



# **ASPHALT TECHNICIAN CERTIFICATION WORKBOOK**

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**ARIZONA TECHNICAL TESTING INSTITUTE**

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**FORWARD:**

The Arizona Technical Testing Institute (ATTI) is a nonprofit organization formed to promote the highest standard in highway construction materials sampling and testing through certification of technicians. ATTI certifications emphasize a hands-on approach, that is, applicants must satisfactorily demonstrate test methods as well as pass a written exam to receive certification. The organization is represented by members from the Arizona Department of Transportation (ADOT), highway contractors, materials suppliers, materials testing laboratories, Arizona Rock Products Association (ARPA), Federal Highway Administration (FHWA), and Arizona General Contractors (AGC). ATTI certifications satisfy ADOT and federal requirements which specify that technicians performing materials sampling and testing on ADOT projects are properly qualified.

**ATTI provides the following certifications:**

**ATTI FIELD TECHNICIAN – field sampling and testing of soils, aggregates, asphalt, and asphaltic concrete,**

**ATTI LABORATORY SOILS/AGGREGATE TECHNICIAN – laboratory sampling and testing of soils and aggregate,**

**ATTI ASPHALT TECHNICIAN – laboratory sampling and testing of asphaltic concrete.**



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## **INTRODUCTION:**



The ATTI Field Technician Certification program evaluates the competency of applicants performing sampling and testing of soils, aggregates, bituminous materials, and hot mix in the field.



Certification is based on satisfactory demonstration of all specified sampling and testing methods, as well as passing a written examination. Applicants are advised to receive training or have experience performing the test methods and calculations before attempting to obtain certification.



This workbook provides information regarding the requirements for ATTI Field Technician certification, administration of the certification process, and topics covered during the certification, administration of the certification process, and topics covered during the certification examinations.



Brief coverage is given to safety issues, plan and profile, representative samples, record keeping, and properties of soils, aggregates, and asphaltic hot mix. Most importantly, the workbook contains copies of the applicable testing methods which a certified ATTI Field Technician must be able to perform.

## **PERFORMANCE EXAMINATION:**



As Stated earlier, the emphasis of this certification program is technician demonstration of proficiency in performing all test methods which have been specified above.



Technicians may not use any notes or books while taking the performance exam. The examiner will maintain possession of all examination paperwork.



Instead of performing both Method A and Alternate Method D one point proctor tests, the examiner may ask the technician to verbally recite the differences between the two tests.



The examiner will use standardized checklists to verify proper procedure by the technician. During the performance examination, the examiner will indicate a technician's compliance with each identified item on the individual test method checklist with a "Yes" or "No" in the space provided. If any significant deficiencies are observed during the exam, the examiner must indicate "No" for that item. Any "No" will constitute failure of that test method. All checklist items must be performed correctly or the test method is considered failed.



Once completed, the examiner will inform the technician if the test method was passed or failed. If failed, the examiner will indicate the step or steps that were not performed properly. The failed test method may be demonstrated a second time at the discretion of the examiners. The retest should be performed after all other tests have been completed, the technician has studied the failed test method, and the examiner is available. If a test method is failed a second time, the applicant must schedule a retest within 1 year at a cost of \$50.00.



If the technician requests to start over a test method once they have begun, the examiner will allow the technician to restart the test method and disregard findings of the incomplete test. The technician will be allowed to restart a test method one time only.



If the technician has successfully attained an ATII Asphalt, Soils I Aggregate, or Field Technician Certification within the last 12 months you may receive credit for some of the test methods performed included in that certification.



***It is recommended that technicians perform all test methods during an examination period. Any test methods not performed will be considered failed.***

### **WRITTEN EXAMINATION:**



The written examination has a 3-hour time limit to complete. The questions and calculations are derived directly from the previously mentioned test methods and from information presented in the first few chapters of this manual. Eighty (80) percent of the written examination questions must be answered correctly and all calculations performed correctly to achieve a passing score.



Notes and books may not be used while taking the written examination. The examiner will maintain possession of all examination paperwork.

### **RETEST:**



If a technician fails to successfully demonstrate a test method as prescribed, the technician may be allowed to demonstrate the failed test method a second time during the same examination period at the discretion of the examiners. The retest should be performed after all other tests have been completed, the technician has studied the failed test method, and the examiner is available. Failed test methods must be re-demonstrated within twelve months of the original examination date. All retesting is at the discretion of the examiners.



A technician failing the written or calculations examination is required to retake the entire written or calculations examination within twelve months of the original test date.



If a technician fails the performance and /or written examinations a second time, a fee will be charged for additional testing that must be performed within twelve months of the original examination date. If the failed items are not successfully passed the third try, the technician will be required to register and retake the entire certification examination.

### **CERTIFICATION:**



To receive certification, the technician must successfully demonstrate all test methods as well as correctly answer at least 80 percent of the written exam questions and correctly perform all calculations. Certification is granted for a period of five years. Successful completion of the entire examination program is required for re-certification.

### **CANCELATION / NO SHOW POLICY:**



The cancellation policy is detailed in the ATTI Administration Manual which is available on the ATTI website at [www.attiaz.org](http://www.attiaz.org).

### **APPEALS:**



ATTI certification examinations, policies, procedures, requirements, and materials are developed through a cooperative effort of the ATTI technical advisory board and industry experts. The ATTI Board of Directors approves and provides oversight of the certification program. If a technician feels that the certification exams have not been correctly administered or if the technician desires to appeal their exam scores, they may do so.



Appeals should be made in the following sequence:

1. Senior Examiner
2. Executive Director
3. Technical Advisory Board
4. ATTI Board of Directors



If there is not consensual resolution at any level, the technician may escalate their appeal to the next level. The decision of the Board of directors is final.



Technicians are encouraged to provide feedback to ATTI on any portion of the examinations, manual content, exam administration, or requirements of the ATTI certification process. The comments received will be discussed by the technical advisory board and, if merited, revisions to the program will be initiated.

### **SAFETY:**

- ☛ Some of the test methods in this manual may involve hazardous materials operations, and/or equipment. This manual does not claim to address all relevant safety issues which may be encountered or which may be associated with its use or with the performance of test procedures introduced here.
- ☛ It is the responsibility of the technician to determine, establish, and follow appropriate health and safety practices. The technician must also determine the applicability of any regulatory limitations of test equipment and chemicals.

### **OSHA:**

- ☛ OSHA has established safety requirements for individuals working in various environments. In the field and laboratory these requirements include such measures as wearing hard hats, eye protection, and protective footwear as well as the need to observe certain precautions when operating machinery and other equipment.
- ☛ There are also regulations pertaining to the handling and storage of chemicals, nuclear devices, and other hazardous materials. This short discussion on safety is not meant to preclude or to include OSHA requirements. It is up to the individual technician to be acquainted with OSHA regulations that apply to their particular job assignment.

## PLAN & PROFILE



The plan and profile of a specific segment of a roadway are typically printed on a single sheet of the project plans with the plan view at the top of the sheet and the corresponding profile view at the bottom of the sheet. Plan and profiles are drawn such that profile stationing is directly below the plan stationing. See Figure 1.



The plan shows an aerial view of the roadway, as if the observer is looking directly down on the roadway. Roadway details such as horizontal alignment, roadway width, right-of-way, and structure locations are illustrated on the plan sheet relative to the roadway centerline. The profile shows a longitudinal cross-section view of the roadway elevation, taken through the centerline of the roadway. The profile illustrates details such as vertical alignment of the centerline, existing ground line elevation, culvert elevation, and structure elevations.

### **PLAN DETAILS**



The **centerline**, denoted,  $\text{CL}$  is the surveyed center of the roadway. It may be an existing centerline or a newly established centerline. If both are illustrated, they should be clearly identified.



**Station numbers** are established along the centerline. Each station represents 100 feet; therefore, a distance of 700 feet is equivalent to 7 stations. Most projects will begin at station 0+00 and increase in stationing to the end of the project. For example, the location of a culvert is given as Station 21+76.8 which is equal to 2,176.8 feet from the beginning of the project. When a new centerline is established, and it is desired that the new stationing matches the old, it is often necessary to add a correction equation.



Sampling of roadway materials is conducted randomly; consequently, very few samples are taken on the centerline. Specific sample locations are identified by station and **centerline offset** to the left of centerline or to the right of centerline. As an individual is facing in the direction of increasing stationing, the individual's left defines "left of centerline" and the individual's right defines "right of centerline."

### **PROFILE DETAILS**



**Elevations** of various roadway centerline details are illustrated on the profile sheet. The elevations represent vertical distance above or below sea level.



The existing ground elevation along the **centerline** and the design finished roadway **centerline** are illustrated by lines drawn at the appropriate elevations.



The top elevation and depth of a sample is often drawn on the profile sheet.

## **TYPICAL SECTIONS**



**Typical sections** illustrate the components and dimensional requirements of each pavement structure used on the project. The typical pavement sections are cross-sections taken transversely across the roadway. See Figure 2.



**Pavement structural sections** provide details on the material type and depth of each layer of the pavement structure. The pavement structure includes all pavement materials placed above the subgrade, including aggregate subbase, aggregate base, asphaltic concrete, Portland cement concrete, and asphaltic concrete friction course.

## **REPRESENTATIVE SAMPLES**



As should be apparent, acceptance or rejection of materials is highly dependent on the representativeness of a small sample that is tested to determine the quality of a large quantity of material. If the sample is not truly representative of the larger quantity, acceptable material might be rejected or unacceptable material might be accepted. Unbiased samples must be obtained in a way that the true nature of the material is represented. For example, aggregate stockpiles should not be sampled at the surface where coarser slough material is present. Similarly, all material from an asphaltic concrete plate sample should be obtained with single strokes of the sampling device through the middle of the plate, excluding material that sloughs onto the plate after initial sampling.

## **RANDOM SAMPLING**



A random sample is any sample which has an equal chance as any other sample of being selected from a population. In other words, there is an equal chance for all locations and all fractions of materials to be sampled.



Samples should not be obtained on a predetermined basis or based on the quality of the material in a certain area. If sampling is not performed on a random basis, the quality of the sample can be artificially modified and the sample will no longer be representative of the larger quantity.



When a sample is not representative, it is said to be biased. Examples of biased sampling that should not be used include sampling a roadway at a given interval such as 1500 feet; sampling asphaltic concrete production at a given frequency, such as every 500 tons; or taking samples at a given time, such as every hour on the hour.



Random sampling is usually accomplished with the use of random number generators or tables of random numbers. Most calculators and computers contain a random number generator that merely requires the operator to hit a button. The automated random number generators use programmed tables of random numbers similar to the table shown in figure 3. Random number tables are simply random arrangements of numbers of any table length.

.72	.51	.98	.45	.01	.55	.25	.24	.73	.43
.99	.13	.69	.59	.88	.35	.07	.66	.82	.78
.68	.40	.08	.83	.11	.48	.56	.19	.46	.31
.03	.96	.49	.10	.74	.38	.22	.87	.33	.57
.70	.28	.04	.63	.27	.15	.60	.44	.03	.37
.16	.53	.85	.09	.39	.91	.47	.30	.77	.42

*Figure 3. Table of random Numbers*



ASTM D3665 - "Standard Practice for Random Sampling of Construction Materials" is a reference used by the industry for determining random locations or timing at which samples of construction materials are to be taken. The ASTM method uses a table of random numbers and details the procedures for determining random times for belt sampling, random lengths for windrow sampling, random sampling of in-place paved materials, and random truck load number sampling.



To obtain a group of random numbers, select a starting number in a random number table, never repeating the same starting number, and proceed from the starting number reading left to right, top to bottom, bottom to top, right to left or diagonally. Each number will then correspond to a sampling frequency.

### **Example 1:**

Four samples are required for a 12 feet wide pavement with a lot size determined to be 4000 linear feet. The lot begins at station 100+00. Use the random number table in Figure 3 to determine the sample locations.

Step 1, from the given information:

Lot begins at station 100+00  
 Lot ends at station 140+00  
 Length of lot = 4,000 feet

Step 2, determine the sample location:

Using the random number table, obtain two sets of 4 random numbers each.

Set 1 will be used to determine stationing (X) of the samples by multiplying the random numbers by 4,000 feet.

Set 2 will be used to determine the sampling distance from the right edge of pavement (Y) by multiplying the random numbers by 12 feet.

Step 2a, random numbers chosen from table:

Set 1: .13    .69    .59    .88  
 Set 2: .73    .82    .46    .33

Step 2b, sample coordinate locations determined:

Sample #1:  
 $X = .13 \times 4000 = 520$  feet  
 $Y = .73 \times 12 = 8.8$  feet

Sample #2:  
 $X = .69 \times 4000 = 2760$  feet  
 $Y = .82 \times 12 = 9.8$  feet

Sample #3:  
 $X = .59 \times 4000 = 2360$  feet  
 $Y = .46 \times 12 = 5.5$  feet

Sample #4:  
 $X = .88 \times 4000 = 3520$  feet  
 $Y = .33 \times 12 = 4.0$  feet

Step 2c, samples located by stationing and offset:

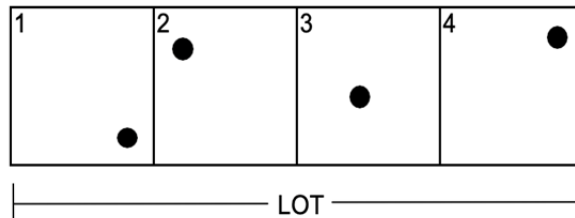
Sample #1:  
Station  $100+00 + 520$  feet = Station  $105+20 @ 8.8$   
feet from right edge of pavement

Sample #2:  
Station  $100+00 + 2760$  feet = Station  $127+60 @ 9.8$   
feet from right edge of pavement

Sample #3:  
Station  $100+00 + 2360$  feet = Station  $123+60 @ 5.5$   
feet from right edge of pavement

Sample #4:  
Station  $100+00 + 3520$  feet = Station  $135+20 @ 4.0$   
feet from right edge of pavement

When obtaining samples from a large area (or lot), divide the area into sublots if necessary and obtain samples from each subplot using stratified random sampling. Stratified random sampling assures that samples are taken from throughout the entire lot and are not concentrated in one area of the lot. See Figure 4.



*Figure 4. Sublots for stratified sampling.*

## **SAMPLING AND TESTING RECORDS**



All data collected during the sampling and testing processes should be documented electronically or retained on paper. This documentation provides:

- Records pertaining to individual samples.
- A process to trace samples and test results.
- Control of samples as they are processed and tested.
- Who did the sampling and testing.
- What testing was done.
- Permanent record of test data and test results.



Sample tickets used for sample identification, work instruction cards directing which tests to perform, logs of samples and tests performed, test data worksheets, and test result reporting forms are all routinely used records which a technician must have familiarity.



Test methods provided in AASHTO Standard Specifications, Part I/tests and in the ADOT Materials Testing Manual define which data to collect, calculations to perform, and what information to report. They also have guidelines for determining if test results are reasonable.

### ***SAMPLE TICKETS***



Sample tickets need to be attached to or accompany all samples. A sample ticket is the document which identifies an individual sample. Sample tickets will usually contain information such as:

- Project number or code.
- Name of the person who obtained sample.
- Type of material.
- Date and time the sample was obtained.
- Purpose of the sample. • Where the sample was taken
- Sample number.
- Type of testing to be performed.

## **TEST RESULTS**



Field sampling and testing must always be done according to test methods. Precise and reliable sampling and testing directly impacts the acceptance and payment of a product. If sampling and testing are not performed correctly, a substandard product could be accepted at full compensation or an acceptable product could be rejected. Test methods used most frequently are contained in the ADOT Materials Testing Manual and the AASHTO Standard Specifications,



Part II, Tests. These methods describe how large a sample should be, step-by-step procedures, what data is to be collected, what calculations are to be performed, and what test results are reported.



The reliability of testing is often checked with the use of split samples which are tested by two different technicians. If individual test results or the comparison of split samples do not seem reasonable, an investigation should be conducted to establish why. Usually, the discrepancy will be due to procedural or equipment deficiencies, errors in calculations, incorrect transposition of data, or the use of procedural shortcuts. Poor equipment calibration or equipment malfunction and improper handling of samples can also cause unreliable test results. Retesting should be performed only after the discrepancies have been corrected.



All test reports should clearly identify the individual who performed the test and the date the test was completed. Test reports should also include the signature of the individual taking responsibility for the validity of the testing. All revisions made to a test report must identify the person making the changes and the date the changes were made. Example copies of test report forms are included in some of the test methods presented in this workbook.

## **MATERIALS PROPERTIES**



Specific strength, durability, water dispersion and other similar properties of soils, aggregates, and asphaltic concrete are the basic properties a highway construction material is designed to satisfy. The soils and aggregate properties of interest to the field-testing technician are briefly discussed below. Compaction testing and sampling of mixtures for laboratory testing are the items of asphaltic concrete construction that are of primary interest to the field technician involved with sampling and testing.

### ***ENGINEERING PROPERTIES OF SOILS***



Selected characteristics of soils directly influence the design, construction, and performance of highway features. The properties of soils on a construction project determine the slope of a cut, the load bearing capacity of a subgrade and the shear strength of embankments. Soils as well as aggregate base courses must have enough strength to support the applied loads of traffic, embankments, and structures under all climatic conditions. Two tests commonly used to determine the strength properties of a subgrade or embankment are the gradation and plasticity index test. These properties directly influence the soil support value of the subgrade under the pavement structure. The plasticity index is an indication of the cohesiveness, bonding, and moisture susceptibility of a soil.



For the purposes of this course, the engineering properties of three major soil types will be considered.

Engineering properties for our use will refer to the properties of these soil types as they relate to highway design and construction.

**These three main soil types consist of:**

Granular soils-Sands and gravels

Fine-grained soils- silts and clays

Organic soils - organic clays and organic peat.



Granular soils, when free draining is not susceptible to frost and will settle quickly under a load. These characteristics make granular soils a good choice for use in foundations, embankments, and as wall backfill material. The drawback to the use of granular soils is that due to their high permeability it can be difficult to dewater them.



Cohesive soils are fine-grained soils. They sometimes possess low shear strength and are compressible and plastic. Wetting of these soils results in a further reduction of shear strength and also in expansion. The expansion will be followed by shrinkage as the material dries. Shear strength is also lost when a cohesive soil is disturbed. These soils can be subject to landslides. Cohesive soils are usually considered a poor choice for construction materials.



Organic refers to decayed animal and vegetable materials. Therefore, an organic soil is any soil containing enough organic material to influence the properties and characteristics of the soil. In general, organic soils are not used in highway construction. All soils, which contain an organic component, should be reviewed carefully and with suspicion when used in highway construction. The presence of organic material in the soils results in an increase in compressibility and a reduction of load bearing capacity. Organic materials can also contain toxic gases, which are released when the soil is disturbed.

***ENGINEERING PROPERTIES OF AGGREGATES***



Particle size and shape, gradation, and cleanliness are three important properties of aggregates that are considered in highway construction. These three properties directly influence the capability of an aggregate mixture to compact, drain water, and adhere to binders.



Aggregate particles are sieved through screens to obtain portions of the same **particle size**. Percentages of the different sizes are then combined to create engineered base, bedding, backfill, and mineral aggregate composites. Particle shape also influences the compactibility and surface to surface contact of aggregates. Angular and irregular particles interlock and resist displacement much better than rounded particles.



**Particle shape** also influences the compactibility and surface to surface contact of aggregates. Angular and irregular particles interlock and resist displacement much better than rounded particles. Particle shapes of interest include irregular, angular, flaky, elongated and rounded. Elongated particles have a long dimension which is 1.8 times the average dimension and flaky particles are those whose shortest dimension is less than 0.6 times the average dimension. Each of these shapes is determined by test methods contained later in this manual.



**Gradation** defines the distribution of a variety of aggregate particle sizes and is often referred to as aggregate grading. The intended use for the aggregate will determine the percentage of each particle size to be used in the gradation or size distribution. Plant screening and crushing processes are used to control gradation. Sieve analyses (AASHTO T27) are performed on an aggregate mixture to determine the true percentage of each size in the mixture.

### ***ENGINEERING PROPERTIES OF ASPHALTIC CONCRETE***



Field sampling of asphaltic concrete mixes is performed to check the produced mix properties for compliance with mix design requirements. Asphaltic concrete mixture performance is affected by the mineral aggregate properties and liquid asphalt cement properties. Consequently, it is important that representative samples are taken. The common method for sampling asphaltic concrete mats is to place a 1' x 4' metal plate in front of the paver. As the paver travels across the plate, material is placed on the plate. When obtaining the asphaltic concrete sample from the surface of the plate, all slough material from the sides of the cut of the surface should not be collected.



Asphalt cements function as a binder, or glue, which hold the aggregate particles together and provide protection against the effects of water. Liquid asphalt cement samples are taken to check viscoelastic, temperature sensitivity and aging properties.

### ***COMPACTION***



Asphaltic concrete, soils and aggregate bases, backfills and beddings are typically compacted to a specified percentage of maximum density in the field by use of rollers or mechanical compactors. Maximum compaction is desirable to reduce settling and deformation, and increase load bearing capacity. The density of a layer of in-place soils/aggregate material is checked by the sand cone density test (AASHTO T191), nuclear density gauge (AASHTO T310), or one-point proctor test (AASHTO T271). Asphaltic concrete compaction is checked with the nuclear density gauge (AASHTO T355) or lab testing of cores (AASHTO T67) taken from the compacted roadway. The in-place density of soils/aggregates is then compared to the maximum dry density determined in the lab by proctor testing to determine the degree of compaction. Similarly, the in-place density of a layer of compacted asphaltic concrete is compared to the maximum density determined by laboratory testing.

# TEST METHODS



## SAMPLING/ REDUCING PROCEDURES

Sampling and reducing allows us to test **aggregate, asphalt mixtures, and asphalt materials** to ensure quality, consistency, and compliance with engineering and construction specifications. Sampling is the process of selecting a representative portion of a larger material stockpile, truckload, or batch. A good sample reflects the properties of the entire batch or lot of material. Poor sampling leads to misleading test results. Reduction is the process of dividing a large sample into a smaller, testable portion with attempting to not alter its characteristics. The significance of reducing large field samples is to break material down to more manageable sizes for lab testing. Also reducing ensures that smaller test samples still accurately reflect the entire batch.



*All aggregate, asphalt mixtures, and asphalt materials sampling AND reducing procedures that will be covered during ATTI ASPHALT:*

- **AASHTO R90: SAMPLING AGGREGATE PRODUCTS**
- **AASHTO R97: SAMPLING ASPHALT MIXTURES**
- **AASHTO R76: REDUCING FIELD SAMPLES OF AGGREGATE TO TESTING SIZE**
- **AASHTO R66: SAMPLING ASPHALT MATERIALS**
- **AASHTO R67: SAMPLING ASPHALT MIXTURES AFTER COMPACTION (OBTAINING CORES)**
- **AASHTO R47: REDUCING SAMPLES OF HOT MIX**

Learning objectives for these sections are:



*How to obtain a representative sample of aggregate, asphalt materials, & asphalt mixtures through various methods.*



*How to reduce aggregate and asphalt samples, once collected, to their appropriate testing size in a representative manner.*



PLEASE REFER TO THE PROCEDURE FOR MORE DETAIL. NOT ALL SECTIONS WILL BE COVERED BY ATTI. SECTION NUMBERS WILL BE PROVIDED FOR REFERENCE. SUBJECT TO CHANGE.



# AASHTO R90: SAMPLING AGGREGATE PRODUCTS

## DEFINITIONS:

**Nominal maximum size** - is the smallest sieve size through which the majority of the sample passes (up to 10% can be retained).

**Windrow** - is a long ridge of loose construction material.

**Stockpile** - is a collection of materials in piles that are segregated by type & size and intended for specific uses on a construction site.

**Increment** - is a portion of material that is collected by a sampling device in a single operation.



## SCOPE:

1.1.

This practice covers the procedures for obtaining representative samples of coarse, fine, or combinations of both to determine compliance with all relevant specifications.

## EQUIPMENT:

4.0.

- **SHOVELS OR SCOOPS**
- **BROOMS, BRUSHES, AND SCRAPING TOOLS**
- **MECHANICAL SAMPLING SYSTEMS-** Normally, a **permanently attached** device that allows a sample container to **pass perpendicularly through** the entire **stream** or **diverts the material** into the container.
- **BELT TEMPLATE-** a device that is the **shape and width of the aggregate belt**.
- **SAMPLING CONTAINERS-** Bags or other **containers** that **prevent loss or contamination of the sample**. Must also prevent damage to the contents from any mishandling. For moisture content samples, containers must prevent moisture loss.
- **SAMPLING TUBE – plastic, aluminum, or similar tube** whose diameter is **at least three times the nominal maximum aggregate size**; the end of the tube may be angled to assist in sampling.

## PROCEDURE:

- The technician shall use every precaution to **obtain samples that are representative** of the material. 5.1
- Make sure all **equipment and containers are clean and dry** before sampling. 5.1.1
- Field **samples** should meet or exceed **TABLE 1** found in the procedure. 5.2.

**Table 1—Recommended Sample Sizes**

Nominal Maximum Size		Minimum Mass	
mm	(in.)	kg	(lb)
90	(3½)	175	(385)
75	(3)	150	(330)
63	(2½)	125	(275)
50	(2)	100	(220)
37.5	(1½)	75	(165)
25.0	(1)	50	(110)
19.0	(¾)	25	(55)
12.5	(½)	15	(35)
9.5	(¾)	10	(25)
4.75	(No. 4)	10	(25)
2.36	(No. 8)	10	(25)



**NOTE 1:** Sample size is based upon the test(s) required. Generally, the field sample size should be enough that if the technician splits it twice the result will be the approximate testing size amount. (SECTION 5.2.)



Record the sampling time or location or both. If being used for quality control or acceptance use a random sampling procedure to obtain the time and location. (SECTION 5.1.)

**FOLLOWING ARE THE DIFFERENT METHODS FOR SAMPLING OUTLINED IN THE PROCEDURE:**

**SAMPLING FROM CONVEYOR BELT USING A TEMPLATE:**

By taking regular samples from the conveyor belt, technicians can obtain their representative samples at the production facility. This allows for corrective actions to be taken before potentially substandard aggregate is used or transported to the job site. (The method of sampling a technician employs are generally project and/or agency specific.)

- 1 Have the **belt stopped**. 5.3.1
- 2 Set the **sampling template** on the **belt** in a way that avoids adjacent material from falling into the space inside the template.
- 3 **Remove** the material from **INSIDE** the **template**; including any **material adhering** to the belt utilizing scoops and brushes. 5.3.3
- 4 If that increment is not enough **repeat the process** obtaining equal increments each time. **Combine** the increments to form a **single sample**. 5.3.4./ 5.3.5.



When sampling aggregate from the conveyor belt avoid sampling from the beginning or the end of the aggregate run to avoid segregation of material. (SECTION 5.3.)



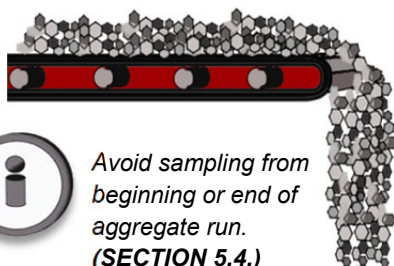
Clean all material (including fines) off belt.



Be careful when sampling in the rain it can make removing the finer material more difficult due to material sticking to the belt or washing away. (SECTION 5.3.3.)

**SAMPLING FROM CONVEYOR BELT DISCHARGE:**

Similar to sampling from the conveyor belt with a template, this form of sampling can be utilized and may be easier to accomplish in certain instances. By taking regular samples from the conveyor belt, in general, technicians can obtain their representative samples at the production facility. This allows for corrective actions to be taken before potentially substandard aggregate is used or transported to the job site. (The method of sampling a technician employs are generally project and/or agency specific.)

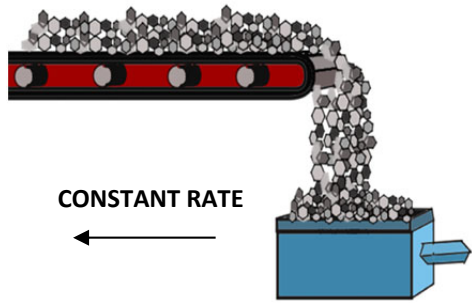


Avoid sampling from beginning or end of aggregate run. (SECTION 5.4.)

Illustrated example of Sampling Device



- 1 The **sampling device** (manual or automatic) must be passed through the **full stream** of material as it runs off conveyor belt. 5.4.
- 2 Pass the **sampling device** through the full stream of material **once in each direction**. Sampling must be done at a **constant speed** and **perpendicular** to the flow of the material **without overflowing**. Alternately, the full stream of material can be diverted into the container. 5.4.1



3

Empty the sampling device into an appropriate **sampling container**. (Considered 1 increment)

5.4.1

4

If that increment is **not enough** repeat the process obtaining equal increments each time. **Combine the increments to form a single sample.**

5.4.2 / 5.4.3.



Empty the sampling device. Repeat as necessary.



When emptying the sampling device include all material that may adhere to the device. (**SECTION 5.4.1.**)

**SAMPLING FROM TRANSPORT UNITS:**



Sampling from transport units ensures that samples taken are representative of the entire batch being delivered to the job site. This ensures that the material actually delivered conforms to the required specifications. (The method of sampling a technician employs are generally project and/or agency specific.)

1

Visually **divide** the transport unit into **four** quadrants.

5.5.1

2

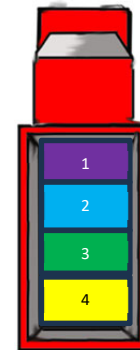
Pick **one quadrant** and identify a **random sampling location** within.

5.5.2

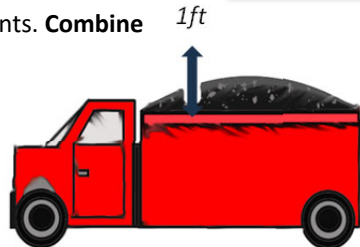
3

**Remove** approximately **1 ft** of material from sampling area. **Obtain an increment** from the exposed surface and **repeat procedure** in each of the remaining quadrants. **Combine** increments into one sample.

5.5.3 / 5.5.4.



Visually Divide into Four Quadrants



**SAMPLING FROM ROADWAY – BERM OR WINDROW:**



Sampling aggregate and soils from a windrow (a long pile or ridge of material) or berm (a raised strip or mound of material) is an essential procedure in obtaining a representative sample for later testing at the job site itself. (The method of sampling a technician employs are generally project and/or agency specific.)



WINDROW



BERM



Make sure **NOT** to take the sample or any increment from the beginning or end of the windrow or berm. (SECTION 5.6.1.)

