- _____ x 100 = _____
Sample # 3	_____	-	_____ ÷ _____		- _____ x 100 = _____
					Average = _____

Comments:
