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*.

2.8 *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± 5°F (60 ± 3°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 77ºF (25ºC). 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 AASHTO R 58 shall be prepared. The sample shall be large enough to produce 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 than 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 ± 15ºF (121 ± 8ºC).

5.1.2 Stabilize the hot plate at 425ºF to 475 ºF (218ºC to 246ºC).

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 ± 9ºF (110 ± 5ºC).

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 140ºF (60ºC).

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 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 ± 15ºF (121± 8ºC).

5.2.2 Stabilize the hot plate at 425 to 475ºF (218 to 246ºC).

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± 9ºF (110± 5ºC).

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 (W1). 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 specimens 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 (W2). 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 (W3). 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.

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

$$S = \frac{V_2 - V_1}{V_1} x100$$

where:
S = volume swell, percent
V1 = volume of specimen before immersion, by caliper
V2 = volume of specimen after immersion

6.1.2 Percent Volume Swell by Mercury Method

$$S = \frac{W_2 - W_3}{W_1 - W_2} x100$$

where:
S = volume swell, percent
W1 = weight of cup filled with mercury
W2 = weight of mercury and cup minus mercury lost because of immersion of cured briquette
W3 = 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.