1

Remove the top 1/3 of the windrow or berm **before** taking increment.

5.6.2

2

Obtain a minimum of **3** approximately equal increments from **random** locations along the windrow or berm.

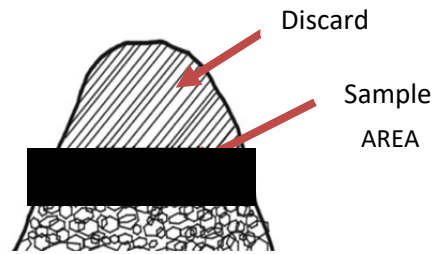
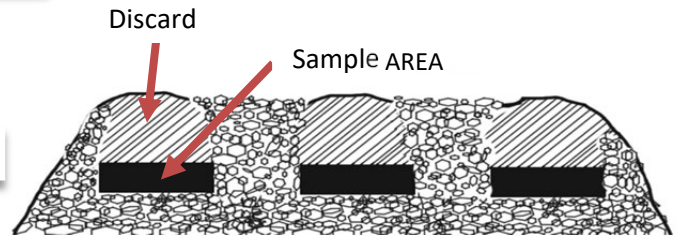
5.6.3

3

Fully insert the shovel into the location (**exclude underlying material**), roll back and lift the shovel slowly so as not to lose any material. **Combine** the increments to form a **single sample**.

5.6.3.1

5.6.4



SIDE VIEW

**SAMPLING FROM ROADWAY- INPLACE:**

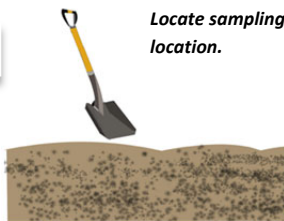


*Sampling aggregate and soils from the roadway in place is a commonly quick but least sophisticated way to obtain representative samples for analysis. (The method of sampling a technician employs are generally project and/or agency specific.)*

1

Obtain representative sample **after spreading** and **before compacting**.

5.7.1.



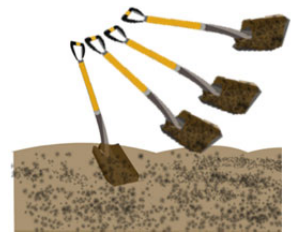
Locate sampling location.

5.7.2.

Fully insert the shovel to the full depth of the material. Excluding underlying material.



Roll back the material avoid material rolling off. Repeat as necessary.



**SAMPLING FROM STOCKPILE – FRONT LOADER PAD:**



*Stockpiled materials often experience segregation, where fine particles settle at the bottom and larger particles accumulate at the top and the sides. Using a front loader to sample and mix material from different layers of the stockpile helps ensure that the sample taken is representative of the entire stockpile, rather than just the surface or just one section. (The method of sampling a technician employs are generally project and/or agency specific.)*

1ft above the ground



1

The **front loader** must enter the stockpile with the bucket at least **1ft above** the ground **without contaminating the stockpile.**

5.8.1.1

2

Discard the **1<sup>st</sup> bucket full.**

5.8.1.2

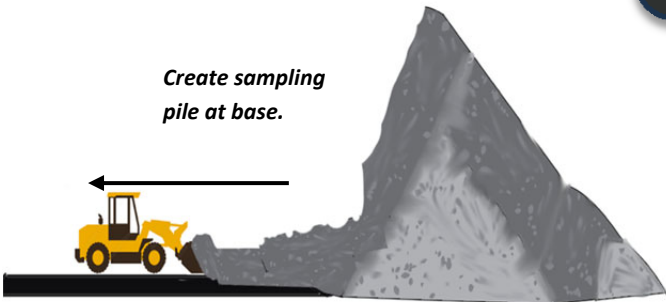
3

Have the front loader **re-enter** the stockpile securing another **bucket full then tilting the bucket back and up.** Keep taking buckets full until desired amount is obtained. Create a small **sampling pile at the base** of the stockpile by gently rolling the material out of the bucket at a sufficient height to permit free flow of the material. **Repeat as necessary.**

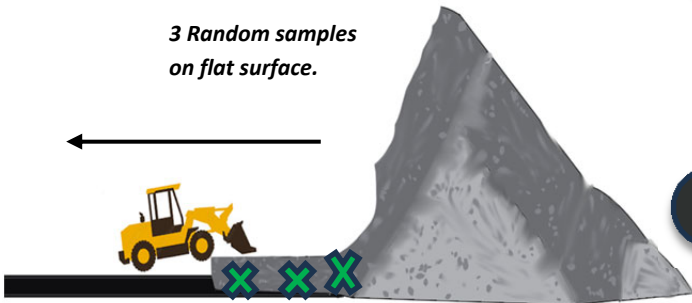
5.8.1.3

5.8.1.4

Create sampling pile at base.



3 Random samples on flat surface.



4

Have the loader create a **flat surface** by back dragging the pile. Obtain **increments** from at least **3 randomly** selected locations on the flat surface at least **1 ft** from the edges.

5.8.1.6

5

**Fully insert the shovel** into the location and lift shovel slowly (**excluding the underlying material**) so as not to lose any material. **Combine** each increment to form a **single sample.**

5.8.1.7

5.8.1.8

### SAMPLING FROM STOCKPILE – HORIZONTAL SURFACE ON FACE:

*Sampling from the face of the stockpile utilizing the following procedure helps mitigate some of the material segregation issues had while obtaining a representative sample from a material stockpile. (The method of sampling a technician employs are generally project and/or agency specific.)*

1

Create **horizontal surfaces** with vertical faces in the **top, middle, and bottom third** of the stockpiles with a shovel or loader.

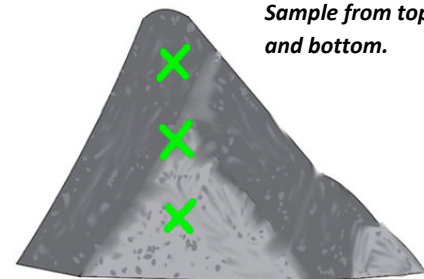
5.8.2.1

2

Insert a flat board against the **vertical face** behind sampling location to prevent sloughing. Discard slough material to create horizontal surface.

5.8.2.2

Sample from **top, middle, and bottom.**



3

Obtain sample from the horizontal surface as close as possible to the **intersection of the horizontal and vertical faces.**

5.8.2.3

4

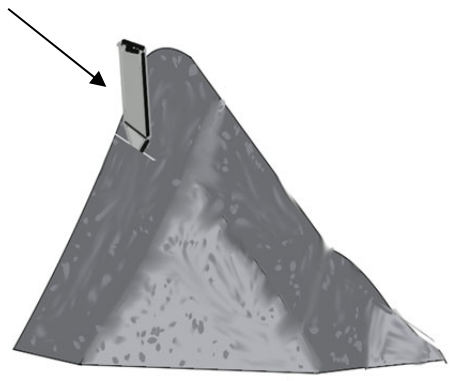
Obtain at least **1 increment** of equal size from **each** of the **top, middle, and bottom thirds** of the pile. Combine all increments into a single sample.

5.8.2.4

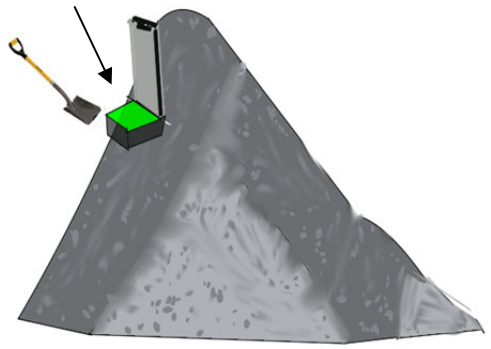
5.8.2.5



Flat board / shield



Intersection



**IDENTIFICATION & SHIPPING (example)**

**IDENTIFICATION & SHIPPING:**

Date  
 Time  
 Sampling Location  
 Quantity of Material (if applicable)  
 Material Type  
 Supplier

6.

- Please refer to approved agency or companies' internal procedures and forms. This EXAMPLE does not necessarily demonstrate all that may be required.

**SECTIONS NOT COVERED:**



**Please refer to the standard for any material not covered. Not all methods are covered:**

- **SAMPLING FROM STOCKPILE- FINE AGGREGATE (ALTERNATE TUBE METHOD) (SEC:5.9)**

# AASHTO R97: SAMPLING ASPHALT MIXTURES

## DEFINITIONS:

**Asphalt Mixture** – is a composite of asphalt (binder), aggregates, and other components used to pave roads and parking lots.

**Asphalt paver** – is a machine used to lay, spread, and compact asphalt.

**Paver auger** – is a screw like component on an asphalt paver that moves asphalt product from the conveyor to screed.

**Compaction (Asphalt)** – is the process of reducing the volume of asphalt and aggregate in hot mix asphalt concrete by applying external forces.



## SCOPE:

This standard practice covers the procedures for sampling of asphalt mixtures at point of manufacture, storage, or delivery. Samples obtained by this procedure may be used as representative samples of asphalt mixtures to determine compliance with requirements of the specifications under which the asphalt mixture is furnished.

1.1.

## EQUIPMENT:

4.

- **SAMPLING CONTAINERS** – cardboard boxes, metal buckets, stainless steel bowls or pans, or other appropriate containers.
- **MECHANICAL SAMPLING SYSTEMS** – a permanently attached device that allows a sample receptacle to pass perpendicularly through the entire stream of material or diverts the entire stream of material into the container by manual, hydraulic, or pneumatic operation.
- **SHOVELS OR METAL SCOOPS** – shovels at least 5.5 inches wide.
- **BELT TEMPLATE**- A template that is the width and shape of the asphalt mixture stream belt. See procedure for additional details.
- **SAMPLING PLATE** – Thick metal plate, minimum 8 gauge, sized to accommodate sample size requirements. Wire long enough to reach from center of paver to outside of farthest auger extension attached at one corner. Each corner of the plate should have 0.25-inch diameter hole.
- **COOKIE CUTTER SAMPLING DEVICE** – Steel angle with two 100mm by 150mm by 9mm handles sized to accommodate sample size. Minimum 2 inches smaller than the sampling plate when used together.
- **RELEASE AGENT** – nonstick spray. See procedure for additional details.



**EXAMPLE SIZE FOR SAMPLING PLATE:** procedure states that an example of an acceptable plate is 15 inches square while following the additional requirements. This is just an example it must be sized to accommodate sample size requirements. (SECTION 4.)

**MANY DIFFERENT SAMPLING LOCATIONS AND TECHNIQUES ARE COVERED IN THIS STANDARD, EXERCISE CARE THAT SAMPLES ARE OBTAINED ACCORDING TO THE APPROPRIATE REQUIREMENTS:**

## PROCEDURE:

- Make sure asphalt samples are covered to prevent contamination from dust or other foreign matter.

5.1.2



When sampling asphalt mixtures, inspect for uniformity and utilize random sampling or stratified random sampling. Select a minimum of 3 locations to best represent the material being tested. (SECTION 5.1.1.)

- Consult the **test method OR agency specifications** for the **sample size**. **Obtain sufficient quantity to perform all testing.**

5.2.



*If using containers that are made of absorbent materials and the mix is hot open-graded mixture then allow to cool in stainless steel bowls or pans first so there is no loss of binder. (SECTION 5.3.3.)*

- Make sure the **containers** and sampling **equipment** are **clean and dry** before sampling.

5.3.1

- Use **cardboard boxes, metal containers, or other acceptable containers** for **dense-graded mixture samples**.

5.3.2



### SAMPLING USING ATTACHED SAMPLING DEVICE:

1

An **attached sampling device** is defined as permanent and allows a sampling receptacle to **pass through** a stream of asphalt mixture **perpendicularly twice**, once in each direction without overfilling. The device maybe hydraulic or pneumatic.

5.4.1.

2

**Lightly coat** the attached receptacle with a **release agent** or **preheat** it, or both.

5.4.2.

3

**Pass** the receptacle **twice through** the material **perpendicularly** without overfilling.

5.4.3.



*As an alternative the stream of asphalt mixture can be entirely diverted to get a representative sample. (SECTION 5.4.1.)*

4

**Transfer** from sampling receptacle to **sample container** without loss of material. Repeat until you have the proper sample size.

5.4.4.

5.4.5.

### SAMPLING FROM CONVEYOR BELT USING A SAMPLING TEMPLATE:

1

**Stop the belt** containing the asphalt mixture.

5.5.2.

2

**Set the sampling template** into the asphalt mixture on the belt, **avoiding intrusion by adjacent material**.

5.5.3.



*Do not sample from the beginning or end of an asphalt mixture production run due to the potential for segregation. Make sure to capture fines that may stick to the belt. (SECTION 5.5.1)*

3

**Remove the asphalt mixture** from **inside the template**, including **all fines**, and place in a sample container.

5.5.4.

4

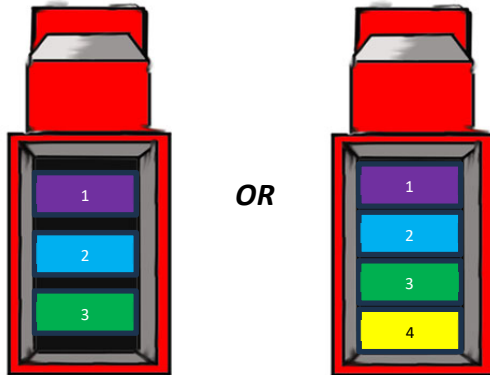
Obtain **equal sample increments** when one increment is inadequate for the required testing. **Combine** the increments to form a **single sample** of the required size.

5.5.5.

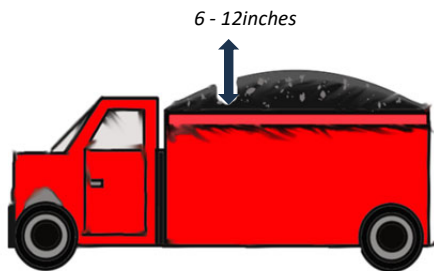
5.5.6.

## SAMPLING FROM TRANSPORT UNITS:

Transport units are, essentially, any vehicle approved to haul asphalt materials. Sampling from these vehicles is essential to ensure that the material being delivered to the construction site meets quality control standards and complies with project specifications. (The method of sampling a technician employs are generally project and/or agency specific.)



OR



1

Visually **divide** the unit into **three or four** equal sections.

5.6.1

2

Remove approximately **6 to 12 inches** of material from **the top of the section** you have decided to sample from.

5.6.2

3

**Obtain the increment** from the exposed surface of that section. **Repeat for the remaining sections.**

5.6.2

4

**Combine** all increments into **one sample.**

5.6.3

## SAMPLING FROM A WINDROW:

When on site, the technician has an option to obtain their representative sample from a windrow which is a continuous, long pile, usually using a bottom-dump truck, where the material is deposited in a controlled manner to form a row of loose asphalt. This method is widely used in the industry. (The method of sampling a technician employs are generally project and/or agency specific.)

1

Visually **divide** the windrow section into approximately **3 equal parts.**

5.8.2.

2

Remove approximately **1 ft** of material from the **top** of the windrow.

5.8.3.

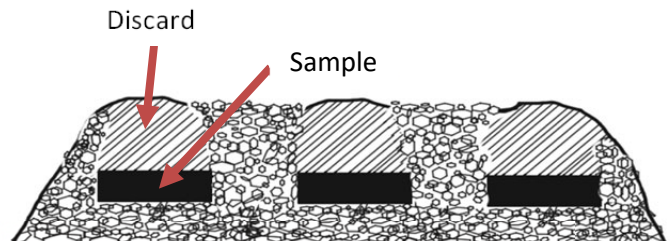
3

Obtain **approximately equal** sample increments by fully inserting the shovel into the flat surface as vertically as possible roll back and lift the material slowly out of the windrow to avoid material rolling off the shovel. **Take care to exclude underlying material.**

5.8.3.



When obtaining a representative sample from the windrow of a transport unit make sure not to take any increment from the beginning or end of the windrow section. (**SECTION 5.8.1.**)

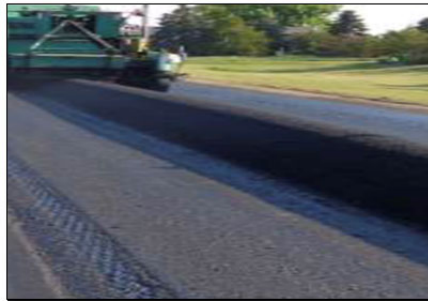
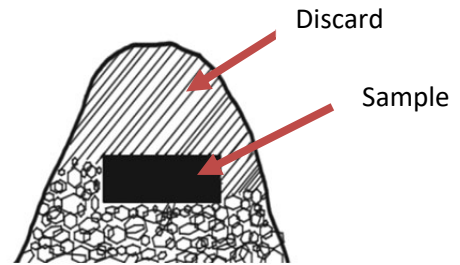


**4** Place the **increment** into the **sample container** and repeat for the remaining thirds.

5.8.3.

**5** **Combine** all increments to form **one sample** of the required size.

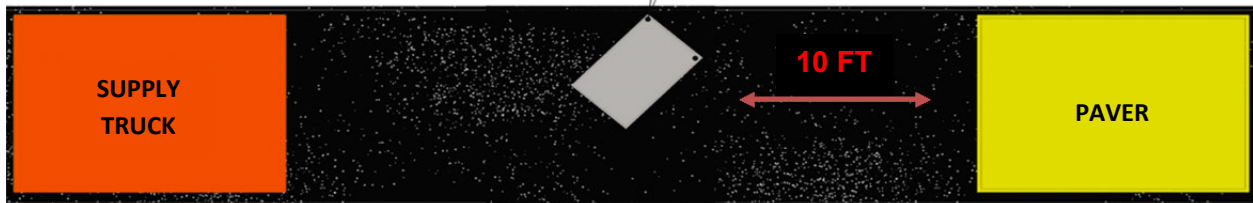
5.8.3.



**Asphalt Windrow Example**

**SAMPLING PLATE METHOD:**

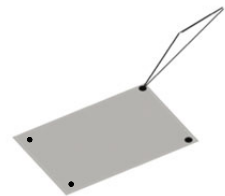
**The plate method allows for the collection of a representative sample from a continuous asphalt layer being placed by the paver on grade or base material. Asphalt mixtures can vary slightly in its properties during placement it's important to obtain a sample that reflects the material being actually placed on the road. (The method of sampling a technician employs are generally project and/or agency specific.)**



**ADOT PLATE**



**PAVING TRAIN**



**AASHTO PLATE**



**For safety, the ROLLER must remain at least 10 feet behind the sampling operation until the sample has been taken and the hole filled with loose asphalt mixture. (SECTION 5.9.1.)**



- 1 The **plate** is to be placed at least **10 ft in front** of the **paver or pickup device**. 5.9.2.1.1.
- 2 **No technician** is to be **between the supply trucks and paver** unless supply truck is moving forward. If this is the case then the **technician** needs to be at least **10 ft behind** the truck. 5.9.2.1.2.
- 3 **If obtaining a sample is unsafe. Stop sampling until made safe or stop while plate is being installed.** 5.9.2.1.3.
- 4 **Remove loose material** from the location Infront of the paver at least **2ft inside the edge of the mat**. 5.9.2.1.4.
- 5 **Lay down the plate diagonally** with the **direction of travel** of the paver (in front). The technician must keep the plate **flat and tight** to the base with the **lead corner facing the paver**. 5.9.2.2.
- 6 **Hold the wire** attached to the outside corner of the plate **taut** as the paver operation passes over. 5.9.2.3.
- 7 **Pull the wire up** through the asphalt mixture to locate the corner of the plate. 5.9.2.5.
- 8 Using a **square pointed shovel** **remove the full depth** of the mixture from the plate. Take care to prevent sloughing of adjacent material. 5.9.2.6.
- 9 Place **all material** including all that adheres to the plate into **sample container**. 5.9.2.7.
- 10 **Remove the plate** from the roadway. The **hole** left must be **filled** with loose asphalt before compaction. 5.9.2.7.



*The technician (if possible) must have contact and communication with the paving machine for safety. If not possible have a third party to assist. (SECTION 5.9.2.1.1.)*



*Thoroughly clean all equipment before any additional sampling.*

## SAMPLING FROM STOCKPILES (ASPHALT):

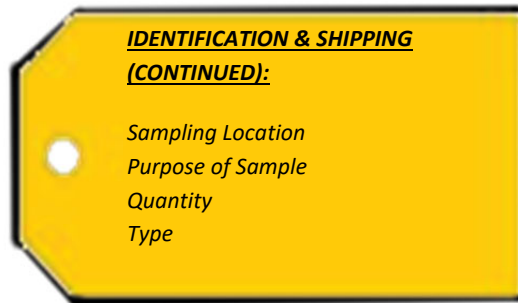
Procedures relating to sampling from asphalt stockpiles are identical to AASHTO R90- Sampling from Stockpiles except for the following:

- **Remove** at least **4 inches** from the **surface before sampling**. Asphalt mixtures in stockpiles may develop an oxidized crust. 5.11.
- Also, if sampling from an **Asphalt Stockpile** with a front loader the **first bucketful** does **not** have to be **discarded**. 5.11.1.

### IDENTIFICATION & SHIPPING (example)



- Please refer to approved agency or companies' internal procedures and forms. This EXAMPLE does not necessarily demonstrate all that may be required.



### SECTIONS NOT COVERED:



**Please refer to the standard for any material not covered. Not all methods are covered:**

- **SAMPLING FROM A PAVER AUGER (SEC:5.7.1)**
- **PLATE METHOD – PLATE WITH COOKIE CUTTER (SEC:5.9.2.8)**
- **NON-PLATE METHOD (SEC:5.9.3)**
- **SAMPLING FROM A PAVER HOPPER (SEC:5.10.1)**
- **SAMPLING FROM ASPHALT STOCKPILE – FRONT LOADER (SEC: 5.11.1 - partially discussed)**
- **SAMPLING FROM ASPHALT STOCKPILE- HORIZONTAL SURFACE ON FACE (SEC: 5.11.1 - partially discussed)**

# AASHTO R76:

## REDUCING SAMPLES OF AGGREGATE TO TESTING SIZE

### DEFINITIONS:

**Coarse Aggregate** - is a granular or irregular material that is typically larger than #4 (4.75mm) screen and is used in concrete.

**Fine Aggregate** - are the particles that pass through a #4 (4.75 mm) sieve and retain on a #200 (0.075mm) sieve.

**Splitting** - is the process of dividing a sample of aggregate into fractions that contain particles within specific limits. The resulting particle size distribution is called the gradation.

**Saturated Surface Dry** - the condition of the aggregate when all permeable pores of each particle are completely saturated with water and its surface has no free moisture.



### SCOPE:

These methods cover the reduction of large samples of aggregate to the appropriate size for testing, employing techniques that are intended to minimize variation in measured characteristics between the test samples and the larger sample.

1.1.

5.

### METHOD:

- The following is quick reference on the method selection for common types of material. There is a detailed description of each method with the type of equipment used.

### METHOD'S AT A GLANCE:

#### METHOD OF REDUCING

FINE AGGREGATE > SSD (WET) ----- A, B, C

FINE AGGREGATE DRIER SSD ----- A

COARSE AGGREGATE ----- A, B

COARSE & FINE AGGREGATE COMBINED (DRIER THAN SSD) ----- A, B

COARSE & FINE AGGREGATE COMBINED (WETTER THAN SSD) ----- B

FINE AGGREGATE  
(DRIER THAN SSD)



METHOD A –  
MECHANICAL SPLITTER

5.1.



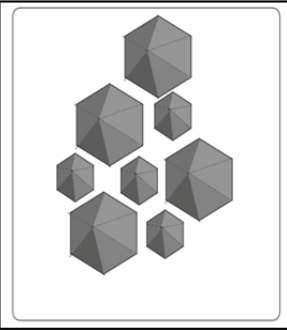
For fine aggregate drier than SSD, if the technician wants to utilize METHOD B or METHOD C. The sample can be moistened, and thoroughly mixed. Then reduced accordingly. (SECTION 5.1.1.)



Similarly, If the technician desires to utilize METHOD A for Fine Aggregate wetter than SSD. The entire sample can be dried to at least the SSD condition using temperatures that doesn't exceed specs for other potential testing. (SECTION 5.1.2.)

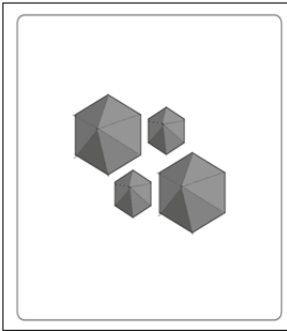
**GOAL OF REDUCING:**

Example of particle distribution of aggregate BEFORE reduction.



**GOAL OF REDUCING:**

Example of particle distribution of aggregate AFTER reduction.



**FINE AGGREGATE (WETTER THAN SSD)**



**METHOD C – MINATURE STOCKPILE**

5.1.2

**METHOD B - QUARTERING**

- QUARTERING ON CLEAN AND LEVEL SURFACE 10.1.1
- QUARTERING ON TARP 10.1.2
- QUARTERING SECTORING 10.1.3



If the moist sample is very large a preliminary split can be made using a mechanical splitter (METHOD A) with chute opening of 1 1/2 inches or more. The sample can't be reduced less than 5000 grams. (SECTION 5.1.2.)

**COARSE AGGREGATE**



**METHOD A – MECHANICAL SPLITTER**

5.2.

**METHOD B - QUARTERING**

- QUARTERING ON CLEAN AND LEVEL SURFACE 10.1.1
- QUARTERING ON TARP 10.1.2
- ~~QUARTERING SECTORING 10.1.3~~

**COARSE & FINE AGGREGATE (DRIER THAN SSD)**



**METHOD A – MECHANICAL SPLITTER**

5.3.

**METHOD B - QUARTERING**

- QUARTERING ON CLEAN AND LEVEL SURFACE 10.1.1
- QUARTERING ON TARP 10.1.2
- ~~QUARTERING SECTORING 10.1.3~~



**NOTE 1:** Method (quick approximation) described in AASHTO T84 for determining saturated surface-dry condition is if the fine aggregate will retain its shape when molded in the hand. This can be considered to be wetter than saturated surface-dry. (SECTION 5.1.1.)

**COARSE & FINE AGGREGATE (WETTER THAN SSD)**



5.3.

**METHOD B - QUARTERING**

- QUARTERING ON CLEAN AND LEVEL SURFACE
- QUARTERING ON TARP 10.1.2
- ~~QUARTERING SECTORING 10.1.3~~



**NOTE 2:** The dryness of a sample can be tested by squeezing tightly a portion of the material in your hand. If it crumbles easily, you've reached the correct moisture range. (SECTION 5.3.)



For COARSE & FINE aggregate WETTER than SSD, If the technician finds it advantageous to utilize METHOD A the entire sample may be dried to where it appears dry or until clumps can be broken up, using temperatures that don't exceed any specs other potential testing. (SECTION 5.3.)

**Splitting aggregate down to size is necessary in the process of construction materials testing. It enables technicians to ensure that the material is representative, the aggregate is properly distributed, and is the amount indicated in the test method. The process allows for accurate testing of gradation, moisture content, and other performance characteristics.**

**SAMPLING:**

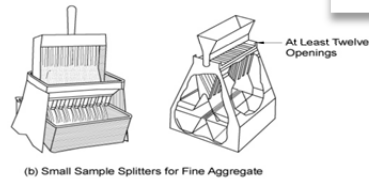
- Obtain samples of aggregate according to AASHTO R90, or as required by individual test methods. 6.1.

**EQUIPMENT:**

**METHOD A – MECHANICAL SPLITTER:**

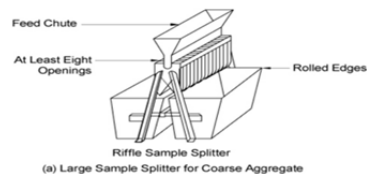
**SAMPLE SPLITTER (SEE PROCEDURE FOR ADDITIONAL DETAILS):**

- Sample splitters **MUST** have an **even number** of **equal-width chutes**. At least **8 chutes** for **coarse aggregate**, and **12 chutes** for **fine aggregate**. 7.1.



- Discharge** will be on **either side** of the splitter with **two receptacles** to catch the material. 7.1.

- If the material is **coarse or mixed aggregate** then the **minimum width** of the chutes will be **approximately 50% larger** than the **largest particle**. 7.1.



- If the material is **dry fine aggregate** which **100% entirely passes the 3/8" screen** the **minimum width** of the individual **chutes** shall be at least **50% larger** than the **largest particle** and the **maximum width** will be **3/4"**. 7.1.



- If the splitter will be equipped with **2 receptacles** to hold the **2 halves of the sample** following splitting. 7.1.

**Coarse aggregate with largest particle is 1/4", what's the minimum width of the individual chutes using the mechanical splitter?**

**ANSWER: 3/8"**

- It will also be equipped with a **hopper or straightedge pan**, which has a **width equal to or slightly less than the overall width of the assembly** of chutes, by which the sample may be fed at a controlled rate to the chutes. 7.1.



**NOTE 3:** The mechanical splitters for coarse aggregate should be used on particles 1 ½" or less. (SECTION 8.1.)

**PROCEDURE:**



**1** Place the **sample** in the **hopper or pan** and distribute sample from **edge to edge**. Introduce at a **rate** that allows **approximately equal amounts** of material to **flow freely** through the chutes.

8.1.

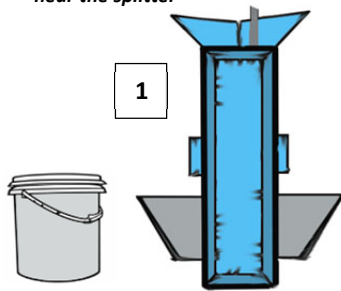
**2** Place **one portion** of the sample from one of the receptacles **back into the splitter** while placing the **other portion into a container**.

8.2.

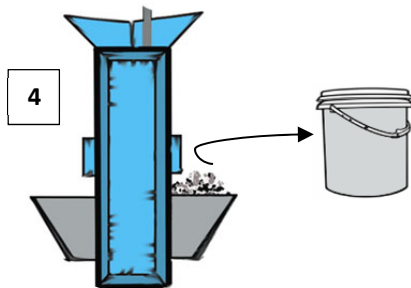
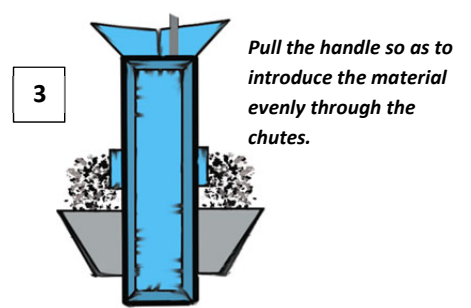
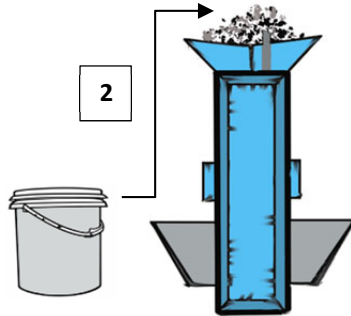
**3** Keep **splitting** until the sample is **reduced** to the size for the specific test desired.

8.2.

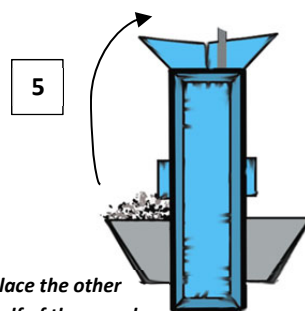
Place your bucket near the splitter



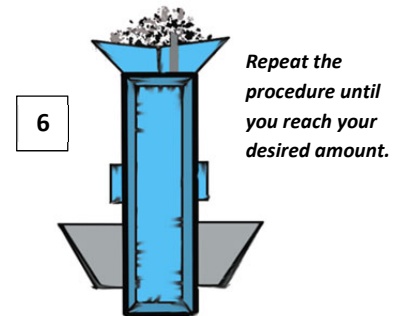
Place the contents of the bucket in the hopper distributing evenly.



Place half of the sample portion back into the bucket.



Place the other half of the sample portion back into the hopper distributed evenly.

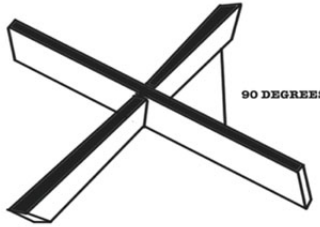


## METHOD B – QUARTERING:

### EQUIPMENT:

9.

- STRAIGHT EDGE OR SHOVEL
- SPATULAS OR TROWELS
- BROOM OR BRUSH
- STICK OR PIPE
- TEAR RESISTANT RECTANGULAR TARP- appropriate for the amount and size of the material being reduced.
- **QUARTERING TEMPLATE:** In the shape of 90° sides that exceed the diameter of the flattened cone of material. The height of the sides must be sufficient to extend above the thickness of the flattened cone of the sample. (See procedure for additional details)



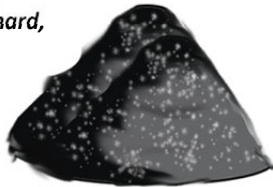
*Illustrated  
QUARTERING  
TEMPLATE (EXAMPLE  
OF DIMENSIONS)*

### PROCEDURE:

#### 10.1.1 Quartering on a Clean, Hard, Level Surface:

For quartering, use the procedure described in Section 10.1.1., 10.1.2 (refer to procedure), 10.1.3 or any combination.

Stockpile on clean, hard, level surface.



1

Place the **sample** on a **clean, hard, level surface** where there will **NOT** be loss of material or contamination by foreign material.

10.1.1.1.

2

**Turn the entire** sample over at least **three times** to **mix** the sample. On the **last turn** form the material into a **conical pile**.

10.1.1.2

Go around the perimeter turning the sample to mix and form a cone.



3

**Flatten the conical pile** to a **uniform thickness** and the **diameter** should be approximately **four to eight** times the thickness by pressing down the top with a shovel or trowel.

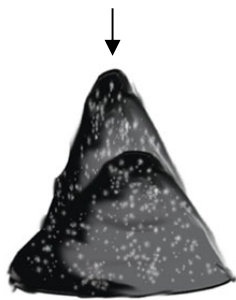
10.1.1.3

4

**Divide the flattened mass** into **approximately four equal parts**. With:

10.1.1.4

Final cone



Shovel



Trowel

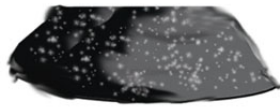


Straight edge



Quartering Template

Flatten sample.



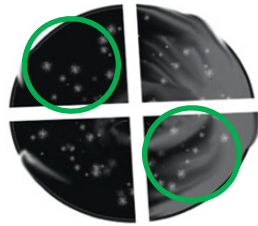
5

Remove the **two diagonally opposite** quarters (**including all the fine material using a brush**). Set aside the unused quarters for later testing. **Repeat** the above steps until the **required amount** is achieved.

10.1.1.5

10.1.1.6

Sample is obtained from the combined diagonally opposite quarters.



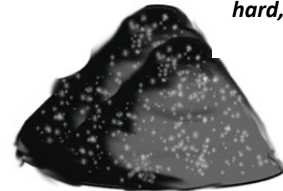
### 10.1.3 Quartering Sectoring:

1

Place the sample on a clean, hard, level surface. (Refer to section 10.1.1. in the manual for details; step is identical)

10.1.3.1

Stockpile on clean, hard, level surface.



2

Turn the **entire** sample over **three times** to mix. On the **last turn** form the material into a **conical pile**. (Refer to section 10.1.1. in the manual for details; step is identical)

10.1.3.2

Go around the perimeter turning the sample to mix and form a cone.

3

**Flatten** the conical pile. (Refer to section 10.1.1. in the manual for details; step is identical)

10.1.3.3



4

Divide the **flattened** mass into approximately **four equal parts**. (Refer to section 10.1.1. in the manual for details; step is identical)

10.1.3.4



Shove



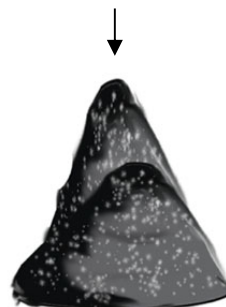
Straight edge



Trowel



Quartering Template



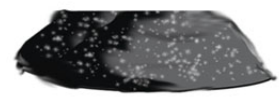
Final cone

5

Use a **straight edge** to slice through the center of one of the **quarters**. Achieve complete separation. (*Refer to section 10.1.1. in the manual for details; step is identical*)

10.1.3.5

*Flatten sample.*

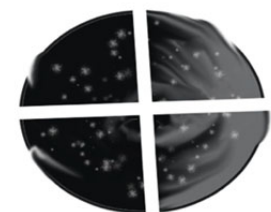


6

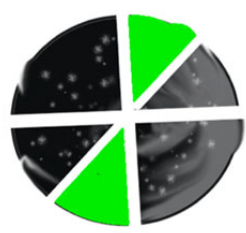
Remove approximately equal sectors from **diagonally opposite quarters** and combine. Repeat procedure until the required amount is obtained.

10.1.3.7

*Divide into quarters.*



*Divide the quarters in half and sample is obtained from the combined diagonally opposite sectors.*



**EQUIPMENT:**

**METHOD C – MINATURE STOCKPILE SAMPLING:**

- **STRAIGHT EDGE, FLAT BOTTOM SCOOP, SQUARE POINT SHOVEL, OR TROWEL** – for mixing the aggregate.
- **A SMALL SAMPLING THIEF, SMALL SCOOP, OR SPOON** – for sampling.

11.1.

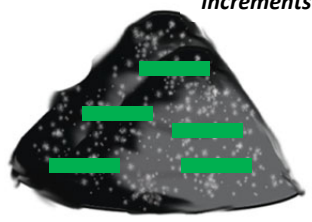
**PROCEDURE:**

1

Place the original **damp fine aggregate** sample on a **clean, hard, level surface** where there will **NOT** be loss of material or contamination from foreign material.

12.1.

*5 Random increments*



2

Turn the **entire sample** over **three times** to mix. On the **last turn** form the material into a **conical pile**. Ensure that the material is **thoroughly mixed**.

12.2.

12.3

3

**Obtain** a sample for each test by selecting at least **5 increments from random locations**. Using any of the sampling equipment described in 11.1.

12.3

**SECTIONS NOT COVERED:**



***Please refer to the standard for any material not covered. Not all methods are covered:***

- ***QUARTERING ON A TARP (SEC:10.1.2)***

# AASHTO R66: SAMPLING ASPHALT MATERIALS

## DEFINITIONS:

**Asphalt Binder** - is a black viscous material created from petroleum refining. Acts as the glue that holds together the aggregates in asphaltic concrete.

**Emulsions** - are a liquid mixture of asphalt, water, and an emulsifying agent that is used in road construction and maintenance.

**Asphalt Cement Grades** - types of asphalt binder that vary in consistency and flow resistance.



## **SIZE OF CONTAINER:**

- Size of container must accommodate the required amount of the sample.

5.2.1

## **PROTECTION & PRESERVATION:**

- All sample **containers** will be **new** and the **top will fit** together with the container **tightly**.
- To **prevent contamination**, tightly seal the container immediately after filling.
- **Protect** emulsified asphalt samples from **freezing**.

6.1.

6.2.

6.4

## **SCOPE:**

This method covers sampling of asphalt materials at production facilities, storage facilities, transport units, or at the point of delivery.

1.1

## **SIZE OF SAMPLES:**

## **MINIMUM SAMPLE SIZE:**

- 1 Quart of Asphalt Binder
- 1 Quart of Emulsified Asphalt

4.1.1

4.1.2

## **CONTAINERS:**

## **TYPE OF CONTAINERS:**

For Liquid Asphalt (not emulsions):

- Double-seal friction-top can.
- Square Cans with screw tops.
- Small mouth cans with screw caps.



D.F.T.C. =

Double-seal

Friction

Top

Can

5.1.1

For Emulsions:

- Plastic wide-mouth jars.
- Bottles with screw caps.

5.1.2



**IF A CONTAINER NEEDS CLEANING CAN THE TECHNICIAN USE SOLVENT?**

**ANSWER:** No solvent can be used on any sampling container. If the container needs cleaning only a clean dry cloth. (**SECTION 6.3.**)

- **DO NOT** sample emulsified asphalt under pressure.

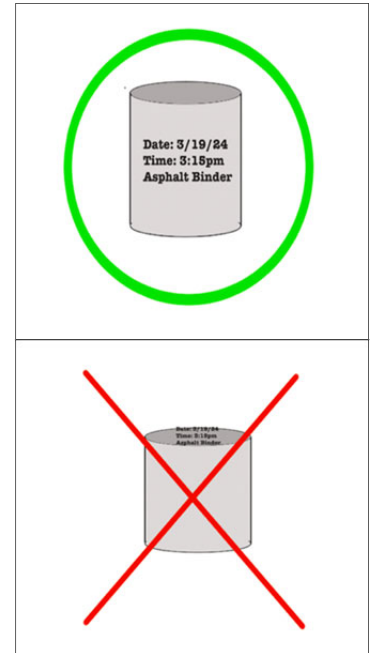
6.4



**NOTE 1:** Pressure may allow trapped air, which could lead to inaccurate test results. Bubbles in the material are an indication of trapped air. (SECTION 6.4.)



**NOTE 2:** The sampling container should be completely filled to minimize skin formation at the air- emulsion boundary. Alternately one can fill the container until a small amount of space remains. Squeeze the container to cause the contents to fill to the top. Position the cap on the container and securely tighten it. The space remaining will aid in mixing the sample prior to testing. (SECTION 6.4.)



- Transferring samples from one container to another shall be avoided.

6.5.

- Properly identify the sample containers with a suitable marker after filling, sealing, and cleaning. Write on the body of the container itself.

6.6.

- Do not write on the lid.

6.6.



If labels / tags are used, they have to be securely fastened to the side of the container and clearly marked. All Identification materials must maintain integrity at temperatures up to 392 degrees Fahrenheit. (SECTION 6.6.)



### PROCEDURE:

The following methods within the procedure are applicable to both emulsions and binder unless stated otherwise.

Sampling emulsions at various points in the production or delivery process (e.g., from the tank, transport units, or the distributor truck), allows you to verify that the emulsion is consistent and homogeneous, and adheres to all applicable specs and provisions.

Sampling asphalt binder is important in understanding how the asphalt mix performs in terms of durability, flexibility, and resistance to wear. It allows for the verification of binder quality, consistency, and compliance with the specifications and standards for the project.

**SAMPLING AT PLACE OF MANUFACTURE**

**BULK STORAGE TANKS NOT EQUIPPED WITH MECHANICAL AGITATORS  
(LIQUID ASPHALT MATERIALS OR MATERIALS LIQUIFIED BY HEATING):**

Obtain sample using one of the following methods

**TANK TAP METHOD:**

- 1** Use the **valves** or taps at the **top, middle, and lower** locations of the tank to obtain sample **after clearing** out the line. 7.1.1.
  
- 2** If there is only **one valve** available at the **bottom** then draw off your **entire sample** **after clearing out the line** from that valve. 7.1.1



**CLEARING OUT THE LINE:**  
*When sampling it's mandatory to clear out the line by drawing and discarding a minimum of 1 Gallon of the material. (SECTION 7.1.1.)*

**THIEF SAMPLER METHOD (NOR SUITABLE FOR ASPHALT BINDER):**

- 1** Samples will be obtained at the **top, middle, and lower levels** of the tank by lowering a **thief sampler** into the material. *(See procedure for additional details)* 7.1.2.



**BULK STORAGE TANKS EQUIPPED WITH MECHANICAL AGITATORS (LIQUID ASPHALT MATERIALS OR MATERIALS LIQUEFIED BY HEATING):**

- 1** A **single sample** is taken by the same method as section **7.1.1 & 7.1.2.** 7.2.

**SAMPLING FROM TANK CARS, VEHICLE TANKS, OR DISTRIBUTOR TRUCKS:**



**WHERE IS THE VALVE (GENERALLY) LOCATED?**

**ANSWER:** *Near the pump within the recirculation line.*

- 1** Vehicle will be equipped with **sampling valve.** 8.1.

**ASPHALT DISTRIBUTOR TRAILER**

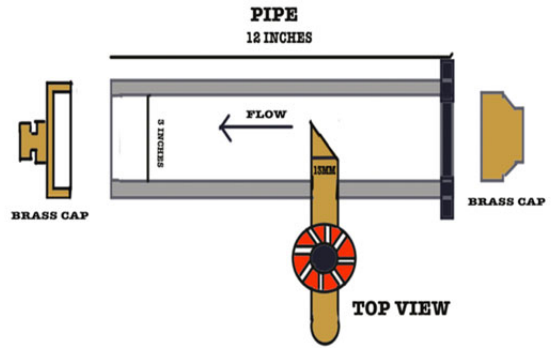


**Some alternatives to obtaining representative samples (if allowed by the purchaser):**

- **DIP METHOD**- taking a clean wide-mouth plastic jar or friction-top can in a suitable holder. A clean container must be used to take each sample, and the material sampled will then be transferred to another new and clean container for retaining or testing the sample. 8.2.1
- **DETACHABLE OR PERMANENT PIPE FITTING**- Similar design as the illustrated image. This will be inserted into the discharge line that is located between the unloading pipe and hose as close to the end as possible. Take the sample after 1/3 and not more than 2/3 of the load has been removed. Remember to draw and discard 1 gallon before taking the sample. 8.2.2.
- **NOZZLE ON SPRAY BAR**- if the distributor is not equipped with a sampling valve, sample from flushed spray bar nozzle. 8.2.3

**2** The **valve** will be installed at least **1 ft from the shell** and have a **sampling valve label**. 8.1.

**3** **Before** the sample is taken a **minimum of 1 gallon** will be **drawn** from the sample valve and **discarded**. 8.1



**SAMPLING FROM PIPELINES DURING ASPHALT BINDER PRODUCTION (HMA HOT PLANT):**

- 1** Obtain the sample from the **line feeding** the mixing plant while the plant is **in operation**. 11.1.
- 2** The sampling valve will be located **downstream** of the mixing and blending process takes place. 11.1.
- 3** The **diameter** of the sampling pipe will not be more than **1/8<sup>th</sup> of the diameter** of the **pipe line** and its opening should be turned to face the flow of the liquid. The pipe will be provided with a valve or plug cock and shall discharge into a sample receiver. 11.1.
- 4** Before the sample is taken a minimum of **1 gallon** will be **drawn** from the sample valve and **discarded**. 11.1.

**SAMPLING AT POINT OF SHIPMENT DELIVERY:**

- 1** **Sampling** must be performed as **soon as possible** after the asphalt material **arrived** at the **plant site, storage site, or job site** or at the time of unloading. 14.1.



The required number of samples shall be taken from each delivery of asphalt material or follow your agencies rules for the required number of samples to be taken. For small delivery units take samples necessary to represent a maximum of 10,000 gallons. **(SECTION 14.2.)**

Follow the method for sampling from **Section 7:**

14.3.1



Sampling at point of shipment delivery is generally done on emulsions not binder.

OR

2

**Bleeding through a sample valve or tap in the transfer line** during the unloading of the **middle third** of the load. Remember to **draw and discard minimum 1 gallon** before taking sample.

14.3.2.



Tests for acceptability will be performed on one of the samples taken. Retain the other samples for retesting if the first fails. **(SECTION 14.4.)**

#### SECTIONS NOT COVERED:



Please refer to the standard for any material not covered. Not all methods are covered:

- **SAMPLING FROM TANKERS & BARGES (SEC:9.1.1.)**
- **SAMPLING FROM PIPELINES DURING LOADING & UNLOADING (SEC:10.1.)**
- **SAMPLING FROM DRUMS & BARRELS: (SEC:12.1)**
- **SAMPLING SEMISOLID MATERIALS (SEC:13.1)**

# AASHTO R67:

## SAMPLING ASPHALT MIXTURES AFTER COMPACTION (CORES)

### DEFINITIONS:

**Cores** - is a reliable method for the extraction of representative samples from completed asphalt or concrete installations.

**Lift** - is a layer of asphalt pavement that is applied to a base or previous layer.



**Coring asphalt is a common practice in the construction of roads and pavements. The process involves extracting a cylindrical sample (core) from an asphalt pavement using a core drill. This sample is then analyzed to assess the properties and condition of the pavement.**

### SCOPE:

This standard covers the process for removal of core samples for laboratory testing. Core diameter range may be from 2 inches to 12 inches.

1.1.

4.

### EQUIPMENT:

- **CORE DRILLING MACHINE-** Must be **power driven** and capable of obtaining a **core to the full depth** of the **asphalt mixture**. Have a rigid frame or platform so that the core barrel can be **maintained perpendicular to the surface during the drilling process**. The core drilling machine must be of sufficient horsepower and have the ability to reach a sufficient depth to **minimize distortion** of the compacted cores. *(See procedure for additional details)*
- **CORE DRILL BIT** – The **cutting edge** of the **core drill bit** must be made of **hardened steel or other suitable material with diamond chips** embedded in the metal **or see manufacturer’s recommendation**. *(See procedure for additional details)*
- **SEPARATION EQUIPMENT** – A **saw or other method** that provides a clean, layer to be tested without damage. *(See procedure for additional details)*
- **RETRIEVAL DEVICE-** A device that will **remove the core without affecting the integrity of the sample**.
- **COOLING AGENT** – Water, Ice, Dry Ice, or liquid nitrogen.
- **SAMPLE MARKING TOOL-** *(See procedure for additional details)*
- **PACKAGE CONTAINERS-** Suitable packaging containers for **securing and transporting the core samples**.

### PROCEDURE:

- 1 Provide a means such as water or air to aid in the removal of cuttings and to minimize the generation of heat caused by friction.
- 2 Position the core drilling machine over the desired sampling location. Begin the machine (along with the water or air) and advance slowly until it meets the asphalt surface.
- 3 Keep the core bit perpendicular to the surface while applying constant pressure downward.

5.2.

5.3.

**!** Allow compacted asphalt mixtures to cool sufficiently prior to coring to avoid damage. To accelerate the process the area may be cooled with water, ice, dry ice, or liquid nitrogen. **(SECTION 5.1.)**

5.4.

4

Continue **drilling to the bottom or slightly below** the asphalt mixture intended to be sampled to **allow full separation** of the core sample at the desired depth from the underlying pavement.

5.5.

5

After drilling, **separate the core sample from the underlying layers** using the **retrieval device** **without damaging or distorting the sample**. **Brush off** or use **water** to **wash off** any loose particles on the sample.

5.6.

6

Clearly **label** the core with the marking tool.

5.7.

7

**Fill the resulting hole** with **asphalt mixture**, non-shrink grout, or other suitable material. Compact the material in multiple lifts if necessary. **Make sure the final surface is level** with the surrounding surface.

5.8.

EXAMPLE OF CORING MACHINE:



Open-Head



Closed-Head



EXAMPLE OF CORE BITS:



**WHAT HAPPENS IF CONSTANT PRESSURE IS NOT APPLIED OR TOO MUCH PRESSURE IS APPLIED?**

*If constant pressure is not applied or too much pressure is applied then this may cause the core drill to bind or distort the core. (SECTION 5.4.)*



**NOTE 4:** *If the core is damaged to a point that it cannot be used, a new core shall be obtained within 6 inches. (SECTION 5.8.)*

**PACKAGING & TRANSPORT:**

- Place **cores** in suitable **protective containers**. If **multiple cores** must be **placed** in the same **container**, then **separate from one another** using **suitable separation material**. 6.1.
- Transport** samples in a way that **prevents** damage from **jarring, rolling, or impact with any object**. 6.2.
- Prevent** cores from **freezing** or from **excessive heat**. 6.3.
- If the core is **damaged significantly** during transport, then the core **cannot be used for testing**. 6.4.



**NOTE 6:** *In extreme ambient temperature conditions, an insulated container should be used during transport. (SECTION 6.3.)*

**LAYER SEPARATION:**

- Using appropriate separation equipment, separate two or more pavement courses, lifts, or layer along the designated lift line.

7.1.



**NOTE 7:** Lift lines are often more visible by rolling a wetted core on a flat surface. **(SECTION 7.1.)**

**REPORT**

**IDENTIFICATION & SHIPPING**

Date  
Paving Date  
Coring Location  
Lift / Layer  
Average Thickness (if required)

8.1

**IDENTIFICATION & SHIPPING**  
**(CONTINUED)**

**IF KNOWN:**  
Nominal Maximum Aggregate Size  
Asphalt Mixture Design Info  
Grade of Binder

- Please refer to approved agency or companies' internal procedures and forms. This EXAMPLE does not necessarily demonstrate all that may be required.

# AASHTO R47:

## REDUCING SAMPLES OF ASPHALT MIXTURES TO TESTING SIZE

### DEFINITIONS:

**Asphalt Mixture** – is a composite of asphalt (binder), aggregates, and other components used to pave roads and parking lots.

**Mastic** – a mixture of asphalt binder and fine mineral material.

**Asphalt Mixture Reduction** – is the process of dividing a large field sample of hot mix asphalt (HMA) into smaller, representative portions for laboratory testing.



**Specification for asphalt mixtures require sampling portions of the material for testing. Generally larger samples will tend to be more representative of the total supply. This method provides procedures for reducing the large sample obtained in the field or produced in the laboratory to a convenient size in a way that will most likely represent the larger sample as well as the total supply. This smaller portion makes the testing process easier to conduct.**

### SCOPE:

This standard practice outlines methods for the reduction of large samples of asphalt mixture to the appropriate size for testing, employing techniques that are intended to minimize variations in the measured characteristics between the test samples so selected and the large sample.

1.1

### SELECTION OF METHOD:

- **The selection of a method to reduce a sample to test size depends on the amount of material.** It is recommended that for a large amount of material, a mechanical splitter be used when possible.
- **A mechanical splitter lessens the time needed for reduction and minimizes the loss of temperature.** To further reduce the sample size, a quartering or incremental method can be used.

5.1

5.1

### SAMPLING:

- **Obtain samples of asphalt mixture according to AASHTO R97 or as required by individual test methods.**
- When additional tests are needed, make sure that the **initial size of the field sample is adequate to accomplish all intended tests.** The sampling methods & concepts outlined above similarly goes for asphalt mixtures produced in the laboratory.

6.1

6.1



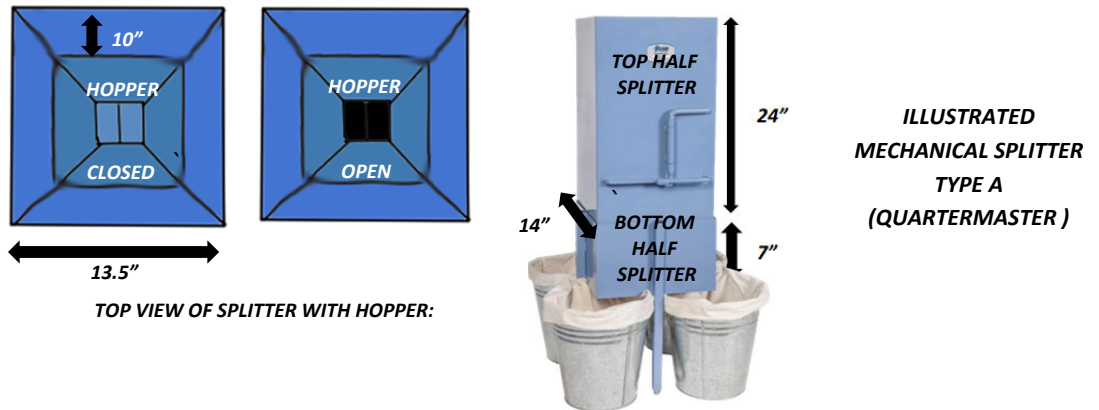
## MECHANICAL SPLITTER METHOD:

METHODS:

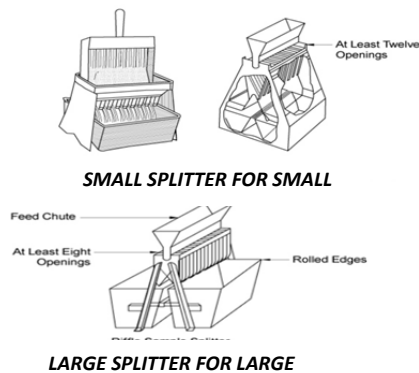
EQUIPMENT:

7.

- MECHANICAL SPLITTER TYPE A (QUARTERMASTER)** – a mechanical splitter with 4 equal-width chutes that discharge the material into 4 appropriately sized containers, designed with a receiving hopper to hold the asphalt mixture field sample until a handle releases the material to fall through a divider and distribute it into 4 equal portions without restriction or the loss of material (REFER TO PROCEDURE FOR MORE DETAIL)



- MECHANICAL SPLITTER TYPE B** – a mechanical splitter with an even number of equal-width chutes (*no fewer than a total of eight for a large splitter and no fewer than twelve for a small splitter*), which discharge alternately to each side of the splitter. The minimum width of the individual chutes shall be approximately 50 % larger than the largest particle to be split. The splitter shall be equipped with 2 receptacles to catch the 2 halves of the sample following splitting. It shall also be equipped with a hopper or straight-edged pan that has a width equal to or slightly less than the overall width of the assembly of chutes, by which the sample may be fed at a controlled rate to the chutes. The splitter and accessory equipment shall be so designed that the sample will flow smoothly and freely without restriction or the loss of material.

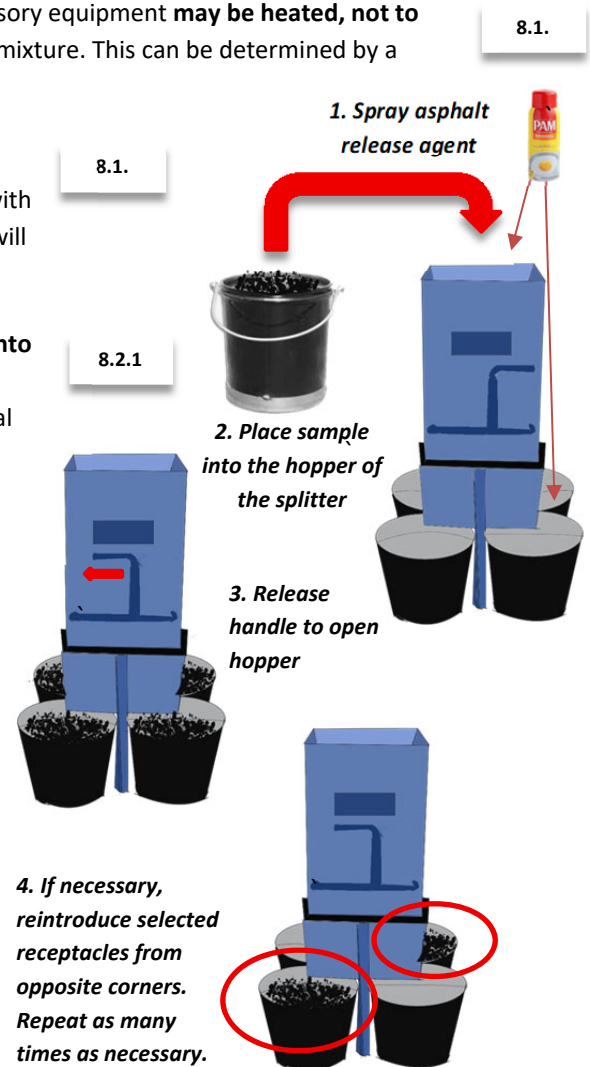


- NON-CONTACT TEMPERATURE DEVICE (OPTIONAL)**- a non-contact temperature device suitable for determining the temperature of a heated splitter and meeting the requirements of AASHTO M339. (REFER TO PROCEDURE FOR MORE DETAIL)
- RELEASE AGENT** – nonstick spray. Shall not contain any solvents or petroleum-based products that could affect asphalt binder properties.

**PROCEDURE:**

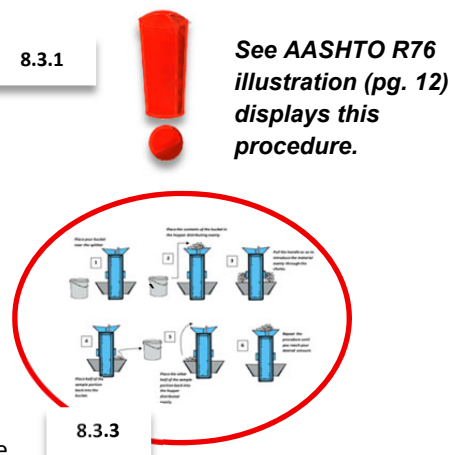
**MECHANICAL SPLITTER TYPE A:**

- 1 Place the splitter on a **level surface**. The splitter and accessory equipment **may be heated, not to exceed the maximum mixing temperature** of the asphalt mixture. This can be determined by a noncontact temperature device.
- 2 The **mechanical splitter (only surfaces that will come in contact with the asphalt mixture)** may be **lightly coated** with an approved **asphalt release agent (nonstick spray)**. This will prevent a buildup and loss of asphalt binder and fines.
- 3 **Place** the field (or laboratory prepared) **asphalt mixture into** the mechanical **splitter hopper**, and situate **four sample receptacles** to receive the **reduced portions** of the original sample. Make sure that the hopper is closed before introducing the sample.
- 4 **Fill the hopper** in a way that **avoids segregation** of the asphalt mixture, typically using a continuous or segmented pour from multiple directions around the hopper.
- 5 **Release the handle** to drop the asphalt mixture through the dividers into the sample receptacles.
- 6 **Reintroduce** selected receptacles from **opposite corners** into the splitter hopper as **many times as necessary** to further reduce the asphalt mixture sample to the required size specified.



**MECHANICAL SPLITTER TYPE B:**

- 1 Place the field (or laboratory prepared) asphalt mixture **into the sample splitter pan or hopper** and **uniformly distribute** it from edge to edge so that when it is introduced into the chutes, **approximately equal amounts will flow through each chute**.
- 2 **Release the handle** at a rate that allows the asphalt mixture to **flow freely through the chutes** into the receptacles. The entire sample may be mixed by repeated use of the mechanical splitter.
- 3 **Reintroduce the portion** of the sample from **one of the selected receptacles** into the splitter as **many times as necessary** to reduce the sample to the required size.



**QUARTERING METHOD:**

9.

**EQUIPMENT:**

- **QUARTERING TEMPLATE** – a quartering template manufactured from a suitable metal that **withstands heat and use without deforming formed in the shape of a 90-degree cross with equal length sides** that **exceed the diameter** of the **flattened** cone of material sufficient to allow complete separation of the quartered sample. The **height of the sides must be sufficient to extend above the thickness of the flattened cone** of the asphalt mixture sample to be quartered.
- **FLAT BOTTOM SCOOP** – a **large, straight edged, flat bottom scoop** should be used to sample the asphalt mixture. **A square shovel or trowel** will meet this requirement.
- **STRAIGHT EDGE** – **large spatula, trowel, or metal straightedge.**
- **NONSTICK PAPER**
- **RELEASE AGENT** – nonstick spray. **Shall not contain any solvents or petroleum-based products** that could affect asphalt binder properties.

**PROCEDURE:**

1

Place the **original sample on a hard, nonstick, clean, level surface** where there will be **neither a loss of material nor the accidental addition of foreign material.**

10.1

2

Make sure the **surface is nonstick** by **applying** an approved asphalt **release agent** or **nonstick paper.**

10.1

3

The **template and other tools** may be **heated, not to exceed the MAXIMUM mixing** temperature of the asphalt mixture.

10.1

4

Mix the material thoroughly by **turning the entire sample** over a **minimum of four** times with a flat-bottom scoop or by **alternately lifting each corner** of the paper and **pulling it over the sample diagonally toward the opposite corner**, causing the material to be rolled.

10.2

5

Create a **conical pile** by either depositing each scoop or shovelful of the last turning on top of the preceding one, or lifting both opposite corners.

10.2

6

Carefully **flatten the conical pile** to a **uniform thickness with a diameter four to eight times the thickness** by pressing down the top with a shovel or large, flat-bottomed, square scoop. Make a visual observation to ensure that the material is homogeneous if not then remix.

10.3

7

**Divide into four quarters** by inserting the quartering template and pressing down until the template is in complete contact with the work surface.

10.4



*Straightedges may be used in lieu of the quartering device to completely separate the material into approximately equal quarters. (SECTION 10.4)*

**REDUCE THE SAMPLE USING ONE OF THE FOLLOWING PROCEDURES:**

**QUARTERING:**

- Remove two diagonally opposite quarters, including all fine mastic material.

10.5.1.1.

- If used, remove the quartering template.

10.5.1.2.

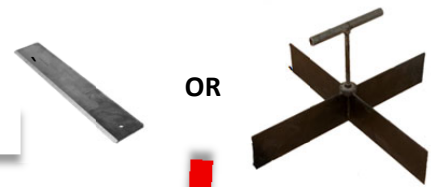
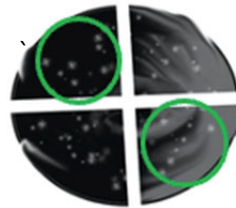
- If necessary, repeat mixing, flattening, and dividing the sample until the required sample size is obtained.

10.5.1.3.



The final test sample consists of two diagonally opposite quarters. (SECTION 10.5.1.3.)

Sample from diagonally opposite quarters.



OR

Divide into quarters.

**SECTORING:**

- Using a straightedge, obtain a sector by slicing through the center of one of the resulting quarters of the asphalt mixture. The slice must extend from the center point to the outer edge of the quarter.

10.5.2.1.

- Pull or drag the sector from the quarter holding one edge of the straightedge in contact with the quartering device.

10.5.2.2.



Two straightedges may be used in lieu of the quartering device. (SECTION 10.5.2.2.)

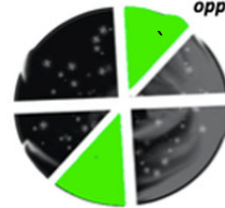
- Remove an approximately equal sector from the opposite quarter.

10.5.2.3.

- If necessary, repeat Sections 10.5.2.1 through 10.5.2.3 until the required sample size is obtained.

10.5.2.3.

Divide the quarters in half and sample from opposite corners.



## INCREMENTAL METHOD:

- **FLAT BOTTOM SCOOP** – a large, straight edged, flat bottom scoop should be used to sample the asphalt mixture. A square shovel or trowel will meet this requirement.
- **SPATULAS, TROWELS, METAL STRAIGHTEDGE, OR 12 INCH DRYWALL TAPING KNIFE**
- **NONSTICK HEAVY PAPER**
- **MISCELLANEOUS EQUIPMENT** – including hot plate; non asbestos, heat-resistant gloves or mittens; pans; buckets; and cans.

**EQUIPMENT:**

11.

### PROCEDURE:

1 Cover a hard, nonstick, clean, level surface with a non-stick heavy paper.

12.1

2 Tools may be heated, not to exceed the **MAXIMUM** mixing temperature of the asphalt mixture.

12.1

3 Place the **original sample** on the **covered surface**. Do not lose any material or introduce any foreign material.

12.2

4 Mix the material thoroughly by:

12.3

turning the entire sample over a **minimum of four** times with a **flat bottom scoop**

**OR**

by **alternately lifting each corner** of the paper and **pulling it over** the sample **diagonally toward the opposite corner**, causing the material to be rolled. The entire sample has been **turned over ONCE** after **all 4 corners have been pulled over**. Repeat this process for a total of 4 times.

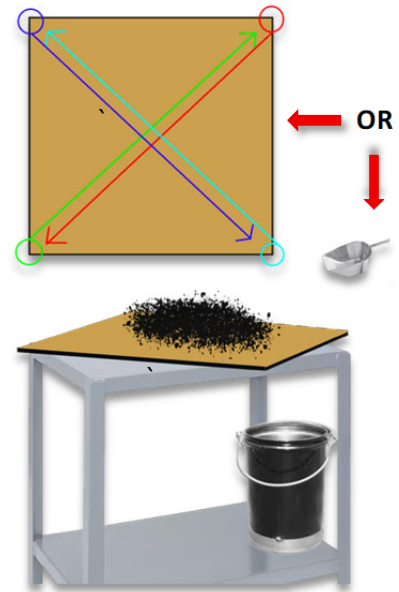
5 Create a **conical pile** by either **depositing each scoop or shovelful of the last turning on top** of the preceding one or **lifting both opposite corners**. Ensure that the material is homogeneous.

12.4

6 Grasp the paper; **roll the material into a cylindrical roll (loaf shape)**.

12.5

**MIX MATERIAL A MINIMUM OF 4 TIMES: WITH A FLAT BOTTOM SCOOP OR BY PULLING EACH CORNER DIAGONALLY TOWARD THE OPPOSITE CORNER**



**DURING THE LAST STEP OF MIXING ENSURE THE FINAL TURN OR SCOOP RESULTS IN A CONICAL PILE**



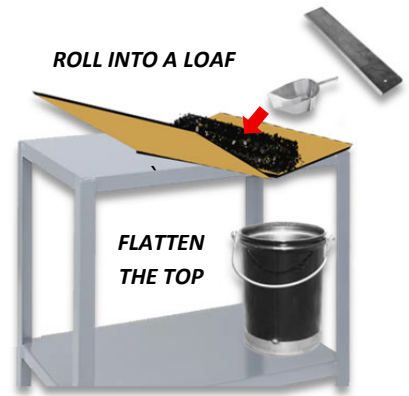
7

Flatten the top.

12.6



Alternately, use a straightedge to slice off approximately one fourth of the length of the loaf and place the material in a sample pan or container. (SECTION 12.8.)

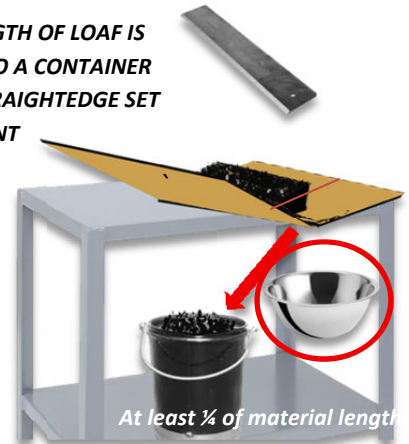


8

Pull the paper so that at least one-fourth of the length of the loaf is off the edge of the counter.

12.7

PULL THE PAPER SO AT LEAST ¼ OF THE LENGTH OF LOAF IS OFF THE COUNTER AND CAN BE DROPPED INTO A CONTAINER OR SLICE THE SAME AMOUNT OFF WITH A STRAIGHTEDGE SET ASIDE OR DISCARD THIS AMOUNT



9

Allow this material to drop into a container.

12.8



Alternately, use a straightedge to slice off an appropriate size sample from the length of the loaf and place in a sample pan or container. (SECTION 12.10.)

10

Set the material obtained aside.

12.9

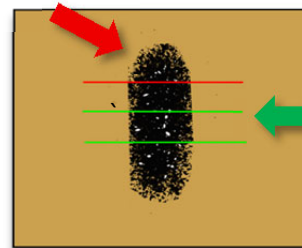
DISCARD OR SET ASIDE

REPEAT REMOVING MATERIAL INCREMENTALLY. TAKING ¼ AT A TIME UNTIL YOU OBTAIN A CORRECT TEST SAMPLE AMOUNT

11

Pull additional material off the edge of the counter and drop the appropriate-size sample into a sample pan or container.

12.10



SAMPLE

12

Repeat pulling additional material (or slicing off additional material) (Section 12.10) until the required-size sample has been obtained (NOTE 3). Repeat sections 12.7 through 12.10 until all the samples for testing have been obtained. At any time while obtaining test samples, it may be necessary to remix the material and repeat the process.

12.11



**NOTE 3:** 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. (SECTION 12.11.)

ANSWERS:

1. c
2. b
3. b
4. c
5. a
6. a
7. c



**PRACTICE QUESTIONS:**

1. When sampling aggregate roadway in place you obtain your sample **after** \_\_\_\_\_ and **before** \_\_\_\_\_ (according to AASHTO R90)?
  - a. Compacting, spreading
  - b. Spreading, icing
  - c. Spreading, compacting
2. When reducing according to **METHOD C**, turn the entire sample over \_\_\_\_\_ **times** to mix (according to AASHTO R76)?
  - a. 2
  - b. 3
  - c. 1
3. When performing the **mechanical splitting method** while splitting with a **splitter type A (quartermaster)** one must obtain test samples from buckets adjacent to each other (according to AASHTO R47)?
  - a. TRUE
  - b. FALSE
4. When coring, provide a means such as \_\_\_\_\_ or \_\_\_\_\_ to aid in the removal of cuttings and to minimize the generation of heat (according to AASHTO 67)?
  - a. Nothing is needed
  - b. Grease, non-stick spray
  - c. Water, air
5. What method is used to reduce **fine aggregate (Dry)** (according to AASHTO R76)?
  - a. METHOD A – Mechanical Splitter
  - b. METHOD B – Quartering
  - c. METHOD C – Miniature Stockpile
  - d. ALL OF THE ABOVE
6. **DO NOT** sample **emulsified asphalt under pressure** (AASHTO R66)?
  - a. TRUE
  - b. FALSE
7. When sampling with a plate **lay down** the **plate** \_\_\_\_\_ with the plate \_\_\_\_\_ the paver (AASHTO R97)?
  - a. In hopper, in front
  - b. In hopper, behind
  - c. Diagonally, in front
  - d. Diagonally, behind

## **BURN / SIEVING/MOISTURE/ MARSHALL / GYRATORY/ RICE**

Volumetric testing in asphalt refers to the group of methods used to measure the volume-related properties of a compacted hot-mix asphalt (HMA), such as air voids, voids in mineral aggregate (VMA), and voids filled with asphalt (VFA), the percent of asphalt binder in a mix, and the mixtures density. These factors are critical in ensuring the structural integrity and long-term performance of pavements. Several tests are essential in this process and discussed in this section they are the: Ignition Burn, Gradation (Moisture Content), Marshall, Gyratory, and Rice.



*The procedures for burn, moisture content assessment, sieving and the Marshall, Gyratory and Rice methods utilized for HMA testing that will be covered during ATTI ASPHALT:*

Learning objectives for these sections are:

- 🔗 *How to perform an ignition burn and calculate the asphalt binder content of an asphalt mixture sample as well as associated correction factors. Also demonstrated is how to determine the moisture content of a sample.*
- 🔗 *How to determine the particle distribution of the asphalt mixture sample after the burn has been accomplished.*
- 🔗 *How to perform the Marshall, Gyratory, and Rice procedures and how to calculate their respective specific gravities.*

- **AASHTO T308:** DETERMINING THE ASPHALT CONTENT OF HMA BY THE IGNITION METHOD
- **AASHTO T30:** MECHANICAL ANALYSIS OF EXTRACTED AGGREGATE
- **AASHTO T329:** MOISTURE CONTENT OF HOT-MIX ASPHALT (HMA) BY OVEN METHOD
- **AASHTO R68:** STANDARD PRACTICE FOR PREPARATION OF ASPHALT MIXTURES BY MEANS OF THE MARSHALL APPARATUS
- **AASHTO T312:** PREPARING HMA SPECIMENS BY MEANS OF THE SUPERPAVE GYRATORY COMPACTOR
- **AASHTO T209:** MAXIMUM SPECIFIC GRAVITY OF HMA (RICE)



PLEASE REFER TO THE PROCEDURE FOR MORE DETAIL. NOT ALL SECTIONS WILL BE COVERED BY ATTI. SECTION NUMBERS WILL BE PROVIDED FOR REFERENCE. SUBJECT TO CHANGE.



# AASHTO T308:

## DETERMINING THE ASPHALT BINDER CONTENT OF ASPHALT MIXTURES BY THE IGNITION METHOD

### DEFINITIONS:

**Asphalt Binder Content** - refers to the **percentage of asphalt binder** (also called **bitumen**) in a hot mix asphalt (HMA) mixture

**Asphalt Binder** - (also known simply as bitumen) is the black, sticky, and highly viscous material used in road construction to bind together the aggregate particles (rocks, sand, etc.) in asphalt pavement.

### SCOPE:

1.1.

This test method covers the determination of asphalt binder content of asphalt 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. The aggregate remaining after burning can be used for sieve analysis using T30.

### EQUIPMENT:

5.

### EQUIPMENT (CONTINUED):

5.



- **SAFETY EQUIP** – safety glasses or face shield, dust mask, high-temperature gloves, long sleeved jacket, a heat-resistant surface capable of withstanding 1202 °F (650 °C), and a protective cage capable of surrounding the specimen baskets during the cooling period.
- **MISCELLANEOUS EQUIP** – a pan larger than the specimen basket(s) for transferring the specimen after ignition, spatulas, bowls, and wire brushes.
- **THERMOMETER (IGNITION OVEN VERIFICATION)**- with a temperature range of at least 986°F and 1013 °F (530 °C and 545 °C) and an accuracy of  $\pm 2.25$  °F ( $\pm 1.25$  °C). See procedure for additional details.
- **THERMOMETER (OVEN VERIFICATION)**- with a temperature range of at least 194°F and 266 °F (90 °C and 130 °C) and an accuracy of  $\pm 2.25$  °F ( $\pm 1.25$  °C). See procedure for additional details.
- **IGNITION FURNACE** – a forced-air ignition furnace that heats the specimens by either the convection or direct IR irradiation method. The convection type furnace must be capable of maintaining a temperature of  $1000 \pm 9$  ° F ( $538 \pm 5$  ° C). The furnace chamber dimensions shall be adequate to accommodate a specimen size of 3500 grams.
  1. **5.1.1:** For Method A, the furnace shall also have an internal balance thermally isolated from the furnace chamber and accurate to 0.1 grams. The balance shall be capable of weighing a 3500-gram specimen in addition to the specimen baskets. The furnace shall provide 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.

See procedure for all ignition furnace requirements.
- **SPECIMEN BASKET ASSEMBLY** - consisting of specimen basket(s), catch pan, and an assembly guard to secure the specimen basket(s) to the catch pan.
- **SPECIMEN BASKET**- of appropriate size to allow the specimens to be thinly spread and allow air to flow through and around the specimen particles. Sets with two or more baskets shall be nested. The specimen shall be completely enclosed with screen mesh, perforated stainless steel plate, or other suitable material. See procedure for all specimen basket requirements.
- **CATCH PAN** – of adequate size to hold the specimen basket(s) so that aggregate particles and melting asphalt binder falling through the screen are caught.
- **OVEN**- capable of maintaining a temperature of  $230 \pm 9$  °F ( $110 \pm 5$ °C). The oven(s) for heating shall be capable of operation at the temperatures required, between 212°F and 248 °F (100 °C and 120 °C), within  $\pm 9$  °F ( $\pm 5$  °C) as corrected, if necessary, by standardization.
- **BALANCE**- of adequate capacity and conforming to the requirements of M231, Class G2- to the nearest 0.1 grams.

**This method can be used for quantitative determinations of asphalt binder content and gradation in asphalt mixture and pavement specimens for quality control, specification acceptance, and mixture evaluation studies. This method does not require the use of solvents. Aggregate obtained by this test method may be used for gradation analysis according to AASHTO T30.**

**SAMPLING:**

- Obtain samples of freshly produced asphalt mixture according to AASHTO R97. 6.1
- To achieve the proper test sample size required for this procedure, reduce the larger asphalt sample obtained according to AASHTO R47. 6.2
- If the mixture is not soft enough to separate with a spatula or trowel, place it in a large, flat pan in an oven at  $230 \pm 9^\circ\text{F}$  ( $110 \pm 5^\circ\text{C}$ ) until it is workable. 6.3
- The size of the test sample is dictated by the nominal maximum aggregate size of the asphalt mixture and will conform to the mass requirement shown in Table 1. 6.4



*Do not leave the specimen in the oven for an extended period of time. Excessive heating may cause detrimental effects such as asphalt drain down or oxidation. (Section 6.3.)*

- When the mass of the sample is too large for the equipment used, the specimen may be divided into suitable increments, tested, and the results appropriately combined for calculation of the asphalt binder content (using a weighted average). Specimen sizes shall not be more than 500 grams greater than the minimum recommended specimen mass. 6.4

**Table 1—Mass Requirements**

Nominal-Maximum Aggregate Size, <sup>a</sup> mm	Sieve Size	Minimum Mass of Specimen, g
4.75	No. 4	1200
9.5	$\frac{3}{8}$ in.	1200
12.5	$\frac{1}{2}$ in.	1500
19.0	$\frac{3}{4}$ in.	2000
25.0	1 in.	3000
37.5	$1\frac{1}{2}$ in.	4000

<sup>a</sup> Nominal-maximum aggregate size—one size larger than the first sieve to retain more than 10 percent.



**NOTE 4:** Large specimens of fine mixes tend to result in incomplete ignition of asphalt binder. (SEC 6.4)

**METHOD A – INTERNAL BALANCE**

**TEST PROCEDURES:**

- 1 For the convection-type furnace, preheat the ignition furnace to  $1000 \pm 9^\circ\text{F}$  ( $538 \pm 5^\circ\text{C}$ ) or to the temperature determined by the correction factor process according to Annex A. Record the furnace temperature (set point) prior to the initiation of the test IF the furnace does not record automatically. 7.1.1.

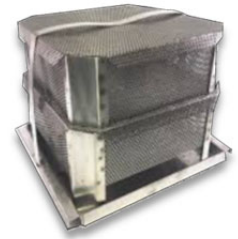


*Refer to the procedure for details on the direct IR irradiation-type furnace or the procedure that applies. Will not be tested on during ATTI ASPHALT.*

**2** Use AASHTO T329 to oven dry the asphalt mixture sample to a constant mass or determine the moisture content on a separate moisture test sample (Split out from the original same field or laboratory material obtained).

7.2.

**EXAMPLE OF SAMPLE BASKET ASSEMBLY**



**3** Enter into the ignition furnace (or manually record) the asphalt binder correction factor for the specific mix to be tested, as determined in ANNEX A.

7.3.

**4** Weigh and record the mass of the specimen basket assembly to the nearest 0.1 grams.

7.4.

**5** Place the sample basket(s) in the catch pan. Evenly distribute the test sample in the basket(s), taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the specimen.

7.5.



**6** Weigh and record the total mass of the sample and basket assembly at room temperature to the nearest 0.1 grams. Calculate and record the initial mass of the specimen. Record as (AASHTO Example):  $M_i = \text{total mass minus the mass of the sample basket assembly}$ .

7.6.

**7** Input the initial mass of the sample,  $M_i$  to the nearest whole gram into the ignition furnace controller. Verify that the correct mass has been entered.

7.7.



**1. INPUT BINDER CORRECTION FACTOR**

**2. INPUT THE INITIAL MASS**

**3. RESET SCALE**

**8** Reset the internal balance to zero.

7.8.

**9** Open the chamber door and place the sample basket assembly in the furnace, carefully positioning it so it is not in contact with the furnace walls.

7.9.

**4. PLACE SAMPLE IN IGNITION OVEN (AFTER IT HAS BEEN WEIGHED AND RECORDED)**



**10** Close the chamber door and verify that the sample mass (including the basket assembly) displayed on the furnace scale equals the total mass recorded in Section 7.6 (STEP 6 IN THE MANUAL) within  $\pm 5$  grams.

7.9.

**5. VERIFY WEIGHT DISPLAYED IS WITHIN  $\pm 5$  GRAMS OF THE WEIGHT RECORDED**

**6. BEGIN THE BURN**



**NOTE 5** – due to the extreme heat of the furnace, the operator should wear safety equipment- high temperature gloves, face shield, and fire-retardant shop coat- when opening the door to load or unload the specimen. (SECTION 7.9.)



Differences greater than 5 grams or failure of the furnace scale to stabilize may indicate that the specimen basket assembly is contacting the furnace wall. (SECTION 7.9.)

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

7.10.

12

Allow the test to continue until the stable light and audible stable indicator indicates the test is complete (*the change in mass does not exceed 0.01 percent for three consecutive minutes*). Press the start/stop button. This unlocks the sample chamber and causes the printer to print out the test results.

7.11.



**NOTE 6** – 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 the specimen size and asphalt binder content. (SECTION 7.10.)

13

Open the chamber door, remove the sample basket assembly, and place it on a cooling plate or block.

7.12.



**NOTE 7** – an ending mass loss percentage of 0.02 may be substituted when the aggregate exhibits an excessive amount of loss during ignition testing. Both precision and accuracy may be adversely affected by using 0.02 percent. Applies to Method B also (NOTE 10 in the procedure). (Refer to the procedure for additional details) (SECTION 7.11.)

14

Place the protective cage over the sample basket assembly, and allow it to cool to room temperature (approximately 30 minutes).

7.12.

15

Weigh and record the total mass of the specimen and specimen basket assembly after ignition to the nearest 0.1 grams. Calculate and record the final mass of the sample. Record as (AASHTO Example):  $M_f = \text{total mass minus the mass of the sample basket assembly}$ .

7.13.

16

Use the corrected asphalt binder content (percent) from the printed ticket. If this value is NOT CORRECTED, subtract the asphalt binder correction factor. If a moisture content has been determined according to AASHTO T329, subtract the percent moisture from the asphalt binder content on the printed ticket, and report the resultant value as the corrected asphalt binder content. AASHTO Example: record as  $P_b$ .

7.14.



**NOTE 8** – Asphalt binder content can also be calculated using Equation 1 from Method B (Section 8.16) (SECTION 7.14.)

### METHOD B – EXTERNAL BALANCE

1

Preheat the ignition furnace to  $1000 \pm 9^\circ \text{F}$  ( $538 \pm 5^\circ \text{C}$ ) or to the temperature determined by the correction factor process from Annex A.

8.1.

2

Use AASHTO T329 to oven dry the asphalt mixture sample to a constant mass or determine the moisture content on a separate moisture test sample (*Split out from the original same field or laboratory material obtained*).

8.2.

3

Record the asphalt binder correction factor for the specific mix to be tested, as determined by the correction factor process according to ANNEX A.

8.3.

4

Weigh and record the mass of the sample basket assembly to the nearest 0.1 grams.

8.4.

5

Place the sample basket(s) in the **catch pan**. **Evenly distribute the test sample in the basket(s)**, taking care to keep the **material away from the edges of the basket**. Use a spatula or trowel to level the specimen.

8.5.

6

**Weigh and record the total mass** of the sample and basket assembly at room temperature to the **nearest 0.1 grams**. **Calculate and record the initial mass of the sample**. Record as (AASHTO Example):  $M_i = \text{total mass minus the mass of the sample basket assembly}$ .

8.6.

7

Open the chamber door and **place the specimen basket assembly in the furnace**. **Burn the asphalt mixture specimen in the furnace for at least 45 minutes**.

8.7.



**NOTE 9** – the appropriate time for the initial burn of an asphalt mixture sample is dependent on the sample size. For large samples, the time could be significantly longer than 45 minutes. See the manufacturer's instruction manual for guidelines. (SECTION 8.7.)

8

Open the chamber door, **remove the sample basket assembly**, and **place it on a cooling plate or block**.

8.8.

9

**Place the protective cage over the sample basket assembly**, and allow it to **cool to room temperature (approximately 30 minutes)**.

8.8.

10

**Weigh and record the total mass of the specimen and specimen basket assembly**, after cooling, to the **nearest 0.1 grams**.

8.9.

11

**Calculate the sample mass by subtracting the mass of the sample basket assembly from the mass of the sample and sample basket assembly** and record to the **nearest 0.1 g**.

8.9.

12

**Place the sample and sample basket assembly back into the furnace**.

8.10.

13

**Burn the specimen for at least 15 minutes**. **Begin timing** after the furnace reaches the **set point** temperature again.

8.11.

14

**Repeat the previous process** of removing the sample basket assembly & sample, and again allow it to **cool to room temperature (approximately 30 minutes)**.

8.12.

15

**Weigh and record the total mass** of the specimen and specimen basket assembly after cooling to the **nearest 0.1 grams**.

8.13.

16

Calculate the sample mass by subtracting the mass of the sample basket assembly from the mass of the sample and sample basket assembly and record to the nearest 0.1 g.

8.13.

17

Repeat this process until the change in measured mass of the sample after ignition (*minus basket assembly*) does not exceed 0.01 percent of the previous sample mass (*minus basket assembly*).

8.14.

18

Determine percent change by subtracting the new mass determination ( $M_n$ ) from the previous mass determination ( $M_p$ ), dividing by the previous mass determination ( $M_p$ ), and multiplying by 100.

8.14.

19

Once the determined weight does not exceed 0.01 percent then designate that last recorded weight as the final mass after ignition. Record as (AASHTO Example):  $M_f$  = total mass minus the mass of the sample basket assembly.

8.15.

## EXAMPLE:

BINDER CORRECTION FACTOR: 0.40 %

MOISTURE CONTENT: 0.04 %

MASS OF BASKET ASSEMBLY: 2922.5 grams

INITIAL MASS OF SAMPLE & BASKET ASSEMBLY = 5282.2 grams

5282.2 grams - 2922.5 grams = 2359.7 grams

$M_i$  = 2359.7 grams

SAMPLE MASS OF SAMPLE & BASKET AFTER IGNITION = 5144.4 grams

5144.4 grams - 2922.5 grams = 2221.9 grams

$M_p$  = 2221.9 grams

SAMPLE MASS OF SAMPLE & BASKET AFTER ADDITIONAL 15 MINUTES IGNITION = 5144.2 grams

5144.2 grams - 2922.5 grams = 2221.7 grams

$M_n$  = 2221.7 grams

8.16.

CALCULATION:

$$\% P_b = \left[ \frac{(M_i - M_f)}{M_i} \times 100 \right] - C_f - MC$$

$\% P_b$  = the measured (corrected) asphalt binder content, percent;

$M_i$  = the total mass of the asphalt mixture sample prior to ignition, grams;

$M_f$  = the total mass of the aggregate remaining after the ignition, grams;

$C_f$  = the correction factor, percent by mass of asphalt mixture sample;

$MC$  = the moisture content of the separate asphalt mixture sample, percent. According to AASHTO T329. If the sample was oven dried prior to initiating the procedure,  $MC = 0$ ;

$M_p$  = previous mass determination of burn, grams;

$M_n$  = new mass determination after 15-minute burn, grams;

CHECK THAT THE PERCENT CHANGE DOES NOT EXCEED 0.01 PERCENT BETWEEN THE PREVIOUS MASS DETERMINATION AND THE NEW

$$\frac{M_p = 2221.9 \text{ grams} - M_n = 2221.7 \text{ grams}}{M_p = 2221.9 \text{ grams}} \times 100 = 0.0090013052 = 0.009 \% \quad \leftarrow \text{DOES NOT EXCEED 0.01 PERCENT}$$

$M_p$  = 2221.9 grams

BECAUSE THE DIFFERENCE IN WEIGHT DOES NOT EXCEED 0.01 PERCENT THE LAST WEIGHT RECORDED WILL BE THE FINAL MASS FOR THE CALCULATION

$M_f$  = 2221.7 grams

$$\% P_b = \left[ \frac{(M_i = 2359.7 \text{ grams} - M_f = 2221.7 \text{ grams})}{M_i = 2359.7 \text{ grams}} \times 100 \right] - C_f = 0.40\% - MC = 0.04\%$$

ANSWER:  $\% P_b = 5.408201043 = 5.41\%$

### GRADATION:

1

Allow the contents of the specimen baskets to **cool to room temperature** prior to performing the **gradation analysis**.

9.1.

2

**Empty the contents of the baskets** into a container, being careful to **capture all material**. Use a small wire sieve brush to ensure that any residual fines are removed from the baskets and catch pan.

9.1.

3

Perform the **gradation analysis** according to **AASHTO T30**.

9.2.

10.

### REPORT:

**NOTE 11:** THE PRECISION OF THIS TEST METHOD INDICATES THAT THE BINDER CONTENT IS REPORTED TO THE NEAREST 0.01 PERCENT. TEST RESULTS SHOULD NOT BE REPORTED TO A GREATER NUMBER OF DECIMAL PLACES THAN THE SPECIFIED BINDER CONTENT LIMITS.

**NOTE 12:** IF METHOD A IS PERFORMED, ATTACH THE ORIGINAL PRINTED TICKET TO THE REPORT.

### ANNEX A -CORRECTION FACTOR:

- Asphalt **binder content results** may be **affected by the type of aggregate in the mixture and the ignition furnace**. Therefore, **asphalt binder and aggregate correction factors** must be created by testing a set of correction specimens for each **job mix formula (JMF) mix design**.
- Correction factor(s)** must be determined before any **acceptance testing is completed** and **repeated** each time a **change in the mix ingredients or design occurs**. Any changes greater than **5 percent** in **stockpiled aggregate proportions** require a **new correction factor**. **Historical data or scientific studies** may be used to **determine the correction factor(s)** in place of using this testing procedure **IF the testing agency provides reference to the studies / data**.

A1.1.

A1.1.

- **ASPHALT BINDER CORRECTION FACTOR** – Each ignition furnace will have its **own unique asphalt binder correction factor** determined in the location where testing will be performed. Certain **aggregate types** may result in **unusually high correction factors (greater than 1.0 percent)** Such mixes should be corrected and tested at a lower temperature, described in the **ANNEX procedure**. A1.2.
- **AGGREGATE CORRECTION FACTOR** – Due to **potential aggregate breakdown** during the ignition process, an **aggregate correction factor** will be determined 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 from an unknown source.** A1.3.

### **BINDER CORRECTION FACTOR**

#### **PROCEDURE:**

- 1 Obtain samples of aggregate according to **AASHTO R90**. Reduce the samples to testing size as needed according to **AASHTO R76**. A2.1
- 2 Obtain samples of asphalt binder according to **AASHTO R66**. **NOTE A1:** Include other additives that may be required by the JMF such as admixture. A2.2
- 3 Prepare an initial, or “butter” mix at the design asphalt binder content. Mix and discard the butter mix prior to preparing any of the correction samples to ensure an accurate asphalt binder content. A2.3
- 4 Prepare two correction samples at the JMF design asphalt binder content and gradation. Aggregate used for correction samples shall be sampled from the material designated for use in production. A2.4
- 5 An additional “blank” (aggregate only) sample will be batched at the JMF gradation. Conduct an aggregate gradation in according to **AASHTO T30** on the “blank” specimen. A2.4
- 6 Place the freshly mixed test samples directly into the sample basket assembly. If the specimens are allowed to cool prior to placement in the sample basket assembly, the samples must be dried to constant mass at a temperature of  $230 \pm 9$  °F ( $110 \pm 5$ °C). **Do not preheat the specimen basket assembly!** A2.5
- 7 Perform an ignition burn on the samples according to **METHOD A** or **METHOD B** of the procedure. A2.6
- 8 Once both of the correction specimens have been burned, calculate the asphalt binder content for each sample or obtain from the printed oven tickets, if available. A2.7



**OBTAIN AGGREGATES AND BINDER AND ADMIXTURE FROM MATERIAL TO BE USED IN PRODUCTION**



**9** If the **difference between the asphalt binder contents of the two samples exceeds 0.15 percent**, repeat the process with **two more samples** and, from the **four results**, **discard the high and low result**. A2.8

**EXAMPLE:**

MEASURED BINDER %	
SAMPLE 1	5.10 %
SAMPLE 2	5.12 %

$5.12 \% - 5.10 \% = 0.02\%$

*The difference between the two samples does NOT exceed 0.15 % ONLY these two samples are necessary for calculating the correction factor*

**10** Determine the correction factor by **subtracting the Binder content** given in the **ACTUAL (the known binder content obtained from JMF design)** and **MEASURED (what binder content calculation shows after ignition) asphalt binder contents %** for each sample. Then **average** the differences (expressed as a percentage by mass of the asphalt mixture) this **will produce the asphalt binder correction factor**. A2.8

**EXAMPLE:**

	ACTUAL BINDER %	MEASURED BINDER %	DIFFERENCE %
SAMPLE 1	5.20 %	5.10 %	0.10 %
SAMPLE 2	5.20 %	5.12 %	0.08 %

**THEN AVERAGE:**  $\frac{0.10\% + 0.08\%}{2}$

**ANSWER (BINDER CALIBRATION FACTOR %) = 0.08 %**

**11** If the asphalt binder correction factor exceeds **1.0 percent**, the test **temperature** should be lowered to **900 ± 9 °F (482 ± 5°C)** for a **convection-type furnace**. If there is **no improvement** in the correction factor, it is **permissible to use the higher temperature**. **NOTE A2** – *The temperature for determining the asphalt binder content of asphalt mixture specimens by the procedure shall be the same temperature determined for the correction samples.* A2.8.1.

**AGGREGATE CORRECTION FACTOR**

**12** Perform a gradation analysis on the residual aggregate according to **AASHTO T30**, if required. The results will be utilized in developing an **aggregate correction factor** and should be **calculated and reported to the nearest 0.1 percent**. A2.9.



*Refer to the procedure for details on the direct IR irradiation-type furnace or the procedure that applies. Will not be tested on during ATTI ASPHALT.*

**13** From the **gradation** results, **subtract the percent passing EACH sieve** for both test samples from the **percent passing EACH sieve** of the **“blank” sample** gradation results. A2.9.1.

**14** Calculate the average difference for the two values (this will be the aggregate correction factor for that sieve). If the difference for **ANY single sieve exceeds the allowable difference** for that sieve as listed in **Table A2.1.**, then **aggregate gradation correction factors for ALL sieves will be applied to all acceptance gradation test results** determined by **AASHTO T30**, prior to final rounding and reporting. If the **#200 sieve is the only sieve outside the limits in Table A2.1**, apply the aggregate correction factor to only the #200 sieve. A2.9.2.

**Table A2.1**

Permitted Sieving Difference

Sieve	Allowable Difference
Sizes larger than or equal to 2.36 mm (No.8)	± 5.0%
Sizes larger than to 75 µm (No.200) and smaller than 2.36 mm (No.8)	± 3.0%
Sizes 75 µm (No.200) and smaller	± 0.5%

1. SUBTRACT THE % PASSING FOR EACH INDIVIDUAL SIEVE FOR SAMPLE #1 FROM THE % PASSING FOR EACH INDIVIDUAL SIEVE OF THE BLANK SAMPLE
2. SUBTRACT THE % PASSING FOR EACH INDIVIDUAL SIEVE FOR SAMPLE #2 FROM THE % PASSING FOR EACH INDIVIDUAL SIEVE OF THE BLANK SAMPLE

BLANK CALIBRATION SAMPLE	INDIVIDUAL % PASSING
1"	
3/4"	100
1/2"	91.0
3/8"	77.0
1/4"	62
#4	51.3
#8	118.7
#10	89.2
#16	65.2
#30	61.6
#40	51.4
#50	48.9
#100	35.4
#200	15.5

CALIBRATION SAMPLE #1	INDIVIDUAL % PASSING	
1"		
3/4"	100	
1/2"	90.5	91.0 - 90.5
3/8"	77.5	77.0 - 77.5
1/4"	61.3	62.0 - 61.3
#4	51.6	51.3 - 51.6
#8	117.5	118.7 - 117.5
#10	88.7	89.2 - 88.7
#16	68.3	65.2 - 68.3
#30	60.3	61.6 - 60.3
#40	50.7	51.4 - 50.7
#50	51.3	48.9 - 51.3
#100	34.9	35.4 - 34.9
#200	14.9	15.5 - 14.9

CALIBRATION SAMPLE #2	INDIVIDUAL % PASSING	
1"		
3/4"	100	
1/2"	90.8	91.0 - 90.8
3/8"	77.1	77.0 - 77.1
1/4"	60.7	62.0 - 60.7
#4	50.5	51.3 - 50.5
#8	119.1	118.7 - 119.1
#10	90.7	89.2 - 90.7
#16	63.5	65.2 - 63.5
#30	63.1	61.6 - 63.1
#40	49.8	51.4 - 49.8
#50	50.1	48.9 - 50.1
#100	36.2	35.4 - 36.2
#200	15.9	15.5 - 15.9

6. RECORD THE RESULTS (NOTE WHETHER THE RESULT IS A POSITIVE NUMBER OR A NEGATIVE NUMBER).

5. AVERAGE BOTH RESULTS AND RECORD. THIS NUMBER WILL BE YOUR INDIVIDUAL SIEVE AGGREGATE CORRECTION FACTOR (IF THE RESULT IS OUT OF RANGE). CHECK AGAINST VALUES FROM TABLE A2.1. NOTE WHETHER THEY FALL IN THE RANGE

3. IF ANY RESULTS ARE OUT OF RANGE, THEN APPLY EACH CORRECTION FACTOR TO EVERY SEIVE WHILE PERFORMING AASHTO T30 FOR THAT PARTICULAR ASPHALT MIX

SAMPLE 1/SAMPLE 2

	DIFFERENCES %	
1"		
3/4"		
1/2"	+0.5/+0.2	$\frac{(+0.5) + (+0.2)}{2}$
3/8"	-0.5/-0.1	$\frac{(-0.5) + (-0.1)}{2}$
1/4"	+0.7/+1.3	$\frac{(+0.7) + (+1.3)}{2}$
#4	-0.3/+0.8	$\frac{(-0.3) + (+0.8)}{2}$
#8	+1.2/-0.4	$\frac{(+1.2) + (-0.4)}{2}$
#10	+0.5/-1.5	$\frac{(+0.5) + (-1.5)}{2}$
#16	-3.1/+1.7	$\frac{(-3.1) + (+1.7)}{2}$
#30	+1.3/-1.5	$\frac{(+1.3) + (-1.5)}{2}$
#40	+0.7/+1.6	$\frac{(+0.7) + (+1.6)}{2}$
#50	-2.4/-1.2	$\frac{(-2.4) + (-1.2)}{2}$
#100	+0.5/-0.8	$\frac{(+0.5) + (-0.8)}{2}$
#200	+0.6 / -0.4	$\frac{(+0.6) + (-0.4)}{2}$

AGGREGATE CORRECTION FACTOR

	AVERAGE DIFFERENCES %	
1"		
3/4"		± 5.0%
1/2"	+0.4	± 5.0%
3/8"	-0.3	± 5.0%
1/4"	+1.0	± 5.0%
#4	+0.3	± 5.0%
#8	+0.4	± 3.0%
#10	-0.5	± 3.0%
#16	-0.7	± 3.0%
#30	-0.1	± 3.0%
#40	+1.2	± 3.0%
#50	-1.8	± 3.0%
#100	-0.2	± 3.0%
#200	+0.1	± 0.5%

4. IF JUST THE #200 IS OUT OF RANGE, THEN JUST APPLY THE AGGREGATE CORRECTION TO JUST THE #200 SIEVE

NO AGGREGATE CORRECTION FACTOR NECESSARY ACCORDING TO THIS EXAMPLE

# AASHTO T30:

## MECHANICAL ANALYSIS OF EXTRACTED AGGREGATE

### DEFINITIONS:

**Particle Size** – refers to the individual dimensions (usually diameter) of the mineral particles or grains that make up an aggregate used in construction materials like asphalt or concrete.

**Maximum Aggregate Size** – The smallest sieve through which 100% of the aggregate sample passes.

**Nominal Maximum Aggregate Size** – The next smallest sieve that retains some (percentages may vary) of the aggregate.



*This method is used to determine the grading of aggregates extracted from asphalt mixtures. The results are used to determine compliance of the particle-size distribution with applicable requirements and to provide necessary data for control of the production of various aggregates to be used in asphalt mixtures.*

### SCOPE:

*This method covers a procedure for the determination of the particle-size distribution of fine and coarse aggregates extracted from asphalt mixtures using sieves with square openings.*

1.1.

### EQUIPMENT:

5.

- **BALANCE** – shall have **sufficient capacity**, and be **readable to 0.1 grams** or better.
- **SIEVES** – for the **washing portion** of the test procedure (sections 8.2, 8.3, and 8.4) a **nest of two sieves is required**. The **lower sieve being a #200 sieve** and the **upper sieve being in the range of #8 to #16 in opening size**.
- **MECHANICAL SHAKER** – a mechanical sieving device, if used, shall create **motion of the sieves** to cause the **particles to bounce, tumble, or otherwise turn** so as to **present different orientations** to the **sieving surface**. The sieving action shall meet the requirements for **sieving adequacy** described in **section 7** in a reasonable time period.
  1. **NOTE 1:** *use of a mechanical sieve shaker is recommended when the size of the sample is 44lbs (20kg) or greater, and may be used for smaller samples, including fine aggregate. Excessive time (more than 10 minutes) to achieve adequate sieving may result in degradation of the sample. The same mechanical sieve shaker may not be practical for all sizes of samples, because a large sieving area is needed for practical sieving of a large nominal size coarse aggregate. Use of the same device for a smaller size of coarse aggregate or fine aggregate will likely result in loss of a portion of the sample.*
- **OVEN**- of adequate size, capable of **maintaining the set temperature within  $\pm 9^{\circ} \text{F}$  ( $\pm 5^{\circ} \text{C}$ )**.
- **WETTING AGENT** – any dispersing agent that will **promote separation of fine materials** without degrading the extracted aggregate. Any detergent used shall not leave a residue on the sample during the washing procedure.
- **CONTAINER** – a pan or vessel of a size sufficient to **contain the sample covered with water** and to **permit vigorous agitation** without loss of any part of the sample or water.
- **SPOON OR MIXING UTENSIL** – or similar item for agitating the sample during the washing procedure.
- **MECHANICAL WASHING APPARATUS (OPTIONAL)** – *refer to the procedure for details regarding this equipment.*

**SAMPLE:**

- The **test sample** will consist of the aggregate material **obtained according to AASHTO T308** after the **binder material has been extracted** (Refer to the procedure for other extraction methods).

6.1.

**PROCEDURE:**

1

**IF NECESSARY** dry the sample to constant mass according to AASHTO T255, (REFER NOTE 3). Weigh and record the mass of the sample to the nearest 0.1 grams (initial specimen mass).

7.1.



**NOTE 3:** if more than 24 hours pass between the completion of AASHTO T308 and the beginning of this test procedure, or if the sample is stored in a high humidity environment, or has otherwise been subjected to moisture, the sample should be dried again to constant mass. (SECTION 7.1.)

2

If the sample consists of aggregate obtained from AASHTO T308, the mass recorded in the beginning of this procedure (after being dried to constant mass if applicable. Refer to section 7.1.) must agree with the mass of aggregate remaining after ignition ( $M_f$  obtained according to AASHTO T308). The difference between the two must be within 0.1 percent.

7.1.2.



Refer to the procedure for details on how to perform this procedure if binder extraction was performed according to AASHTO T164 OR AASHTO T319. Will not be tested on or referenced during ATTI AASHTO.

3

If the variation exceeds 0.1 percent, the results should not be accepted for acceptance purposes.

7.1.2.

4

Place the test sample in a container (or in a mechanical wash apparatus) and cover it with water. Add an adequate amount of wetting agent to ensure that the material finer than the #200 sieve is thoroughly separated from the coarser particles (REFER NOTE 5).

7.2.

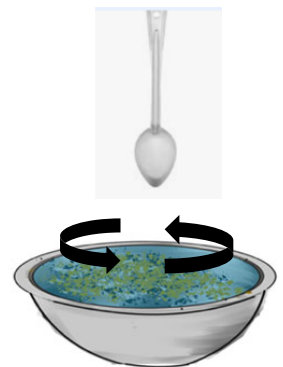


**NOTE 5:** There should be enough wetting agent to produce a small amount of suds when the sample is agitated. The quantity will depend on the hardness of the water, the quality of the detergent, and the agitation process. Excessive suds may overflow the sieves and carry some material with them. (SECTION 7.2.)

5

Agitate the test sample vigorously in the container (or in the mechanical washing apparatus) bringing the particles finer than the #200 sieve into suspension. Use a large spoon (or similar means) to agitate the test sample.

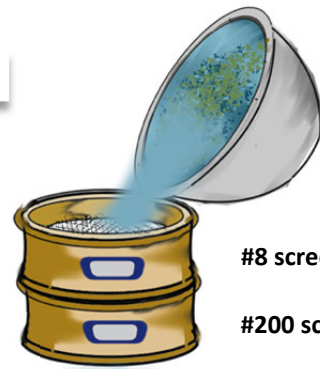
7.3.



6

Immediately decant the suspension over the nest of two sieves (the lower sieve will be a #200 sieve and the upper sieve will be a sieve that is in the range of #8 to #16). The goal is to completely separate the fine particles from the coarse particles. Avoid, as much as possible, the decantation of the coarse particles of the sample onto the sieve nest.

7.3.



#8 screen- #16 screen

#200 screen



Do not overflow or overload the #200 sieve. (SECTION 7.3.)

7

Repeat washing until the water is REASONABLY clear, where there is no appreciable change in water clarity with continued washing (limit agitation by mechanical washing equipment to a maximum of ten minutes).

7.3.



NOTE 7: A spray nozzle or a piece of rubber tubing attached to a water faucet may be used to rinse any of the material that may have fallen onto the sieves. The velocity of water, which may be increased by pinching the tubing or by use of a nozzle, should not be sufficient to cause any splashing of the sample over the sides of the sieve. (SECTION 7.4)



NOTE 6: When mechanical washing equipment is used, introducing the water, agitating, and decanting may be a continuous operation. (SECTION 7.3)

8

After washing the sample, return all material retained on the nested sieves to the container. Flush any materials retained on the spoon or mixing utensil and the two nested sieves back into the container. NO water will be decanted from the container except through the nest of two sieves to avoid loss of material. (If a mechanical washing apparatus is used, transfer material on the nest of sieves and the washing apparatus to a drying container).

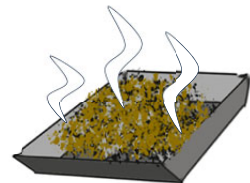
7.4.

9

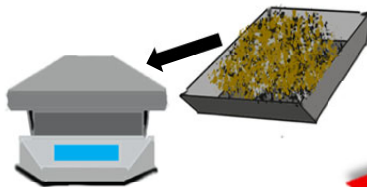
Dry the washed aggregate to constant mass according to AASHTO T255. Weigh and record its mass to the nearest 0.1 grams.

7.4.

DRY TO  
CONSTANT  
MASS



WEIGH & RECORD



PREPARE SIEVE SET

INTRODUCE SAMPLE TOP SIEVE

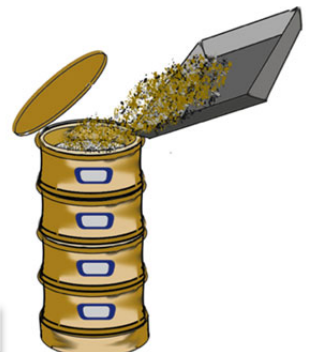
10

Sieve the aggregate over various sieve sizes, including the #200 sieve as required by the specification covering the asphalt mixtures. Additional sieve sizes may be used to regulate the amount of material on a sieve to meet the requirements of Annex A2.

7.5.



7.5.



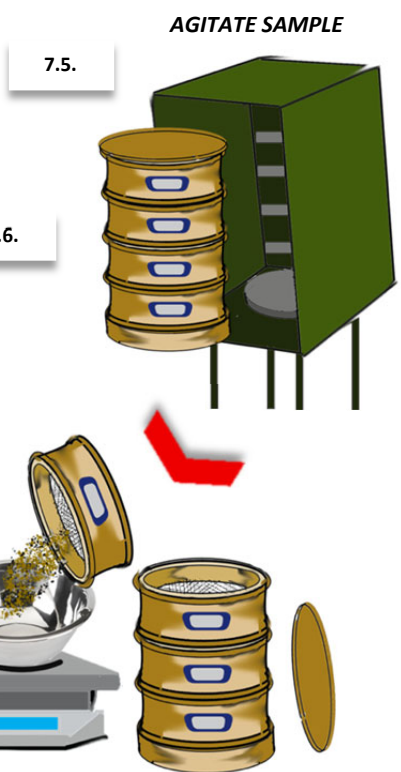
11

Nest the sieves in order of decreasing size of opening from top to bottom and place the sample on the top sieve.

**12** Agitate the sieves by a mechanical apparatus for an adequate period, established by trial or checked by measurement on the actual test sample, to meet the criteria for the adequacy of sieving described in ANNEX A1.

**13** Limit the quantity of material on a given sieve so that all particles have the opportunity to reach sieve openings a number of times during sieving. Do not overload sieves; SEE ANNEX A2.

**14** Record the mass of material passing each sieve, the mass retained on the next sieve, and the amount passing the #200 sieve. *The mass of the dry sample after washing and the mass of the sample after sieving must be within 0.2 percent of each other if more than 0.2 should not use for acceptance.*



WEIGH EACH SIEVE AND CALCULATE

**CALCULATIONS:**

- Add the mass of dry material passing the #200 sieve after the sieving process to the mass removed by washing to obtain the total mass passing #200 sieve.

8.1.

Calculate total percentages retained (or percentages in various size fraction):

- dividing each mass retained by the initial sample mass recorded as the initial mass (Section 7.1.1.) then multiply by 100.

8.1.

Calculate percentages passing:

- subtract the percent retained from the previous percent passing

**!** Calculations can be cumulative or individual for this example only individual (with the fine material split) will be demonstrated.

Record both percentages retained and the percentage passing to the nearest 0.1 percent while performing the gradation operation.

- For aggregate samples obtained from AASHTO T308, apply the aggregate correction factor, as required in AASHTO T308, to obtain the final total passing percentages IF the aggregate correction factor is requisite (SEE AASHTO T308 for details)

8.2.

**!** REPORT percentages to the nearest whole number, except for the percentage passing the #200 sieve, which must be reported to the nearest 0.1 percent. (SECTION 9.1.)

**EXAMPLE CALCULATION**

MASS OF AGGREGATE AFTER IGNITION (T308) : **2422.5 grams**

DRY MASS OF TOTAL SAMPLE BEFORE WASHING (T30) : **2422.3 grams**

DRY MASS OF SAMPLE AFTER WASHING (T30) : **2296.2 grams**

MASS OF SAMPLE AFTER SIEVING (T30) : **2295.3 grams**

AMOUNT OF MINUS #200  
WASHED OUT: **126.1 grams**

1. PERFORM THE MASS VERIFICATION. CALCULATE THE PERCENT CHANGE BETWEEN THE TEST SAMPLE AFTER IGNITION FROM AASHTO T 308 AND THE INITIAL WEIGHT OF THE TEST SAMPLE FOR AASHTO T30. VERIFY THAT IT IS IN RANGE.

2. COMPLETE AASHTO T30 PROCEDURE. WEIGH AND RECORD THE INDIVIDUAL MASS RETAINED FOR EACH SIEVE ON #4 & LARGER (COARSE) TO THE NEAREST 0.1 GRAMS. WEIGH THE AMOUNT IN THE PAN TO THE NEAREST 0.1 GRAMS.

$$1 \text{ MASS VERIFICATION} = \frac{(TOTAL \text{ MASS AFTER IGNITION (T308)} - INITIAL \text{ TOTAL MASS (BEFORE WASH T30)})}{(TOTAL \text{ MASS AFTER IGNITION (T308)})} \times 100$$

$$\frac{(2422.5 - 2422.3)}{(2422.5)} \times 100 = 0.01\% \leq 0.1\% \text{ ACCEPTED FOR ACCEPTANCE: The difference between the two must be within 0.1 percent.}$$

$$2 \text{ SUM CHECK} = \frac{(DRY \text{ MASS AFTER WASHING} - TOTAL \text{ MASS AFTER SIEVING})}{(DRY \text{ MASS AFTER WASHING})} \times 100$$

$$\frac{(2296.2 - 2295.3)}{(2296.2)} \times 100 = 0.04\% \leq 0.2\% \text{ ACCEPTED FOR ACCEPTANCE: The difference between the two must be within 0.2 percent.}$$

3. PERFORM THE SUM CHECK CALCULATION TO VERIFY THAT THE MASS AFTER WASH AND THE MASS AFTER SIEVE DOES NOT EXCEED 0.2 % IN MASS.

**% RETAINED**

4. CALCULATE THE % RETAINED ON EACH SCREEN TO NEAREST 0.1 PERCENT. CALCULATION:

$$\frac{(AMOUNT \text{ OF RETAINED ON SEIVE})}{(DRY \text{ MASS OF TOTAL SAMPLE BEFORE WASHING})} \times 100$$

**% PASSING**

5. CALCULATE THE % PASSING ON EACH SCREEN TO NEAREST 0.1 PERCENT. CALCULATION:

$$PREVIOUS \text{ PERCENT PASSING} - CURRENT \% \text{ RETAINED}$$

6. (FOR THIS EXAMPLE): APPROPRIATELY REDUCE THE MINUS #4 MATERIAL AND RECORD THIS WEIGHT TO THE NEAREST 0.1 GRAMS.

7. PERFORM AASHTO T30 ON FINE SIEVE PORTION EXCEPT ADJUST INDIVIDUAL WEIGHTS RETAINED ON EACH SIEVE USING THE FOLLOWING EQUATION:

$$\frac{(MASS \text{ OF TOTAL ORIGINAL AMOUNT OF MINUS \#4 SCREEN})}{(MASS \text{ OF REDUCED TOTAL PORTION MINUS \#4})} \times \text{WEIGHT OF EACH RETAINED MASS}$$

8. CALCULATE THE % RETAINED & % PASSING ON THE ADJUSTED AMOUNTS FOR THE FINE SIEVE PORTION IN THE SAME WAY.

**EXAMPLE GRADATION**

	INDIVIDUAL MASS RETAINED	CALCULATION FOR PERCENT RETAINED	INDIVIDUAL % RETAINED	CALCULATION FOR PERCENT PASSING	INDIVIDUAL % PASSING	AGGREGATE CORRECTION FACTOR (IF NECESSARY)	REPORTED
1"							
3/4"	0		0		100	N/A	100
1/2"	346.9	$\frac{346.9}{2422.3} \times 100$	14.3	100 - 14.3	85.7	N/A	86
3/8"	207.8	$\frac{207.8}{2422.3} \times 100$	8.6	85.7 - 8.6	77.1	N/A	77
1/4"	140.0	$\frac{140.0}{2422.3} \times 100$	5.8	77.1 - 5.8	71.3	N/A	71
#4	485.4	$\frac{485.4}{2422.3} \times 100$	20.0	71.3 - 20.0	51.3	N/A	51

9. USE THE AGGREGATE CORRECTION FACTOR WHERE APPROPRIATE ON THE INDIVIDUAL % PASSING BEFORE REPORTING. REPORT TO THE NEAREST WHOLE PERCENT EXCEPT #200 SCREEN REPORT TO THE NEAREST 0.1 PERCENT.

REPORT TO NEAREST WHOLE PERCENT

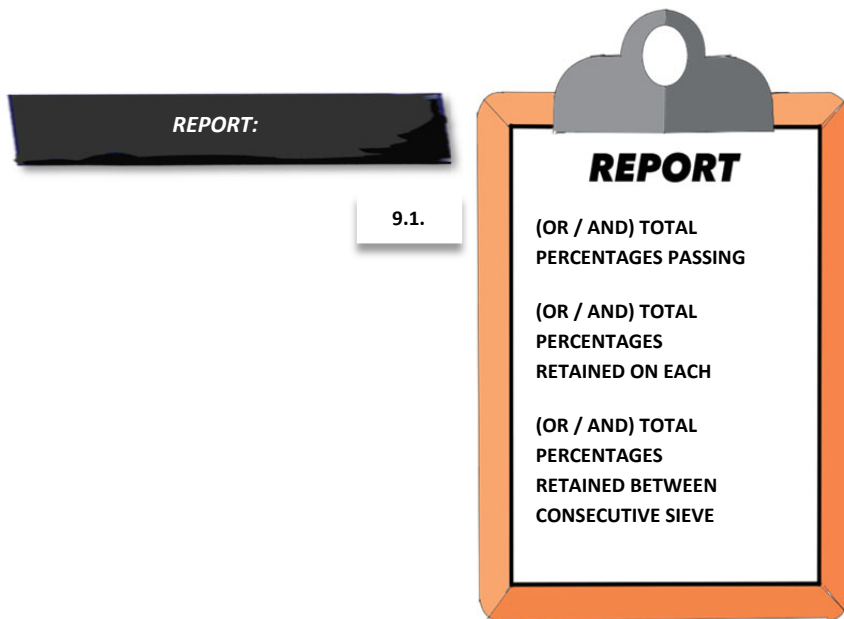
PLUS #4: 1180.1 grams	MINUS #4 SPLIT: 510.5 grams	MINUS #4 SAMPLE (after sieve): 510.0 grams
-----------------------	-----------------------------	--

	INDIVIDUAL MASS RETAINED	CALCULATION FOR PERCENT RETAINED	ADJUSTED INDIVIDUAL WEIGHTS MINUS #4	INDIVIDUAL % RETAINED	INDIVIDUAL % PASSING	AGGREGATE CORRECTION FACTOR (IF NECESSARY)	REPORTED
#8	119.1	$\frac{1115.2}{510.5} \times 119.1$	260.2	$\frac{260.2}{2422.3} \times 100$	10.7	51.3 - 10.7	40.6
#10	87.7	$\frac{1115.2}{510.5} \times 87.7$	191.6	$\frac{191.6}{2422.3} \times 100$	7.9	40.6 - 7.9	32.7
#16	72.2	$\frac{1115.2}{510.5} \times 72.2$	157.7	$\frac{157.7}{2422.3} \times 100$	6.5	32.7 - 6.5	26.2
#30	71.6	$\frac{1115.2}{510.5} \times 71.6$	156.4	$\frac{156.4}{2422.3} \times 100$	6.5	26.2 - 6.5	19.7
#40	51.4	$\frac{1115.2}{510.5} \times 51.4$	112.3	$\frac{112.3}{2422.3} \times 100$	4.6	19.7 - 4.6	15.1
#50	50.1	$\frac{1115.2}{510.5} \times 50.1$	109.4	$\frac{109.4}{2422.3} \times 100$	4.5	15.1 - 4.5	10.6
#100	36.2	$\frac{1115.2}{510.5} \times 36.2$	79.1	$\frac{79.1}{2422.3} \times 100$	3.3	10.6 - 3.3	7.3
#200	21.5	$\frac{1115.2}{510.5} \times 21.5$	47.0	$\frac{47.0}{2422.3} \times 100$	1.9	7.3 - 1.9	5.4
PAN (PASSING #200)	0.2						0.2

APPLY AGGREGATE CORRECTION (IF APPLICABLE SEE T308)

5.4 - 0.7

EXCEPT #200 SCREEN REPORT NEAREST 0.1%.



## TIME EVALUATION

### ANNEX A -EVALUATING ADEQUACY OF SIEVING AND SIEVE OVERLOAD:

The minimum time requirement should be evaluated for each mechanical shaker at least annually by the following method OR perform manual hand shaking steps for test sample if no mechanical shaker is available:

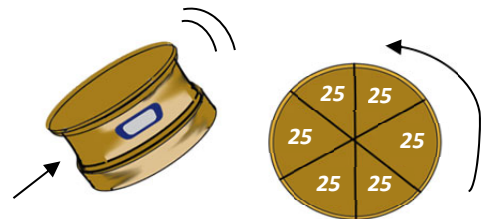
- 1 Shake the sample over **nested sieves** for **approximately ten minutes**.

A1.1.1.

- a. 150 TIMES PER MINUTE
- b. AT 1/6<sup>TH</sup> OF REVOLUTION
- c. 25 TIMES EACH

- 2 Use a **snug-fitting pan and cover** on each sieve, hold the items in a **slightly inclined position** in one hand.

A1.1.2.



- 3 **Hand-shake each sieve continuously for 60 seconds** by **striking the side of the sieve sharply** with an **upward motion** against the heel of the other hand. Strike at a **rate of approximately 150 times per minute**, turning the sieve about **one sixth of a revolution** at intervals of about **25 strokes**.

A1.1.3.

- 4 If **more than 0.5 percent** by mass of the **total sample before sieving passes any sieve** after **one minute of continuous hand-sieving**, **adjust** the shaker time and re-check procedure.

A1.2.

**NOTE A1:** Excessive time (more than ten minutes) to achieve adequate sieving may result in degradation of the sample. If a shake time of over ten minutes is needed in order to meet the 0.5 percent requirement in Section A1.2, it is recommended that the shaker be thoroughly inspected, any necessary repair or maintenance be performed, and the time evaluation as described in Section A1 be redetermined.

5

In determining sieving time of **sieve sizes larger than #4**, limit the material on the **sieve to a single layer of particles**.

A1.3.

6

If the **size of the testing sieves** makes the **described sieving motion impractical**, use **8-inch diameter sieves to verify the adequacy of sieving**.

A1.4.

## OVERLOAD DETERMINATION

1

Do not exceed a mass of **4 g/in<sup>2</sup> (7 kg/m<sup>2</sup>)** of sieving surface for sieves with openings smaller than **#4** at the completion of the sieving operation.

A2.1.

2

Do not exceed a mass in **kg** (convert to grams if necessary) of the **product of 2.5 X (sieve opening in millimeters) X (effective sieving area in square millimeters)** for sieves with openings **#4** and larger. Masses are shown in **Table A2. 1.** **Avoid permanent deformation of the sieve cloth due to overloading.**

A2.2.

**NOTE A2:** The 4 g/in<sup>2</sup> (7 kg/m<sup>2</sup>) amounts to 200 grams for the usual 8-inch diameter sieve [with effective or clear sieving surface diameter 7 ½ inch] or 450 grams for a 12-inch diameter sieve [with effective or clear sieving surface diameter of 11 ½ inch].

3

The amount of material retained on a sieve may be regulated by: **(1) placing a sieve with larger openings immediately above the given sieve, (2) testing the sample in a number of increments, or (3) testing the sample over a nest of sieves with a larger sieve-frame dimension.**

A2.3.

Table A2.1—Maximum Allowable Mass of Material Retained on a Sieve, kg

Sieve Opening Size	Nominal Dimensions of Sieve <sup>a</sup>		
	203.2 mm (8 in.) dia <sup>a</sup>	254 mm (10 in.) dia <sup>a</sup>	304.8 mm (12 in.) dia <sup>a</sup>
	Sieving Area, m <sup>2</sup> (in. <sup>2</sup> )		
	0.0285 (44.2)	0.0457 (70.8)	0.0670 (103.5)
50 mm (2 in.)	3.6	5.7	8.4
37.5 mm (1½ in.)	2.7	4.3	6.3
25.0 mm (1 in.)	1.8	2.9	4.2
19.0 mm (¾ in.)	1.4	2.2	3.2
12.5 mm (½ in.)	0.89	1.4	2.1
9.5 mm (⅜ in.)	0.67	1.1	1.6
4.75 mm (No. 4)	0.33	0.54	0.80

<sup>a</sup> The sieving area for round sieves is based on an effective diameter of 12.7 mm (½ in.) less than the nominal frame diameter because ASTM E11 permits the sealer between the sieve cloth and the frame to extend 6.35 mm (¼ in.) over the sieve cloth. Thus, the effective or clear sieving diameter for a 203.2-mm (8.0-in.) diameter sieve frame is 190.5 mm (7½ in.). Sieves produced by some manufacturers do not infringe on the sieve cloth by the full 6.35 mm (¼ in.).

### AVOIDING OVERLOADING (IN MORE DETAIL)

4

Insert an **additional sieve with an opening size intermediate between** the sieve that may be **overloaded** and the **sieve immediately above** that sieve.

A2.3.1.

5

**Split the sample into two or more portions, sieving each portion individually. Combine the masses of the several portions retained on a specific sieve before calculating the percentage of the sample on the sieve.**

A2.3.2.

6

Alternatively, the **portion finer than the #4 sieve** may be **reduced** in size using a **mechanical splitter according to AASHTO R76**. If this procedure is followed, compute the **mass of each size increment adjusted to the original sample as follows**:

A2.3.2.1.

$$A = \frac{W_1}{W_2} \times B$$

**A** = mass of size increment on total sample basis;

**W<sub>1</sub>** = mass of fraction finer than #4 sieve | total sample;

**W<sub>2</sub>** = mass of reduced portion of material finer than #4 sieve actually sieved;

**B** = mass of size increment in reduced portion sieved;

7

Use sieves having a **larger frame size** and providing **greater sieving area**.

A2.3.3.

# AASHTO T329:

## MOISTURE CONTENT OF ASPHALT MIXTURES BY OVEN METHOD

### DEFINITIONS:

**Moisture Content** - to the amount of moisture present in the asphalt mixture or its components (like aggregates), expressed as a percentage of the dry mass.

**Hot Mix Asphalt (HMA)** - is a mixture of asphalt binder and heated, combined at high temperatures and compacted to form durable pavement for roads, highways, airports, and parking lots.



AASHTO T 329 provides a standardized oven-drying method to determine the moisture content in hot mix asphalt (HMA) mixtures. Moisture inflates total mass of the mix. If not corrected, your binder content by weight will appear lower than it truly is. This method is essential for ignition oven tests (e.g., AASHTO T 308), where moisture must be subtracted to avoid error.

### SCOPE:

This method is intended for the determination of moisture content of asphalt mixtures by drying in an oven.

1.1.

4.

### EQUIPMENT:

- **BALANCE** – shall have **4.4lb (2kg) capacity**, and be readable to **0.1 grams or better**.
- **SAMPLE CONTAINER** – the container in which the sample is dried shall **be of sufficient size** to contain the sample without danger of spilling and to allow the sample to be **evenly distributed** in a manner that will allow completion of the test in an efficient manner.
- **OVEN (FORCED AIR, VENTILATED, OR CONVECTION OVEN)** - of sufficient size, capable of maintaining the **temperature** of the air surrounding the sample at  $325 \pm 25$  ° F ( $163 \pm 14$  ° C).
- **THERMOMETER** – for measuring the temperature of asphalt mixtures, meeting the requirements of AASHTO M339 with a temperature range of at least  $122$  ° F to  $392$  ° F ( $50$  ° C to  $200$  ° C) and an accuracy of  $\pm 3.6$  ° F ( $\pm 2$  ° C). Refer to the procedure for additional details about this equipment.

### SAMPLE:

- An asphalt mixture sample will be obtained according to AASHTO R97.
- The sample will be reduced in size in according to AASHTO R47. The size of the test sample must be a minimum of 1000 grams.

5.1.

5.2.

### PROCEDURE:

1

Weigh and record the mass of the **SAMPLE CONTAINER** (including any material used to line the sample container) to the nearest **0.1 grams**.

6.1.



**NOTE 2:** When using paper or other absorptive material to line the sample container, ensure it is dry before determining the initial mass of the sample container. (**SECTION 6.1.**)

2

Place the **test sample** in the **sample container**. Determine and record the **TEMPERATURE** of the test sample. To assist drying, **evenly distribute the test sample** in the sample container.

6.2.

**3** Weigh and record the **TOTAL MASS** of the sample **CONTAINER AND MOISTURE** test sample to the nearest **0.1 grams**.

6.3.

**4** Dry the sample at the **job mix formula (JMF)** mixing temperature range. If no mixing temperature range is supplied, use **325 ± 25°F (163 ± 14°C)**.

6.4.

**5** Calculate the **mass of the initial, moisture test sample** by **subtracting** the **mass of the sample container** from the **total mass of the sample container and moisture test sample**.

6.5.



**NOTE 3:** For repeatability between operators and/or laboratories, the difference between drying temperatures for samples should not exceed 15°F (9°C). (SECTION 6.4.)



—



==

**INITIAL MASS OF  
TEST SAMPLE**

**6** Dry the sample initially for **90 ± 5 minutes** and then weigh its mass. **Continue to dry the sample to constant mass**, checking at **30 ± 5-minute intervals** until **further drying does not alter the mass by more than 0.05 percent**.

6.6.



**NOTE 4:** The moisture content of test samples and the number of test samples in the oven will affect the rate of drying at any given. Placing wet test samples in the oven with nearly dry test samples could affect the drying process. (SECTION 6.6.)

**7** Cool the **sample container and test sample** to **approximately the same temperature** as was previously recorded (See section 6.2).

6.7.

**8** Weigh and record the **TOTAL MASS** of the **sample container and DRY TEST SAMPLE** to the nearest **0.1 grams**.

6.8.

**9** Calculate the **mass of the final, dry test sample** by **subtracting** the **mass of the sample container** from the **total mass of the sample container and dry test sample** when constant mass has been achieved.

6.9.



**NOTE 5:** Do not attempt to remove the test sample from the sample container for the purposes of determining the dry mass of the test sample. (SECTION 6.8.)

**EXAMPLE:**

**CONSTANT MASS:** further drying does not alter the mass by **more than 0.05 percent.**

**CALCULATIONS:**

**MASS OF INITIAL TEST SAMPLE:** 1134.9 grams

**MASS OF DRIED TEST SAMPLE (after 90 minutes):** 1127.3 grams

**DETERMINE IF THE SAMPLE IS DRY (CONSTANT MASS)**

$$\frac{(1134.9 - 1127.3)}{1134.9} \times 100 = 0.67\% \text{ (rounded) mass was lost by percent.}$$

**NOT CONSTANT MASS** (altered by more than 0.05 percent)

**MASS OF DRIED TEST SAMPLE (after 30 minutes):** 1127.1 grams

**DETERMINE IF THE SAMPLE IS DRY (CONSTANT MASS)**

$$\frac{(1127.3 - 1127.1)}{1127.3} \times 100 = 0.02\% \text{ (rounded) mass was lost by percent.}$$

**CONSTANT MASS** (has not altered by more than 0.05 percent).

$$M_f = 1127.1 \text{ grams}$$

$$M_c\% = \frac{(1134.9 - 1127.1)}{1134.9} \times 100$$

**ANSWER:**  $M_c\% = 0.69\% \text{ (rounded)}$

**MOISTURE CONTENT**

$$M_c\% = \frac{(M_i - M_f)}{M_i} \times 100$$

$M_i$  = mass of the initial, moisture test sample (grams);

$M_f$  = mass of the final, dry test sample (grams);

$M_c\%$  = Moisture content (percent);

- Report the moisture content to the nearest 0.01 percent. (SECTION 8.1)

# AASHTO R68:

## PREPARATION OF ASPHALT MIXTURES BY MEANS OF THE MARSHALL APPARATUS

### DEFINITIONS:

**Laboratory Asphalt Compaction** - is the controlled process of compacting hot mix asphalt (HMA) samples using standardized equipment to simulate field conditions. The purpose is to produce consistent specimens for testing mechanical properties, volumetrics, and mix design evaluation.

**Marshall Test** - is a standardized laboratory procedure used to design and evaluate Hot Mix Asphalt (HMA). It determines the optimum asphalt binder content by analyzing how well the asphalt mixture performs under compaction and loading.



### SCOPE:

This standard practice describes procedures for the compaction of cylindrical specimens of asphalt mixtures using the Marshall compaction hammer. This practice is for use with mixtures containing asphalt binder or asphalt cutback (**cutback will not be discussed in this manual**) and aggregate up the 1-inch maximum size.

1.1

### EQUIPMENT:

3.

- **BALANCE** – meeting the requirements of M231, Class G2; readable to **0.1 grams or better**.
- **SPECIMEN MOLD ASSEMBLY** – mold cylinders **4 inch in diameter by 3-inch height, base plates, and extension collars** details shown in Figure 1 in the procedure. **Three mold cylinders** are recommended. *Refer to the procedure for additional details.*
- **SPECIMEN EXTRACTOR** – steel, in the **form of a disk with a diameter not less than 3.95 inches and ½ inch thick** for extracting the compacted specimen from the specimen mold with the use of the mold collar. **A suitable bar is required to transfer the load** from the ring dynamometer adapter to the extension collar while extracting the specimen. **A hydraulic jack or similar device** may also be used provided specimens are not damaged during extraction.
- **COMPACTION HAMMER MANUAL** – the compaction hammer shall have a **flat, 3 7/8 ± 1/8 inch (98.4 ± 3.2 mm) circular tamping face and a 10 ± 0.02 lbs. (4536 ± 9 grams) sliding weight** (including a safety finger guard of so equipped) with a **free fall of 18 ± 0.06 inches (457.2 ± 1.524 mm)**.
- **COMPACTION HAMMER AUTOMATIC** – an automatic hammer shall **meet the requirements** listed for **manual hammers (Section 3.3.1.)**. The auto hammer consists of the **mechanical compactor, an automatic counter, and a tapered-foot hammer assembly** for rotating-mold models or a **flat-foot hammer assembly** for stationary mold models.

### **HOW TO CALIBRATE AUTOMATIC HAMMERS TO MANUAL HAMMERS?**

**Compact 6 specimens on the same material: 3 using the manual hammer and 3 using the automatic hammer. Use the same number of blows for each specimen. Use AASHTO T166 (other procedures can be applicable refer to method for details) to determine the average bulk densities of the two sets of specimens. If the bulk densities of the two sets of specimens are within 2.0 percent of each other, then the results are comparable. If the results are not within this then the tests need to be repeated using more or fewer blows on the automatic hammer to achieve a comparable density.**

**The Marshall Test is essential and cost effective for designing durable, stable, and high-performing asphalt mixtures. It ensures the right balance between strength, flexibility, and void structure, and it remains one of the most trusted methods for mix design and quality control. The industry uses the Marshall Test to help understand the stability and the flow of asphalt mixtures as well as being crucial in understanding volumetric properties such as densities and air voids in materials.**

- **COMPACTION PEDESTAL** – the compaction pedestal shall consist of an 8in X 8in X 18in (203.2mm X 203.2mm X 457.2mm) wooden post capped with a steel plate with minimum dimensions of 12in X 12in X 1in (304.8mm X 304.8mm X 25.4 mm). The wooden post shall be secured by 4 angle brackets to a solid concrete slab. The steel cap shall be firmly fastened to the post. **The pedestal assembly shall be installed so that the post is plumb and the cap is level.**
- **SPECIMEN MOLD HOLDER** – mounted on the compaction pedestal so as to center the compaction mold over the center of the post. It must hold the compaction mold, collar, and base plate securely in position during compaction of the specimen.
- **OVEN or HOT PLATES** – ovens or hot plates shall be provided for heating aggregates, asphalt material, specimen molds, compaction hammers, and other equipment to the required mixing and molding temperatures. Suitable shields, baffle plates, or sand baths shall be used on the surfaces of the hot plates to minimize localized overheating. Properly standardized ovens or hot plates shall be capable of reaching and maintaining a temperature of  $392 \pm 5.4$  ° F ( $200 \pm 3$  ° C).
- **THERMOMETER (OVEN VERIFICATION)** – meeting the requirements of AASHTO M339 with a temperature range of at least 122° F to 392 ° F (50° C to 200 ° C) and an accuracy of  $\pm 1.35$  ° F ( $\pm 0.75$  ° C). *Refer to the procedure for additional details about this equipment.*
- **HEATING DEVICE** – a small hot plate with continuously variable heating rate, a sand bath, infrared lamp, or other suitable device shall be available for supplying sufficient heat under the mixing bowl to maintain the aggregate and asphalt material at the desired temperature during mixing. If a hot plate is used, a wire mesh or similar material shall be placed on the hot plate to prevent direct contact between the hot plate and mixing bowl.
- **MIXING APPARATUS** – mechanical mixing is recommended. Any type of mechanical mixer may be used provided it can be maintained at the required mixing temperature and will produce a well coated, homogeneous mixture of the required amount in the allowable time, and further provided that essentially all of the batch can be recovered. A metal pan or bowl of sufficient capacity and hand mixing may also be used.
- **AIR BATH** – air bath for asphalt cutback mixtures. *Refer to the procedure for additional details about this equipment.*
- **THERMOMETER (TEMPS OF AGGREGATES, BINDER, AND MIXTURES)** – for measuring the temperature of asphalt mixtures, meeting the requirements of AASHTO M339 with a temperature range of at least 122° F to 392 ° F (50° C to 200 ° C) and an accuracy of  $\pm 4.5$  ° F ( $\pm 2.5$  ° C). *Refer to the procedure for additional details about this equipment.*
- **MISCELLANEOUS EQUIPMENT** – flat-bottom metal pans or other suitable containers for heating aggregates, containers (various) for heating asphalt, flat bottom scoop for batching aggregates, steel trowel (garden type) or spatula for spading and hand mixing, gloves for handling hot equipment, paper disks, marking crayons for identifying specimens, and a large spoon for placing mixture in specimen molds.

## PROCEDURE:

- **NUMBER OF CYLINDRICAL SPECIMENS** – prepare at least three cylindrical specimens for each combination of aggregates and bitumen content.

4.1.





3

Mix the aggregates in each pan and place the pans on a hot plate or in the oven and heat to a temperature not exceeding the mixing temperature (See Section 4.3) by more than approximately 50° F (28° C) for asphalt mixtures (refer to procedure for temperatures relating to Asphalt Cutback mixes).

4.4.3.

4

Heat an adequate amount of asphalt material, for the batch, in a separate container to the established mixing temperature. The weight by mass can be achieved by calculation. EXAMPLE:

4.4.4.

$$\text{Equation 5: } \left[ \begin{array}{l} \text{Weight of} \\ \text{Asphalt Binder} \end{array} \right] = \frac{\left[ \begin{array}{l} \text{Weight of Aggregate} \\ \text{and Mineral Admixture} \end{array} \right]}{100 - \left[ \begin{array}{l} \text{Percent of} \\ \text{Asphalt Binder} \end{array} \right]} \times \left[ \begin{array}{l} \text{Percent of} \\ \text{Asphalt Binder} \end{array} \right]$$

Example (for Marshall specimens with 4.5% Asphalt Binder) (See Note 4):

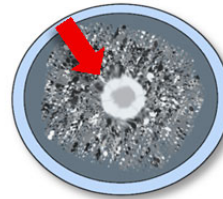
$$\left[ \begin{array}{l} \text{Weight of} \\ \text{Asphalt Binder} \end{array} \right] = \frac{3333}{100 - 4.5} \times 4.5 = 157.1 \text{ grams}$$

5

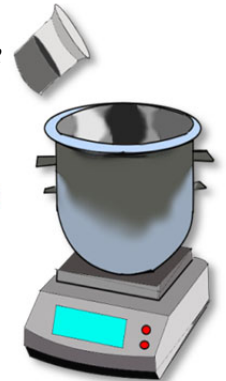
Introduce the heated aggregate into the mixing bowl. Form a crater in the dry blended aggregate and weigh the required amount of asphalt material into the mixture. Prevent loss of the mix during mixing and subsequent handling. At this point, the temperature of the aggregate and asphalt material must be within the limits of the mixing temperature (See Section 4.3.) (refer to procedure for details relating to Asphalt Cutback mixes).

4.4.5.

CRATER



BINDER



INTRODUCED HEATED AGGREGATE INTO THE BOWL. CREATE A CRATER IN THE CENTER OF THE AGGREGATE ADD ASPHALT MATERIAL (BINDER) INTO THE CRATER

6

Mix the aggregate and asphalt material rapidly until thoroughly coated. Maintain proper mixing temperature. (Refer Section 3.8)

4.4.6.

7

Cure mixtures containing asphalt binder according to AASHTO R30.

4.4.7.

8

Curing asphalt cutback mixtures (refer to procedure for details relating to Asphalt Cutback mixes).

4.4.8.



MIX RAPIDLY UNTIL THOROUGHLY COATED. CURE SAMPLE FOR THE APPROPRIATE AMOUNT OF TIME

### PLANT PREPARED MIXTURES

PREPARATION:

1

Obtain the sample according to AASHTO R97.

4.5.1.

2

Reduce the sample according to AASHTO R47 to a test sample size that will result in compacted specimen 2.5 ± 0.05 in (63.5 ± 1.27mm) in height (approximately 1200 grams) (see section 4.4.2).

4.5.2.

3

Place the sample into a pan to a uniform thickness.

4.5.3.


4


Bring the asphalt mixture to the compaction temperature range by careful, uniform heating in an oven immediately prior to compaction.


4.5.4.


## COMPACTION


- 1** Thoroughly clean the specimen mold assembly and the face of the compaction hammer and heat them either in boiling water, on the hot plate, or in an oven, to a temperature between 200° F to 300 ° F (93.3° C to 148.9 ° C).


4.6.1. 
- 2** Place a piece of filter paper or paper towel, cut to size, in the bottom of the mold before mixture is introduced.


4.6.2.  PLACE THE FILTER PAPER INTO A CLEAN MARSHALL MOLD
- 3** Place the entire batch in the mold, and spade the mixture vigorously with a heated spatula or trowel 15 times around the perimeter and 10 times over the interior. Smooth the surface of the mix with a trowel to a slightly rounded shape.


4.6.3.  PLACE ENTIRE BATCH INTO THE MOLD
- 4** Temperatures of the mixtures immediately prior to compaction must be within the limits of the compaction temperature (See Section 4.3.)


4.6.3.  If the temperature of the specimen is too high, allow the specimen to cool within the range of compaction temperatures; however, if the mixture is below compaction temperature, remove the mixture from the mold and replace it in the oven until the desired temperature is reached. This process should not be repeated more than once. The material should be heated for the minimum time required to achieve the compaction temperature. (SECTION 4.6.3.)

 **NOTE 4:** Excessive heating times may cause oxidation and loss of volatiles and should be avoided. (SECTION 4.6.3.)
- 5** Place a piece of filter paper or paper toweling cut to size on top of the mixture and place the mold assembly on the compaction pedestal in the mold holder.

4.6.4.  SPADE 15 TIMES VIGOROUSLY AROUND THE PERIMETER AND 10 TIMES OVER THE INTERIOR

 **ROUNDED**

 Hold the axis of the compaction hammer perpendicular to the base of the mold assembly during compaction. (SECTION 4.6.4.)

 SMOOTH THE SURFACE TO A SLIGHTLY ROUNDED SHAPE AND ENSURE THAT THE MIXTURE IS WITHIN THE COMPACTION TEMPERATURE RANGE
- 6** Unless otherwise specified, apply 50 or 75 blows with the compaction hammer with a free fall in 18 inches.

4.6.4.

7

Remove the base plate and collar, and reverse and reassemble the mold. Apply the same number of compactions blows to the face of the reversed specimen.

4.6.4.

8

After compaction, remove the base plate, carefully extract the cylindrical specimen from the mold and transfer to a smooth, flat surface.

4.6.5.

9

Allow the cylindrical specimen to stand overnight at room temperature

4.6.6.

OR

NOTE 5: table fans may be used to cool the specimen quicker. Mixtures that may not maintain its required cylindrical shape if removed from the mold immediately after compaction may be cooled in the mold in air until sufficient cohesion has developed to result in the proper cylindrical shape.

PLACE THE FILTER PAPER ONTO THE FRESHLY SPADED SAMPLE



PLACE THE MOLD APPROPRIATELY IN THE COMPACTION PEDASTAL. UNLESS OTHERWISE SPECIFIED APPLY 50 TO 75 BLOWS



REMOVE THE BASE PLATE & COLLAR. FLIP THE MOLD OVER AND REASSEMBLE THEN REPEAT



AFTER COMPACTION IS COMPLETE CAREFULLY EXTRUDE CYLINDRICAL SPECIMEN, REMOVE PAPER, AND ALLOW TO COOL

# AASHTO T312:

## PREPARING AND DETERMINING THE DENSITY OF ASPHALT MIXTURE SPECIMENS BY MEANS OF THE SUPERPAVE GYRATORY COMPACTOR

### DEFINITIONS:

Gyratory Asphalt Compaction - refers to the process used in laboratory settings to compact hot-mix asphalt specimens using a gyratory compactor—a device that applies a combination of constant vertical pressure and rotational (kneading) motion at a slight angle.

Asphalt Density - is defined as the mass per unit volume of the pavement, typically measured in pounds per cubic foot (lbs/ft<sup>3</sup>) or kilograms per cubic meter (kg/m<sup>3</sup>) is expressed as a percentage of the theoretical maximum specific gravity (G<sub>mm</sub>) of the mix—this ratio indicates how close the compaction is to the ideal, void-free state



The system may include a connected computer (with suitable software) & printer capable of reporting, acquiring data, and printing test information, such as specimen height per gyration.



### SCOPE:

This standard covers the compaction of cylindrical specimens of asphalt mixtures using the Superpave gyratory compactor.

1.1.

### EQUIPMENT:

4.

- **SUPERPAVE GYRATORY COMPACTOR**- an electrohydraulic or electromechanical compactor with a **ram and ram heads**. The **axis of the ram** shall be **perpendicular to the platen of the compactor**. The ram must apply and maintain a pressure of **600 ± 18 kPa perpendicular to the cylindrical axis** of the **specimen** during compaction (**NOTE 1**). The **compactor** shall **tilt** the specimen molds at an **average internal angle of 20.2 ± 0.35 mrad (1.16 ± 0.02 degrees)**. The compactor will **gyrate** the specimen molds at a rate of **30.0 ± 0.5 gyrations per minute throughout compaction**. **NOTE 1:** This stress calculates to 10600 ± 310 N total force for 150mm specimens. **Refer to the procedure for additional details.**
- **SPECIMEN HEIGHT MEASUREMENT AND RECORDING DEVICE** – when **specimen density** is to be **monitored** during compaction, a means will be provided to **continuously measure and record the height** of the specimen to the **nearest 0.1mm** during compaction **once per gyration**. The loading system, ram, and pressure indicator must be capable of providing and measuring a **constant vertical pressure of 600 ± 60 kPa** during the first five gyrations, and **600 ± 18 kPa** during **the remainder of the compaction period**. **Refer to the procedure for additional detail on this equipment.**
- **SPECIMEN MOLDS** – **molds** must have **steel walls** that are at least **7.5mm thick** and are hardened (**See Rockwell Hardness AASHTO**). New molds shall be manufactured to have an **inside diameter of 149.90 mm to 150.00 mm**. The **inside diameter** of in-service molds shall **not exceed 150.2mm**. Molds must be **at least 250 mm in length**. The inside diameter and length of the molds will be measured in **accordance with Annex A**. **Refer to the procedure for additional details.**
- **RAM HEADS & END PLATES**- Ram heads and end plates shall be fabricated from **steel and hardened** (**See Rockwell Hardness AASHTO**). The **ram heads** must stay **perpendicular to their axis**. The **platen side of each end plate will be flat and parallel to its face**. **All ram and end plate faces** (the sides presented to the specimen) must be **flat to meet the smoothness requirements in the procedure** and must have a **diameter of 149.50 mm to 149.75 mm**. **Refer to the procedure for additional details.**

This standard is used to prepare specimens for determining the mechanical and volumetric properties of asphalt mixtures. The specimens simulate the density, aggregate orientation, and structural characteristics obtained in the actual roadway in the placement of the paving mix. This test method may be used to monitor the density of test specimens during their preparation. It may also be used for field control of an asphalt mixture production process. This procedure is generally considered more accurate than the Marshall test.

**EQUIPMENT CONTINUED:**

- **OVEN**– thermostatically controlled to **maintaining** a temperature of  $\pm 3^{\circ}\text{C}$ , for heating aggregates, binder, asphalt mixtures, and equipment as required. The oven shall be capable of maintaining the temperature required for mixture condition in accordance with AASHTO R30.
- **BALANCE** – meeting the requirements of M231, Class G5, and be readable to the **nearest 1 gram**.
- **THERMOMETER (MEASURING AGGREGATES, BINDER, AND ASPHALT)**– meeting the requirements of AASHTO M339 with a temperature range of at least  $10^{\circ}\text{C}$  to  $230^{\circ}\text{C}$  and an accuracy of  $\pm 2.5^{\circ}\text{C}$ . Refer to the procedure for additional details.
- **MISCELLANEOUS EQUIPMENT** – Flat bottom metal pans for heating aggregates, scoop for batching aggregates, containers (grill type tins, beakers, containers for heating asphalt), large mixing spoon or small trowel, large spatula, gloves for handling hot equipment, paper disks, mechanical mixer (optional), lubricating materials recommended by the compactor manufacturer.

**STANDARDIZATION:**

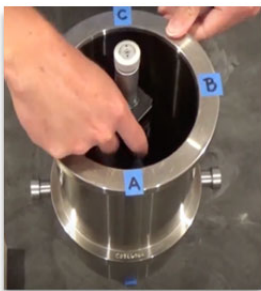
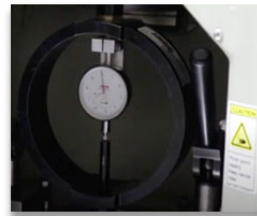
- Items requiring periodic verification of calibration include the **ram pressure, angle of gyration, gyration frequency, LVDT (or other means used to continuously record the specimen height), and oven temperature** (See procedure for details on calibration methods and frequencies).

6.1.

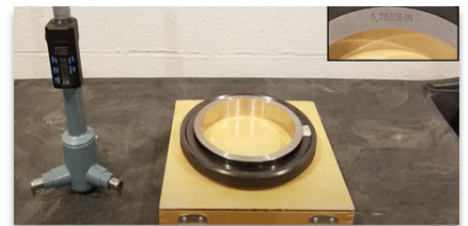


- Verification of the **mold and platen dimensions** and the **inside finish of the mold** are also required. (See procedure for details on calibration methods and frequencies).

6.1.



**VARIOUS STAGES OF CALIBRATION & VERIFICATION OF GYRATORY COMPACTOR & EQUIPMENT**



- For **computer and software, periodically verify the data processing system output** using an established procedure.

6.1.

- **Verification of calibration, system standardization, and quality checks may be performed by the manufacturer, other companies providing such services, or in house personnel.** Frequency of verification shall follow the manufacturer's recommendations or other governing documents.

6.1.



- The **angle of gyration** refers to the internal angle (*the tilt of the mold with respect to the end plate surface with the gyratory mold*). The **calibration of the internal angle of gyration shall be verified**.

6.2.

**PREPARATION OF APPARATUS  
(GYRATORY COMPACTOR & EQUIP):**

- Immediately prior to the time when the asphalt mixture is ready for placement in the mold, **switch on the gyratory compactor** and allow the **machine to warm up** (*see manufactures instructions*).

7.1.

- Verify the machine **settings** are **correct** for **angle, pressure, and number of gyrations**.

7.2.

4. **SWITCH ON & ALLOW TO WARM UP**

- Lubricate any **bearing surfaces** as needed per the manufacturer's instructions.

7.3.



3. **VERIFY MACHINE SETTINGS (ANGLE, PRESSURE, NUMBER OF GYRATIONS)**



2. **LUBRICATE BEARING SURFACES**

1. **CHECK DEVICE USED FOR MEASURING AND RECORDING THE HEIGHT AND MAKE SURE THAT IT IS READY**

- When specimen height is monitored, **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.

7.4.

**LABORATORY PREPARED MIXTURES**

**PREPARATION OF ASPHALT MIXTURE:**

- Obtain and dry aggregate to constant mass. Weigh the appropriate **aggregate fractions** and place into a **separate pan**, combining **them to the desired batch weight**. The **batch weight will vary based on the final characteristics or properties of the test specimens**.

8.1.1.



*A more detailed explanation of the procedure for LABORATORY PREPARED MIXTURES (with illustrations) is found in AASHTO R68.*

- If a **target air void level** is desired (*Superpave mix analysis and performance specimens require this targeting*) batch weights will be **adjusted to create a given density in a known volume**. Meaning If a specific target air void level is needed for a particular asphalt mix, a change in how much material is used may be necessary to fit the required sample size and provide the correct known density.

8.1.1.

3

If the **specimens** are used for the **determination of volumetric properties**, the **batch weights will be adjusted to result in a compacted specimen** having dimensions of **150mm in diameter and 115 ± 5 mm in height** at the **desired number of gyrations**.

8.1.1.



**NOTE 4:** *It may be necessary to produce a trial specimen to achieve this height requirement. Generally, 4500 to 4700 grams of aggregate are required to achieve this height for aggregates with combined bulk specific gravities of 2.550 to 2.700, respectively. (SECTION 8.1.1.)*

4

Place the **aggregate and binder container in the oven**, and **heat** them to the required **mixing temperature**.

8.1.2.

5

The **mixing temperature range** is defined as the range of temperatures where the **unaged binder has a viscosity of 0.17 ± 0.02 Pa-s**. (See AASHTO T316)

8.1.2.1.



**NOTE 5:** *Modified asphalt binder may not adhere to the Equi viscosity requirements noted, and the manufacturer's recommendations should be used to determine mixing and compaction temperatures. (SECTION 8.1.2.1)*

6

**Introduce the heated aggregate (from a single pan) to the mixing bowl and dry-mix** thoroughly. **Form a crater** in the dry-blended aggregate, and **weigh** the required amount of **binder** into the mix. **Immediately begin mixing**.

8.1.3.

7

**Mix the aggregate and binder as quickly and thoroughly as possible**. Ensure that the asphalt mixture has a **uniform distribution of binder**. Mechanical mixing may be used.

8.1.4.

8

After completing the mixture preparation, perform the required **mixture conditioning**. (Refer to AASHTO R30)

8.1.5.

9

Place the **compaction mold(s) in an oven** at the required **compaction temperature** for a **minimum of 30 minutes** prior to the estimated **beginning of compaction** (See AASHTO R30). Place any additional compaction surfaces, such as **base plates and upper plates into the oven** with and for the same time frame as the **molds** (See *manufacturer's instruction*).

8.1.6.

10

Following conditioning period (See AASHTO R30), if the mixture is at the **compaction temperature**, **proceed** immediately with the **compaction procedure** (See Section 9). If the **compaction temperature** is **different** from the **mixture conditioning temperature** place the mix in another **oven** at the **compaction temperature** for a brief time (**maximum of 30 minutes**) to achieve the required temperature.

8.1.7.

11

The **compaction temperature** is the midpoint of the range of temperatures where the unaged binder has a **viscosity of  $0.28 \pm 0.03$  Pa.s**. (Refer to AASHTO T316) See Note 5.

8.1.7.1

### PLANT PREPARED MIXTURES

1

Place the **compaction mold(s)** in an **oven** at the **required compaction temperature** (See Section 8.1.7.1). Place any **additional compaction surfaces**, such as base plates and upper plates, into the oven with and for the same time frame as the molds.

8.2.1.

2

Obtain the **asphalt mixture sample** according to AASHTO R97.

8.2.2

HEAT EQUIPMENT TO REQUIRED COMPACTION TEMPERATURE



3

Reduce the sample to testing size according to AASHTO R47.

8.2.3

4

Place the **sample into a pan** to a **uniform thickness**.

8.2.4

PLACE SAMPLE IN PAN TO A UNIFORM THICKNESS



5

Bring the asphalt mixture to the **compaction temperature range** by careful, **uniform heating** in an **oven immediately prior to molding**.

8.2.5

### COMPACTION

1

When the **compaction temperature is achieved**, **remove** the heated **mold** and any **compaction surfaces** from the **oven**. Place the **base plate** and a **paper disk** in the **bottom of the mold**.

9.1.

2

Place the **mixture** into the **mold** in **one lift**. **Avoid segregation** of the material when placing in the mold.

9.2.

3

After all the material is in the mold, **level the top**, and **place another paper disk on top of the leveled material**.

9.2.



4

Place the **top plate** into the mold and **load** the mold into the **compactor**, **center** the loading ram according to the manufacturer's instructions.

9.2.

5

Apply a pressure of  $600 \pm 18$  kPa on the specimen.

9.3.

6

Apply a  $20 \pm 0.35$  mrad ( $1.16 \pm 0.02$  degrees) average internal angle to the mold assembly and begin the gyratory compaction.

9.4.

7

Allow the **compaction** to proceed until the **desired number of gyrations** (refer to *AASHTO R35* for additional detail) is reached and the gyratory mechanism shuts off.

9.5.



8

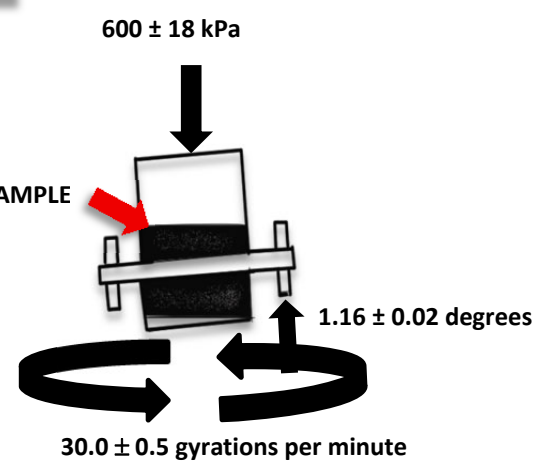
**Remove the angle** from the mold assembly, remove the **ram pressure**, and **retract the loading ram** in the order specified by the manufacturer (the preceding steps may be done automatically by the compactor on some models). **Remove the mold from the compactor** (if required) and **extrude the specimen from the mold**.

9.6.



**NOTE 6:** No additional gyrations with the angle removed are required unless specifically called for in another standard referencing *AASHTO T312*. The extruded specimen may not be a right-angle cylinder. Specimen ends may need to be sawed to conform to the requirements of specific performance tests. (**SECTION 9.6**)

GYRATORY SAMPLE



9

Remove the **paper disks** from the **TOP and BOTTOM** of the specimens.

9.7.



**NOTE 7:** The specimens can be extruded from the mold immediately after compaction for most asphalt mixtures. However, a cooling period of **5 to 10 minutes in front of a fan** may be necessary before extruding some specimens to ensure they are not damaged. (**SECTION 9.6**)



**NOTE 8:** Before reusing the mold, place it in an oven for **at least 5 minutes**. The use of multiple molds will speed up the compaction process. (**SECTION 9.7**)

## DENSITY PROCEDURE

- Use a **companion sample** to determine the **maximum specific gravity ( $G_{mm}$ )** of the loose mix **according to AASHTO T209**. The **companion sample** must be **conditioned the same** as the **compaction sample** or **split out from the same asphalt mix** obtained. 10.1.
- Determine the **bulk specific gravity ( $G_{mb}$ )** of the specimen **according to AASHTO T166** (*refer to the procedure for other AASHTO methods on bulk specific gravity*). 10.2.
- When the specimen height is monitored, **record the specimen height** to the nearest **0.1 mm** after each revolution. 10.3.

## DENSITY CALCULATIONS

- Calculate the **uncorrected relative density ( $\% G_{mmux}$ )** at any point in the compaction process using the following equation:

### UNCORRECTED RELATIVE DENSITY (ANY POINT DURING COMPACTION)

$$\%G_{mmux} = \frac{W_m}{V_{mx} \times G_{mm} \times G_m} \times 100$$

$\% G_{mmux}$  = uncorrected relative density at any point during compaction expressed as a percent of the maximum theoretical specific gravity;

$W_m$  = mass of the specimen, grams;

$G_{mm}$  = theoretical maximum specific gravity of the mix;

$G_m$  = unit weight of water,  $1 \text{ g/cm}^3$ ;

$x$  = number of gyrations;

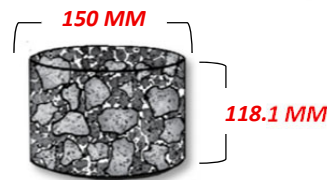
$V_{mx}$  = volume of the specimen, in  $\text{cm}^3$ , at any point based on the diameter ( $d$ ) and height ( $h_x$ ) of the specimen at that point (use "mm" for height and diameter measurements);

EQUATION FOR  $V_{mx}$ :

$$V_{mx} = \frac{\pi \times d^2 \times h_x}{4 \times 1000}$$



**NOTE 9:** this formula gives the volume in  $\text{cm}^3$  to allow a direct comparison with the specific gravity. (SECTION 9.7)



WHAT IS THE (UNCORRECTED) RELATIVE DENSITY AT 159 GYRATIONS?

EXAMPLE:

DIAMETER: 150 MM

HEIGHT (HEIGHT AT 159 GYRATIONS): 118.1 MM

$$V_{mx} = \frac{\pi \times 150.0^2 \times 118.1}{4 \times 1000}$$

$V_{mx} = 2086.0$  (rounded to 0.1  $\text{cm}^3$ )

$W_m = 4500$  grams

$G_{mm} = 2.397$

$G_m = 1 \text{ g/cm}^3$

$$\%G_{mmux} = \frac{4500}{(2086.0 \times 2.397 \times 1)} \times 100$$

ANSWER ( $\% G_{mmux}$ ): 90.0% (rounded to nearest 0.1 %)

**EXAMPLE GYRATORY PRINTOUT:**

	0	1	2	3	4	5	6	7	8	9
0	148.8	143.2	143.4	140.3	138.3	136.7	135.5	134.4	133.5	132.7
10	132.0	131.4	130.8	130.3	129.8	129.4	129.0	128.6	128.2	127.9
20	127.6	127.3	127.1	126.8	126.5	126.3	126.1	125.9	125.7	125.5
30	125.3	125.1	124.9	124.8	124.6	124.5	124.3	124.2	124.0	123.9
40	123.8	123.7	123.8	123.4	123.3	123.2	123.1	123.0	122.8	122.8
50	122.7	122.6	122.5	122.4	122.3	122.2	122.1	122.1	122.0	121.9
60	121.8	121.7	121.7	121.6	121.5	121.5	121.4	121.3	121.3	121.2
70	121.1	121.1	121.0	121.0	120.9	120.8	120.8	120.7	120.7	120.6
80	120.6	120.5	120.5	120.4	120.4	120.3	120.3	120.2	120.2	120.1
90	120.1	120.1	120.0	120.0	119.9	119.9	119.9	119.8	119.8	119.7
100	119.7	119.7	119.6	119.6	119.5	119.5	119.4	119.4	119.4	119.4
110	119.3	119.3	119.2	119.2	119.2	119.2	119.1	119.1	119.1	119.1
120	119.0	119.0	118.9	118.9	118.9	118.9	118.8	118.8	118.8	118.8
130	118.8	118.7	118.7	118.7	118.6	118.6	118.6	118.5	118.5	118.5
140	118.5	118.4	118.4	118.4	118.4	118.4	118.3	118.3	118.3	118.3
150	118.2	118.2	118.2	118.2	118.2	118.2	118.1	118.1	118.1	118.1
160	118.0									

HEIGHT AT 112 GYRATIONS

HEIGHT AT 159 GYRATIONS

FINAL HEIGHT



**WHAT IS THE  
(CORRECTED)  
RELATIVE DENSITY  
AT 112 GYRATIONS?**

EXAMPLE:

$$G_{mb} = 2.418$$

$$G_{mm} = 2.534$$

$$H_m = 118.0 \text{ mm}$$

$$H_{112} = 119.3 \text{ mm mm}$$

At the completion of the bulk specific gravity test ( $G_{mb}$ ), determine the relative density ( $\%G_{mmx}$ ) at any point in the compaction process as follows:

**CORRECTED RELATIVE DENSITY (ANY POINT DURING COMPACTION)**

$$\%G_{mmx} = \frac{(G_{mb} \times H_m)}{(G_{mm} \times H_x)} \times 100$$

$\%G_{mmx}$  = corrected relative density expressed as a percent of the maximum theoretical specific gravity;

$G_{mb}$  = bulk specific gravity of the extruded specimen;

$H_m$  = height in millimeters of the extruded specimen;

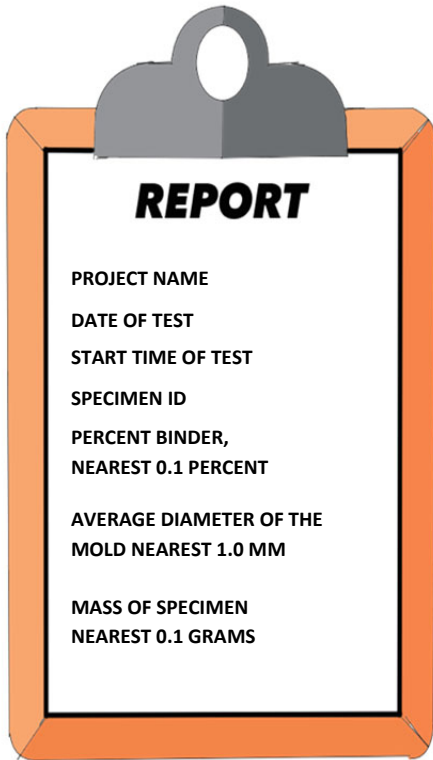
$H_x$  = height in millimeters of the specimen after x gyrations;

$G_{mm}$  = theoretical maximum specific gravity of the mix;

$$\%G_{mmx} = \frac{(2.418 \times 118.0)}{(2.534 \times 119.3)} \times 100$$

ANSWER ( $\% G_{mmx}$ ): 94.4 %

(rounded to nearest 0.1 %)



**REPORT**

PROJECT NAME

DATE OF TEST

START TIME OF TEST

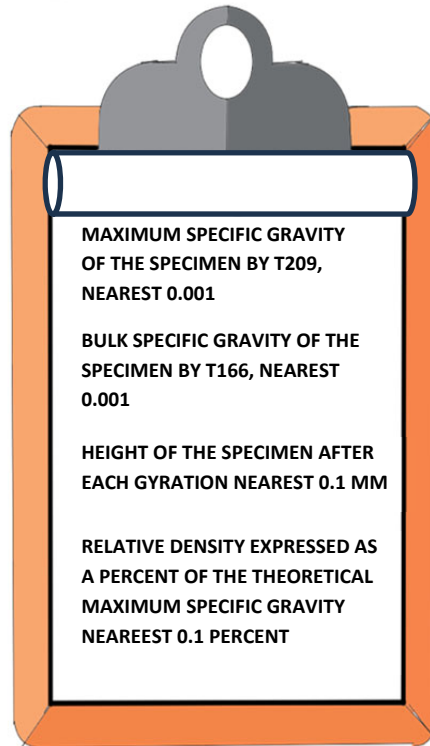
SPECIMEN ID

PERCENT BINDER,  
NEAREST 0.1 PERCENT

AVERAGE DIAMETER OF THE  
MOLD NEAREST 1.0 MM

MASS OF SPECIMEN  
NEAREST 0.1 GRAMS

12.



MAXIMUM SPECIFIC GRAVITY  
OF THE SPECIMEN BY T209,  
NEAREST 0.001

BULK SPECIFIC GRAVITY OF THE  
SPECIMEN BY T166, NEAREST  
0.001

HEIGHT OF THE SPECIMEN AFTER  
EACH GYRATION NEAREST 0.1 MM

RELATIVE DENSITY EXPRESSED AS  
A PERCENT OF THE THEORETICAL  
MAXIMUM SPECIFIC GRAVITY  
NEAREST 0.1 PERCENT

# AASHTO T209:

## THEORETICAL MAXIMUM SPECIFIC GRAVITY ( $G_{mm}$ ) AND DENSITY OF ASPHALT MIXTURES

### DEFINITIONS:

**Density (as determined by this method)** – the mass of a cubic meter ( $\text{kg} / \text{m}^3$ ) of the material at 77 °F (25 °C), or the mass of a cubic foot ( $\text{lb} / \text{ft}^3$ ) of the material at 77 °F (25 °C).

**Residual Pressure (as employed by this method)** – the pressure in a vacuum vessel when vacuum is applied.

**Specific Gravity (as determined by this method)** – the ratio of a given mass of material at 77 °F (25 °C) to the mass of an equal volume of water at the same temperature.



The theoretical maximum specific gravity and density of asphalt mixture are intrinsic properties. The theoretical maximum specific gravity tells you how dense a hot mix asphalt (HMA) mixture would be if it had no air voids. These properties are used to calculate percent air voids in compacted asphalt mixture. These properties provide target values for the compaction of asphalt mixture. These properties are essential when calculating the amount of asphalt binder absorbed by the internal porosity of the individual aggregate particles in asphalt mixture.

### SCOPE:

This test method covers the determination of the theoretical maximum specific gravity/ gravity mix maximum ( $G_{mm}$ ) and density of uncompact asphalt mixture at 77 °F (25 °C).

**NOTE 1:** The precision of the method is best when the procedure is performed on samples that contain aggregates that are completely coated. In order to assure complete coating, it is desirable to perform the method on samples that are close to the optimum asphalt binder content.

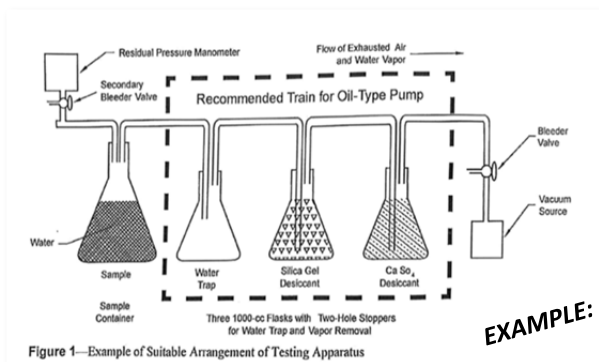
1.1

### EQUIPMENT:

5.

- **VACUUM CONTAINER-** the vacuum containers described must be capable of withstanding the full vacuum applied, and each must be equipped with the fittings and other accessories required by the test procedure. The opening in the container leading to the vacuum pump must be covered by a piece of #200 wire mesh. The capacity of the vacuum container should be between 2000 and 10000 mL and depends on the minimum sample size requirements given in the procedure (See Section 6.3.). Avoid using a small sample in a large container. (See procedure for additional details).
- **BOWL FOR MASS DETERMINATION IN WATER ONLY (SECTION 11.1)** – either a metal or plastic bowl with a diameter of approximately 7 to 10 inches (180 to 260 mm) and a bowl height of at least 6.3 inches (160mm) equipped with a transparent cover fitted with a rubber gasket and a connection for the vacuum line. (See procedure for additional details).
- **FLASK FOR MASS DETERMINATION IN AIR ONLY (SECTION 11.2)** – a thick-walled volumetric glass flask with a factory-inscribed line and a rubber stopper with a connection for the vacuum line.
- **PYCNOMETER FOR MASS DETERMINATION IN AIR ONLY (SECTION 11.2)** – a glass, metal, or plastic pycnometer with a volume determined by use of a glass capillary stopper, capillary lid, or glass plate.
- **BALANCE** – a balance conforming to the requirements of M 231, Class G2, nearest 0.1 grams. Must be standardized every 12 months.
  - For the mass determination in water method (Section 11.1), the balance must be equipped with a suitable apparatus and holder to determine the mass of the sample while suspended below the balance. Ensure that the wire suspending the holder is the smallest practical size to minimize any possible effects of a variable immersed length.
- **VACUUM PUMP OR WATER ASPIRATOR** – Capable of evacuating air from the vacuum container to a residual pressure of 3.4 kPa (25 mmHg). When an oil vacuum pump is used, a suitable trap of one or more filter flasks, or equivalent, must be installed between the vacuum vessel and vacuum source to reduce the amount of water vapor entering the vacuum pump. (See procedure for additional details).

- **VACUUM MEASUREMENT DEVICE** – residual pressure **manometer** or **vacuum gauge** is directly connected to the vacuum vessel and capable of **measuring residual pressure down to 3.4 kPa (25 mmHg) or less (preferably zero)**. The device must be standardized at least annually and be **readable to at least 0.2 kPa (2 mmHg)**. It shall be connected at the end of the vacuum line using an appropriate tube and either a “T” connector on the top of the vessel or a separate opening (from the vacuum line) in the top of the vessel to attach the hose. To avoid damage, the **manometer must not be situated on top of the vessel**. (*See procedure for additional details*).



**NOTE 3:** an example of a suitable arrangement of the testing equipment is shown in figure 1. In the figure, the purpose of the train of small filter flasks is to trap water vapor from the vacuum container that otherwise would enter the oil in the vacuum pump and decrease the pump's ability to provide adequate vacuum. (**SECTION 5.5**)

- **BLEEDER VALVE** – attached to the vacuum train to enable adjustment of the vacuum being applied to the vacuum container. (*See procedure for additional details*).
- **THERMOMETER (MASS DETERMINATION IN AIR & WATERBATH)** –for measuring the temperature of the mass determination in air. Meets requirements for M339 with a temperature range of **at least 68 °F and 113 °F (20 °C and 45 °C)** and an **accuracy of ± 0.45 °F (± 0.25 °C)**. (*See procedure for additional details*).
- **DRYING OVEN** – a thermostatically controlled drying oven capable of **maintaining a temperature of 275 ± 9 °F (135 ± 5 °C) or 221 ± 9 °F (105 ± 5 °C)**. Oven(s) for heating and drying must operate at the temperatures required as corrected, if necessary, by standardization. (*See procedure for additional details*).
- **WATER BATH** – of sufficient size, capable of maintaining a uniform temperature to determine the mass determination in water at **77 ± 2°F (25 ± 1 °C)**. **FOR BOWLS:** a water bath capable of maintaining a **constant temperature between 68 °F and 86°F (20°C and 30°C)** is required. **When using the mass determination in water technique (Section 13.1)**, the water bath must be **suitable for immersion of the suspended container** with its de-aerated sample.
- **THERMOMETER (VERIFYING OVEN)** – meets the criteria for M339, with a temperature range of **at least 194 °F and 302 °F (90 °C and 150 °C)** and an **accuracy of ± 2.25 °F (± 1.25 °C)**. (*See procedure for additional details*).
- **PROTECTIVE GLOVES** – used when **handling** glass equipment under vacuum.
- **LID** – or glass capillary stopper, capillary lid, or glass plate to ensure all entrapped air is removed for Flasks & Pycnometers. (*See procedure for details*)

## PLANT PRODUCED

- Obtain the asphalt mixture sample according to AASHTO R97 or AASHTO R67 (CORES) if testing is to be performed on cores. 6.1.1.
- Reduce the obtained sample down to testing size according to AASHTO R47. 6.1.2.

### SAMPLING PREP:

- Plant produced samples may be short term conditioned according to AASHTO R30 as specified by the agency (NOTE 7). 7.2.1



**NOTE 7:** short term conditioning at the specified temperature is especially important when absorptive aggregates are used. This short-term conditioning will ensure realistic values for the amount of asphalt absorbed by the aggregate and void properties of the mix. Plant produced asphalt mixtures should be evaluated to make sure short-term conditioning has taken place during production and delivery. (SECTION 7.2.1.)

### SAMPLING:



## LABORATORY PRODUCED

- When needed, reduce samples prepared or produced in a laboratory according to AASHTO R47. 6.2.1.
- The size of the sample must conform to Table 1. Samples larger than the capacity of the container may be tested a portion at a time. Results will be combined by calculating the weighted average ( $G_{mm(avg)}$ ). If the increments have a specific gravity difference greater than 0.013, the test must be re-run. 6.3.

(APPROXIMATELY)

37.5 = 1 1/2"  
 25 mm = 1 "  
 19 mm = 3/4"  
 12.5 mm = 1/2"

### SAMPLING:

Table 1—Minimum Sample Sizes

Nominal Maximum Aggregate Size, mm	Minimum Sample Size, g
37.5 or greater	4000
19 to 25	2500
12.5 or smaller	1500

### SAMPLING PREP:

- Samples prepared in a laboratory will be short term conditioned according to AASHTO R30. This conditioning time will be combined with any warming described in the procedure (Section 7.3). 7.1.1.



**PREP CONTINUED:**



For some asphalt mixtures that utilized highly modified binder material, it may be difficult to break down to no larger than 1/4 inch please consult agency when this occurs.

**1**

Separate the particles of the asphalt mixture sample by hand, (avoid fracturing the aggregate when separating), so the particles of the fine aggregate portion are not larger than 1/4 inch.

7.3.



If an asphalt mixture sample is not sufficiently soft to be separated manually, place it in a pan and warm it in an oven until it can be separated to no larger than 1/4 inch. (SECTION 7.3.)



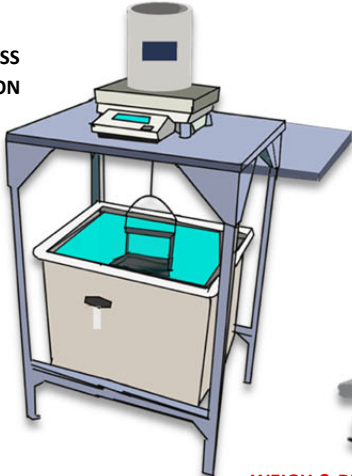
BROKEN UP TO NOT LARGER THAN 1/4 INCH

**2**

Weigh and record the mass of the EMPTY vacuum container (and the glass plate, capillary lid, or capillary glass stopper if performing mass determination in air) to the nearest 0.1 grams.

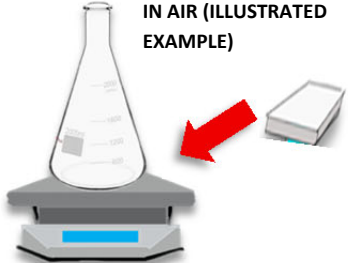
7.4.

BOWL FOR MASS DETERMINATION IN WATER (ILLUSTRATED EXAMPLE)



OR

FLASK (OR PYCNOMETER) FOR MASS DETERMINATION IN AIR (ILLUSTRATED EXAMPLE)



WEIGH & RECORD EMPTY CONTAINER (AND LID IF APPLICABLE)

**3**

Cool the sample to room temperature, and place the test sample in the vacuum container. A container with a container is not to be used.

7.5.

**4**

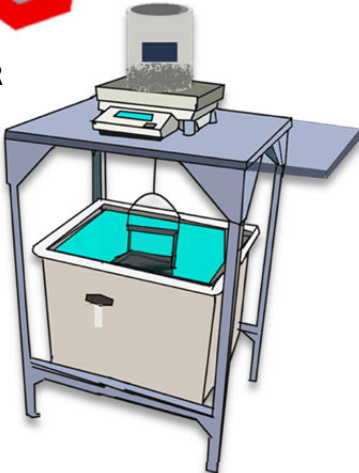
Weigh and record the mass of the sample and container to the nearest 0.1 grams. Subtract the mass of the container from the mass of the sample and the container. Record the net mass of the sample. (Record value as A according to AASHTO calculation)

7.5.



WEIGH & RECORD SAMPLE AND CONTAINER

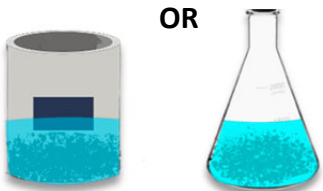
OR



**5**

Add enough water, at a temperature of approximately 77 °F (25 °C), to cover the sample completely.

7.6.



COVER THE SAMPLE COMPLETELY WITH WATER @ APPROXIMATELY 77 °F (25 °C)



**NOTE 8:** the release of entrapped air may be facilitated by the addition of a suitable wetting agent such as aerosol OT in concentration of 0.001 percent or 0.2 grams in 20 L of water. This solution is then diluted by about 20:1 to make a wetting agent of which 5 to 10 mL to be used. (SECTION 7.6.)

## METHOD A – MECHANICAL AGITATION

### ADDITIONAL EQUIPMENT

In addition to the equipment listed in Section 5, the following equipment is required for Method A.

8.

- **MECHANICAL RICE SHAKER** – shaker for removing air from asphalt mixture.



### PROCEDURE:

1

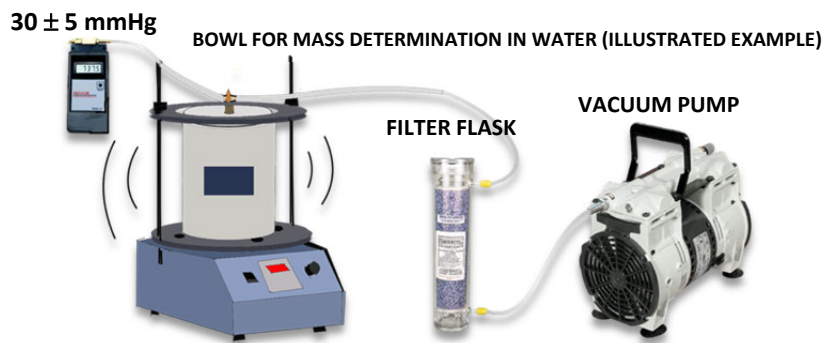
Remove air trapped in the sample by applying gradually increased vacuum until the residual pressure manometer reads  $4.0 \pm 0.6$  kPa ( $30 \pm 5$  mmHg). Once this residual pressure is reached begin a timer for  $15 \pm 1$  minutes. Maintain this residual pressure for the entire vacuum period ( $15 \pm 1$  minutes).

9.1.

2

Agitate the container and contents using the mechanical RICE shaker (see manufacturer instructions) during the vacuum period. Glass vessels should be shaken on a resilient surface such as a rubber or plastic mat, and not on a hard surface, to avoid excessive impact while under vacuum.

9.1.



AGITATE USING MECHANICAL DEVICE FOR  $15 \pm 1$  MINUTES.

3

At the end of the vacuum period, release the vacuum by increasing the pressure at a rate not to exceed 8 kPa (60mmHg) per second and proceed with one of the mass determination methods. (See Section 11)

9.2.

## METHOD B – MANUAL AGITATION

### PROCEDURE:

1

Remove air trapped in the sample by applying gradually increased vacuum until the residual pressure manometer reads  $4.0 \pm 0.6$  kPa ( $30 \pm 5$  mmHg). Once this residual pressure is reached begin a timer for  $15 \pm 1$  minutes. Maintain this residual pressure for the entire vacuum period ( $15 \pm 1$  minutes).

10.1.

2

Agitate the container and contents during the vacuum period by vigorously shaking at intervals of approximately 2 minutes. Glass vessels should be shaken on a resilient surface such as a rubber or plastic mat, and not on a hard surface.

10.1.



VIGOROUSLY SHAKE AT APPROXIMATELY 2 MINUTE INTERVALS FOR  $15 \pm 1$  MINUTES

3

At the end of the vacuum period, release the vacuum by increasing the pressure at a rate not to exceed 8 kPa (60mmHg) per second and proceed with one of the mass determination methods (See Section 11).

10.2.

**MASS DETERMINATION**

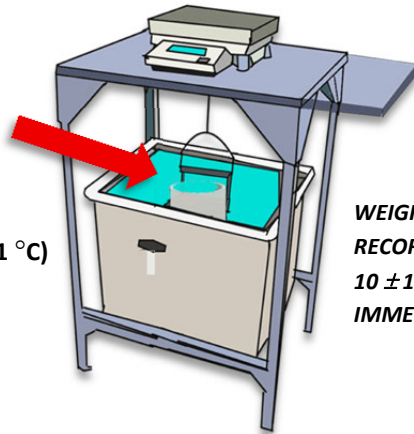
- **MASS DETERMINATION IN WATER –** suspend the container and contents in a water bath at  $77 \pm 2^\circ\text{F}$  ( $25 \pm 1^\circ\text{C}$ ). Weigh and record the mass after a  $10 \pm 1$  minute immersion. Designate the mass of the sample and container in water to the nearest 0.1 grams. (Record value as C according to AASHTO calculation)

11.1.

BOWL FOR MASS DETERMINATION IN WATER (ILLUSTRATED EXAMPLE)

CONTAINER WITH SAMPLE SUBMERGED IN WATER BATH

$77 \pm 2^\circ\text{F}$  ( $25 \pm 1^\circ\text{C}$ )

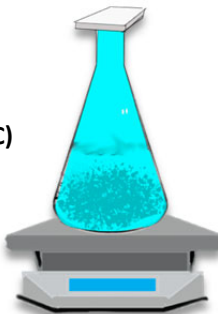


WEIGH & RECORD AFTER  $10 \pm 1$  MINUTE IMMERSION

FLASK FOR MASS DETERMINATION IN AIR (ILLUSTRATED EXAMPLE)

GLASS PLATE

$77 \pm 2^\circ\text{F}$   
( $25 \pm 1^\circ\text{C}$ )



CONTAINER WITH SAMPLE COMPLETELY FILLED, GLASS PLATE (OR OTHER LID), AND CONTAINER WIPED DOWN OF EXCESS WATER

WEIGH & RECORD WITHIN  $10 \pm 1$  MINUTE AFTER VACUUM RELEASED

11.2.

- **MASS DETERMINATION IN AIR–** fill the flask or any one of the pycnometers with water and adjust the contents to a temperature of  $77 \pm 2^\circ\text{F}$  ( $25 \pm 1^\circ\text{C}$ ).
- Cover the measure with the glass plate (or other lids listed previously) in a way so as not to have air bubbles ensuring entrapped air is removed make sure to dry the container off of excess water before weighing (refer to the procedure for additional details Section A1.2.1).
- Weigh and record the mass of the container (lid) and contents, completely filled, to the nearest 0.1 grams. within  $10 \pm 1$  minute after the vacuum has been released. (Record value as E according to AASHTO calculation)



When performing the mass determination in air make sure to obtain the weight of the glass plate or capillary lid, or capillary stopper when obtaining the mass of the empty vacuum container.



The difference between the results of two properly conducted tests is less than or equal to 0.013. When more than 2 tests are to be run multiply the standard deviation in the procedure by the multiplier given in Table 1 of ASTM C670 for the number of actual tests. (SECTION 15.1)

Example for 3 tests (from ASTM C670):

$0.0046 \text{ STD} \times 3.3 = 0.015$

## FAN DRY PROCEDURE (MIXTURES CONTAINING POROUS AGGREGATE)



**NOTE 10:** experiments indicate that the following procedure has an insignificant effect on test results if the asphalt mixture contains aggregate with a water absorption below 1.5 percent. (SECTION 13.)

1

If the pores of the aggregates are not **thoroughly sealed** by an asphalt film, they may become saturated with water during the application of the vacuum. Then the **fan dry process** may be necessary. If it is determined that this procedure is needed perform **after the mass determination step**.

13.1.



### HOW TO KNOW IF A MIXTURE CONTAINS POROUS AGGREGATE?

One way is a visual inspection of the material this may reveal aggregates that were not thoroughly coated. Another way is to break several large pieces of aggregate and examine the broken surfaces for wetness.

2

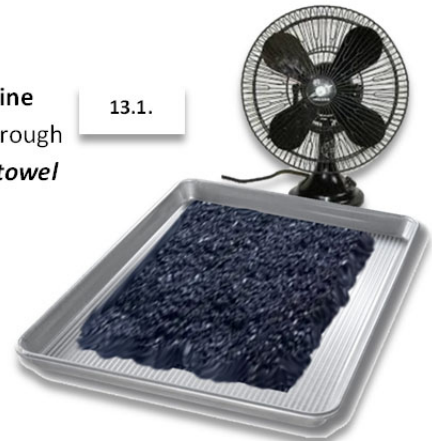
Carefully drain the **water** from the sample, **prevent** any loss of fine particles. Ways to prevent this loss can be a slow decantation through a towel (*taking care to place any fine material adhering to the towel back into the sample*) or through a nest of sieves #40 & #200.

13.1.

3

Spread the test sample out in a pan and put it in front of an electric fan. When it appears that **the surface moisture is removed** then **weigh and record** the mass to the **nearest 0.1 grams**.

13.2.



4

Begin a timer for **15 minutes** and **replace the sample in front** of a fan. **Weigh and record the mass for intervals of 15 minutes until the loss in mass is less than 0.05 percent**. When this occurs, the sample will be considered “**surface dry**”. Generally, this process requires **approximately 2 hours** and the sample must be **intermittently stirred** and **large conglomerates of material broken up by hand**. *Take care not to lose any material.*

13.2.



**REMEMBER:** to calculate what 0.05 percent of a mass:

1. Divide:  $0.05\% / 100 = 0.0005$
2. Multiply:  $\text{mass of sample (grams)} \times 0.0005 = 0.05 \text{ percent of mass of sample (grams)}$ .
3. Compare if the last recorded weight is **less than** this then you have achieved **surface dry**.

### EXAMPLE:

*initial mass = 2000.5 grams*

*mass after drying = 1999.8 grams*

$0.0005 \times 2000.5 = 1.0 \text{ grams}$

$2000.5 - 1999.8 = 0.7 \text{ grams}$

**SURFACE DRY IS ACHIEVED THE DIFFERENCE BETWEEN THE LOSS IN MASS IS LESS THAN 0.05% OF THE MASS.**

5

Calculate the specific gravity of the sample by substituting the final surface-dry mass recorded for **A** in the denominator of equation for the **MASS DETERMINATION IN WATER** or **MASS DETERMINATION IN AIR**.

13.2.

**CALCULATION**

**THEORETICAL MAXIMUM SPECIFIC GRAVITY ( $G_{mm}$ )**

**MASS DETERMINATION IN WATER**

$$G_{mm} = \frac{A}{A + B - C}$$

OR

**MASS DETERMINATION IN WATER (FAN DRY)**

$$G_{mmFD} = \frac{A}{A_{ssd} + B - C}$$

$G_{mm}$  = theoretical maximum specific gravity;

$A$  = mass of the oven-dry sample in air; grams;

$B$  = mass of the container submerged in water; grams determined in **Section A1.1**;

$C$  = mass of the sample and container in water;

$A_{ssd}$  = mass of the saturated surface dry sample in air;

**MASS DETERMINATION IN AIR**

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

OR

**MASS DETERMINATION IN AIR (FAN DRY)**

$$G_{mmFD} = \frac{A}{A_{ssd} + D - E}$$

$G_{mm}$  = theoretical maximum specific gravity;

$A$  = mass of the oven-dry sample in air; grams;

$D$  = mass of the container filled with water; grams determined in **Section A1.2**;

$E$  = mass of the container filled with the sample and water; grams;

$A_{ssd}$  = mass of the saturated surface dry sample in air; grams;

Calculate the theoretical maximum specific gravity ( $G_{mm}$ ) of the sample at 77 °F (25 °C):

**EXAMPLE:**

$A = 1432.7$  grams

$B = 286.3$  grams

$C = 1134.9$  grams

$A_{ssd} = 1434.2$  grams

$$\frac{1432.7}{(1432.7 + 286.3 - 1134.9)}$$

**Answer:  $G_{mm} = 2.453$**  ←

**MASS DETERMINATION IN WATER**

$$\frac{1432.7}{(1434.2 + 286.3 - 1134.9)}$$

**Answer:  $G_{mmFD} = 2.447$**  ←

**MASS DETERMINATION IN WATER (FAN DRY)**

**EXAMPLE:**

$A = 2210.7$  grams

$D = 6800.2$  grams

$E = 8110.9$  grams

$A_{ssd} = 2212.9$  grams

$$\frac{2210.7}{(2210.7 + 6800.2 - 8110.9)}$$

**Answer:  $G_{mm} = 2.456$**  ←

**MASS DETERMINATION IN AIR**

$$\frac{2210.7}{(2212.9 + 6800.2 - 8110.9)}$$

**Answer:  $G_{mmFD} = 2.450$**  ←

**MASS DETERMINATION IN AIR (FAN DRY)**

**WEIGHTED AVERAGE THEORETICAL MAXIMUM SPECIFIC GRAVITY**



**NOTE 9:** an example for calculating the weighted average, if the sample is split into two portions for testing. (SECTION 12.2)

For large samples tested a portion at a time (See Section 6.3), calculate the weighted average theoretical maximum specific gravity ( $G_{mm}$ ) using the mass of the oven-dry sample in air and the theoretical maximum specific gravity ( $G_{mm}$ ) of each portion tested as follows:

$$G_{mm(avg)} = \frac{\sum(A_x \times G_{mmx})}{\sum A_x}$$

**2** TAKE THOSE VALUES AND MULTIPLY WITH THEIR RESPECTIVE A VALUES THEN ADD THESE NUMBERS TOGETHER. THEN THIS RESULT IS DIVIDED BY THE SUM OF THE A VALUES.

$$\frac{[(2210.7 \times 2.456) + (2127.0 \times 2.458)]}{(2210.7 + 2127.0)}$$

**ANSWER:**  $G_{mm(avg)} = 2.457$   
MASS DETERMINATION IN AIR example

**1** SOLVE FOR THE THEORETICAL MAXIMUM SPECIFIC GRAVITY FOR BOTH INCREMENTS

EXAMPLE:

	INCREMENT 1	INCREMENT 2
LARGE SAMPLE	A = 2210.7 grams	A = 2127.0 grams
SPLIT INTO 2 INCREMENTS	D = 6800.2 grams	D = 6789.2 grams
	E = 8110.9 grams	E = 8050.9 grams
	$\frac{2210.7}{(2210.7 + 6800.2 - 8110.9)}$	$\frac{2127.0}{(2127.0 + 6789.2 - 8050.9)}$
	<p><b>Increment 1: <math>G_{mm} = 2.456</math></b></p> <p>MASS DETERMINATION IN AIR example</p>	<p><b>Increment 2: <math>G_{mm} = 2.458</math></b></p> <p>MASS DETERMINATION IN AIR example</p>



IS THE DIFFERENCE BETWEEN THE THEORETICAL MAXIMUM SPECIFIC GRAVITY RESULTS FOR BOTH INCREMENTS  $\leq 0.013$  ?

INCREMENT 2: 2.458 – INCREMENT 1: 2.456 = 0.002

The difference between the two is in range the test does not have to be rerun.

**THEORETICAL MAXIMUM DENSITY AT 77 °F (25 °C):**

Theoretical maximum DENSITY = Theoretical maximum specific gravity X 62.245 lb / ft<sup>3</sup> results in a pounds per cubic feet.

$$G_{mm(avg)} 2.457 \times 62.245 = 152.9$$

**ANSWER (THEORETICAL MAXIMUM DENSITY at 77 degrees F): = 152.9 lb / ft<sup>3</sup>**

OR

Theoretical maximum DENSITY = Theoretical maximum specific gravity X 997.1 kg / m<sup>3</sup> results in a kilograms per cubic meters

## ANNEX A - STANDARDIZATION

### STANDARDIZATION & CHECK OF BOWL FOR MASS DETERMINATION IN WATER:

A1.1.

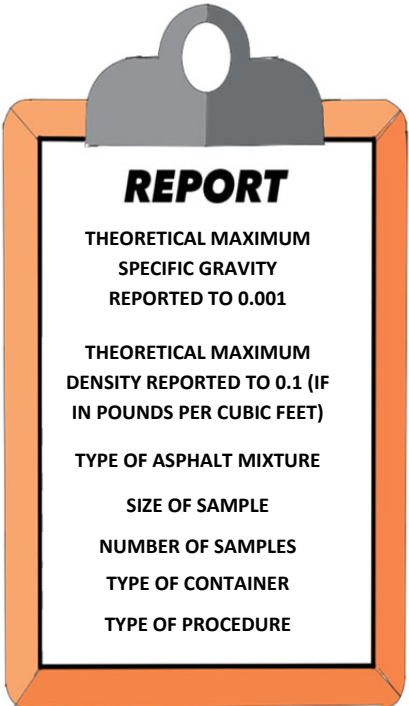
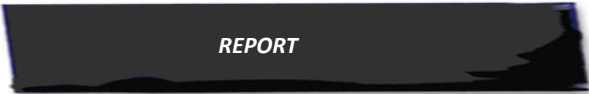
- **STANDARDIZATION** – immerse an empty bowl in water at  $77 \pm 2^{\circ}\text{F}$  ( $25 \pm 1^{\circ}\text{C}$ ) for  $10 \pm 1$  minutes.
  - i. **Weigh and record** the mass of the bowl. Perform this process **3 times**.
  - ii. If the range of the 3 masses is less than or equal to 0.3 grams, use the calculated average as **B** in equation for mass determination in water.
  - iii. If the range of the masses is **greater than 0.3 grams**, perform the process again.
  
- **CHECK** – immerse an empty bowl in water at  $77 \pm 2^{\circ}\text{F}$  ( $25 \pm 1^{\circ}\text{C}$ ) for  $10 \pm 1$  minutes.
  - i. **Weigh and record** the mass of the bowl. If this weight is less than or equal to 0.3 grams, of the standardized value, use the **standardized** value as **B** in the equation.
  - ii. If it is **greater than 0.3 grams**, perform the **standardization** procedure again.
  - iii. If **standardization is performed everyday (or frequently)** calculate the **moving average** and **range** of the last 3 mass determinations and use this average as **B** in equation for mass determination in water.
  - iv. If at any time the **moving average range exceeds 0.3 grams** perform **standardization** procedure again.

### STANDARDIZATION & CHECK OF FLASK AND PYCNOMETER FOR MASS DETERMINATION IN AIR:

A1.2.

- **STANDARDIZATION** – fill the flask or pycnometer with water at approximately  $77 \pm 2^{\circ}\text{F}$  ( $25 \pm 1^{\circ}\text{C}$ ).
  - i. Use a **glass capillary stopper, capillary lid, or glass plate** to ensure all entrapped air is removed.
  - ii. **Stabilize the flask or pycnometer** at  $77 \pm 2^{\circ}\text{F}$  ( $25 \pm 1^{\circ}\text{C}$ ) for  $10 \pm 1$  minute.
  - iii. **Weigh and record** the mass of the flask or pycnometer, water, and lid.
  - iv. **Perform** this process **3 times**.
  - v. If the range of the 3 masses is less than or equal to 0.3 grams, use the average as **D** in the mass determination in air equation.
  - vi. If the range of the masses is **greater than 0.3 grams**, perform the **standardization** process again.

- **CHECK** – fill the flask or pycnometer with water an approximately  $77 \pm 2^{\circ}\text{F}$  ( $25 \pm 1^{\circ}\text{C}$ ).
  - i. Use a glass capillary stopper, capillary lid, or glass plate to ensure all entrapped air is removed.
  - ii. Stabilize the flask or pycnometer at  $77 \pm 2^{\circ}\text{F}$  ( $25 \pm 1^{\circ}\text{C}$ ) for  $10 \pm 1$  minute.
  - iii. Weigh and record the mass of the flask or pycnometer, water, and lid.
  - iv. Perform this process only 1 time.
  - v. If this mass is less than or equal to 0.3 grams, use the standardized value for *D* in the mass determination in air equation.
  - vi. If this mass exceeds 0.3 grams, then perform the standardization procedure again.
  - vii. If standardization is performed everyday (or frequently) calculate the moving average and range of the last 3 mass determinations and use this average as *D* in the mass determination in air equation.
  - viii. If at any time the moving average range exceeds 0.3 grams perform the standardization procedure again.



14.



**PRACTICE QUESTIONS:**

ANSWERS:

1. c
2. b
3. c
4. c
5. b
6. b
7. a

1. For the convection-type furnace, **preheat the ignition furnace** to or to the **temperature \_\_\_\_\_ determined by the correction factor process** according to **Annex A**. (according to AASHTO T308)?
  - a.  $290 \pm 9^{\circ} \text{F}$  ( $110 \pm 5^{\circ} \text{C}$ )
  - b.  $538 \pm 5^{\circ} \text{F}$  ( $1000 \pm 9^{\circ} \text{C}$ )
  - c.  $1000 \pm 9^{\circ} \text{F}$  ( $538 \pm 5^{\circ} \text{C}$ )
2. **Agitate the test sample vigorously** in the container (*or in the mechanical washing apparatus*) bringing the **particles finer** than the \_\_\_\_\_ **sieve into suspension**. (according to AASHTO T30)?
  - a. #100
  - b. #200
  - c. #50
3. Dry the **sample initially for \_\_\_\_\_ minutes** and then weigh its mass. (according to AASHTO T329)?
  - a.  $70 \pm 5$
  - b.  $80 \pm 5$
  - c.  $90 \pm 5$
4. Place the **entire batch in the mold**, and **spade** the mixture **vigorously \_\_\_\_\_ times around the perimeter and \_\_\_\_\_ times over the interior**. (according to AASHTO R68)?
  - a. 10, 15
  - b. 25, 15
  - c. 15, 10
5. Place the **mixture into the mold in TWO lifts**. (according to AASHTO T312)?
  - a. TRUE
  - b. FALSE
6. (AASHTO T27) **Fill the flask or any one of the pycnometers with water** and adjust the contents to a **temperature of \_\_\_\_\_** (according to AASHTO T209).
  - a.  $25 \pm 1^{\circ} \text{F}$  ( $77 \pm 2^{\circ} \text{C}$ )
  - b.  $77 \pm 2^{\circ} \text{F}$  ( $25 \pm 1^{\circ} \text{C}$ )
  - c.  $177 \pm 2^{\circ} \text{F}$  ( $125 \pm 1^{\circ} \text{C}$ )
7. **Weigh and record the total mass** of the specimen and specimen basket assembly **after ignition to the nearest \_\_\_\_\_ grams**. (AASHTO T308)?
  - a. 0.1
  - b. 0.5
  - c. 1.0

## **BULK SPECIFIC GRAVITY/ STABILITY AND FLOW / PERCENT OF AIR VOIDS/ UNCOMPACTED VOID CONTENT / DRYING AGGREGATES/ DENSITY BY NUCLEAR METHOD**

*This section goes over essential tests and supplementary testing methods for Hot mix asphalt. The laboratory is essential for the design and optimization of asphalt mixtures under controlled conditions. These tests allow for asphalt mixes to meet specific performance requirements which leads to an economical and quality mix design. The laboratory also establishes target values for field quality control. These targets are used, in conjunction with the field technician, to verify material consistency, check field compaction, specification compliance, and approve pay factors for acceptance.*



*All bulk specific gravity methods that are relevant to ATTI are covered. Stability & flow, percent air voids in asphalt mixes, uncompact voids, drying aggregates, and density by nuclear method will all be covered in this section for study to take ATTI ASPHALT:*

Learning objectives for these sections are:



**How perform the procedure and associated calculation for bulk specific gravity. How to take this value along with the theoretical specific gravity and calculate amount of air voids in a mix.**

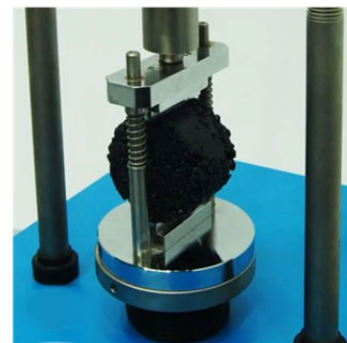


**How to perform the stability and flow test method.**



**How to perform all supplemental procedures related to quality control and acceptance (Uncompact voids, aggregate drying, and density testing with the nuclear gauge)**

- **AASHTO T166:** BULK SPECIFIC GRAVITY OF COMPACTED HMA USING SATURATED SURFACE DRY SPECIMENS
- **AASHTO T245:** STANDARD METHOD OF TEST FOR RESISTANCE TO PLASTIC FLOW OF ASPHALT MIXTURES USING MARSALL APPARATUS
- **AASHTO T269:** PERCENT AIR VOIDS IN COMPACTED BITUMINOUS PAVING MIXTURES
- **AASHTO T304:** UNCOMPACTED VOID CONTENT OF FINE AGGREGATE
- **AASHTO T255:** TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING
- **AASHTO T355:** IN PLACE DENSITY OF ASPHALT MIXTURES BY NUCLEAR METHOD



PLEASE REFER TO THE PROCEDURE FOR MORE DETAIL. NOT ALL SECTIONS WILL BE COVERED BY ATTI. SECTION NUMBERS WILL BE PROVIDED FOR REFERENCE. SUBJECT TO CHANGE.



# AASHTO T166:

## BULK SPECIFIC GRAVITY ( $G_{mb}$ ) OF COMPACTED ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS

### DEFINITIONS:

**Bulk Specific Gravity** – 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

**Constant Mass** – defined as the mass at which further drying does not alter the mass by more than 0.05 percent when weighed at 2-hour intervals when using oven drying, or by more than 0.05 percent when weighed after at least two drying cycles of the vacuum-drying apparatus required in AASHTO R79

**Asphalt Binder** - (also known simply as bitumen) is the black, sticky, and highly viscous material used in road construction to bind together the aggregate particles (rocks, sand, etc.) in asphalt pavement.

**Bulk Specific Gravity essentially measures the ratio of the mass of the specimen to the mass of an equal volume of water, accounting for the permeable and impermeable voids within the compacted asphalt. The importance of such a test is to determine Air Voids ( $V_a$ ) in Asphalt Mixtures, for Quality Control in Construction, Mix Design Verification, and Pavement Density Acceptance Testing.**



### SCOPE:

This method of test covers the determination of bulk specific gravity ( $G_{mb}$ ) of specimens of compacted asphalt mixtures. This method should not be used with specimens that contain open or interconnecting voids, or absorb more than 2.0 percent of water by volume consult procedure for alternative methods.

1.1.

### TEST SPECIMENS:

- The **cylindrical specimens** may be either **laboratory compacted** asphalt mixtures or **sampled** from **asphalt pavements (cores)**.

4.1.

- SIZE OF SPECIMENS** –recommended:

4.2

- the **diameter** of cylindrically compacted 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

AT LEAST 4 X MAXIMUM SIZE OF AGGREGATE

AT LEAST 1 1/2 X MAXIMUM SIZE OF AGGREGATE



- the **thickness** of cylindrical specimens be at least 1 1/2 times the maximum size for the aggregate.

- If specimens are taken from pavements they must be taken using a **core drill, diamond or carborundum saw, or by other suitable means.**

4.3.

- Do not to distort, bend, or crack the specimens during and after the removal from the pavement or mold. Store specimens in a safe, cool place.

4.4.

- Ensure specimens are free from foreign materials such as seal coat, tack coat, foundation material, soil, paper, or foil.

4.5.

- If preferred, specimens may be separated from other pavement layers by sawing or other suitable means. Ensure sawing does not damage the specimens.

4.6.

### SELECTION OF TEST METHOD:

- METHOD A** is intended to be used when performing comparison testing. The acceptable range between two results is less than or equal to 0.006 (Section 18).

5.1

- **METHOD B** is intended to be used when the **testing environment** makes it **difficult** to control the **temperature of a large water bath** or there is **limited access** to a **constant water supply**. 5.2.
- **METHOD C** is intended to be used when a **rapid test result** is needed on a **test specimen** that **contains moisture**. 5.3

## METHOD A

### EQUIPMENT/ MATERIALS:

6.

- **WEIGHING DEVICE** – will have sufficient capacity, be **readable to 0.1 percent** of the specimen mass **or better (weigh and record all specimens to the nearest 0.1 grams)**. Balance must conform to the **requirements of M231**. The **weighing device** must be **equipped** with a suitable **suspension apparatus** and **holder** to permit weighing the specimen while **suspended** from the **center of the scale pan** of the weighing device.
- **SUSPENSION APPARATUS** – the **wire suspending** the sample **holder** must be the smallest practical size to minimize any possible effects of a variable immersed length. When suspended, the sample **holder** must be **immersed** to a **depth sufficient to cover** it and the **test specimen** while weighing. Ensure that **no trapped air bubbles** exist **under** the **specimen** by carefully placing the specimen and slightly shaking.
- **WATER BATH** – a large **container filled** with **water (conforming to section 7.1)** for **immersing** the **specimen** in water while **suspended under the weighing device**. The water bath must be equipped with an **overflow outlet** to maintain a **constant water level** and must be capable of maintaining a uniform **temperature** at **77 ± 2 ° F (25 ± 1 ° C)**.
- **THERMOMETER**- an immersion thermometer with a temperature range that includes the **test temperature range**. The thermometer's **smallest temperature** change that can be reliably detected and displayed must **be 0.2 ° F (0.1 ° C)**, and **maximum permissible error** of **1 ° F (0.5 ° C)**. *See procedure for additional details.*
- **OVEN (IF NEEDED)** – Of sufficient size, capable of maintaining a **uniform temperature** of **126 ± 5 ° F (52 ± 3 ° C)**. The oven(s) shall be capable of operation at the temperatures required as corrected, if necessary, by standardization.
- **WATER** – **clear, potable water for filling the water bath**. The water that is used to fill the water bath shall be potable, but the **water in the bath does not need to maintain a potable condition once used**. The water shall **remain clear** at all times.

### PROCEDURE:

1

If the specimen has been **exposed to moisture**, **dry** the specimen to a **constant mass at a temperature of 126 ± 5 ° F (52 ± 3 ° C)**. Specimens saturated with water must be **initially dried overnight** and then **weighed at 2 hour drying intervals**.

8.1.

2

**Recently compacted laboratory specimens**, which have not been exposed to moisture, **do not require drying**. As an **alternative** to oven drying to constant mass, drying the specimen according to **AASHTO R79** may be used.

8.1.



**Constant Mass** – defined as the mass at which further drying does not alter the mass by more than 0.05 percent when weighed at 2-hour intervals when using oven drying, or by more than 0.05 percent when weighed after at least two drying cycles of the vacuum-drying apparatus required in AASHTO R79. **(SECTION 3.1.2.)**

3

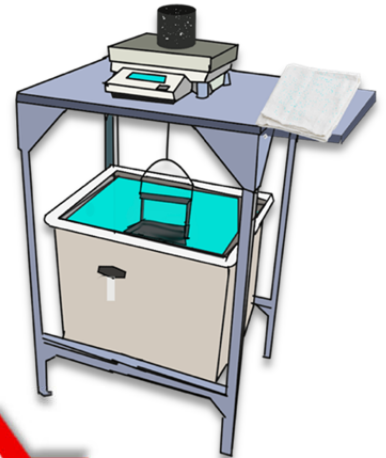
Cool the specimen to room temperature at  $77 \pm 9^\circ \text{F}$  ( $25 \pm 5^\circ \text{C}$ ), and weigh and record the dry mass to the nearest 0.1 grams (see Note 3). (Record this value as *A* according to the calculation in the procedure)



**NOTE 3:** if preferred, the sequence of testing operations may be changed. For example, first the immersed mass *C* can be taken, then the surface dry mass *B*, and finally the dry mass *A*. (SECTION 8.3.)

8.2.

**WEIGH & RECORD DRY (ROOM TEMPERATURE) SPECIMEN**



4

Immerse the specimen in the water bath at  $77 \pm 2^\circ \text{F}$  ( $25 \pm 1^\circ \text{C}$ ) from the suspension apparatus for  $4 \pm 1$  minute, and weigh and record the immersed mass to the nearest 0.1 grams. (Record this value as *C* according to the calculation in the procedure)

8.2.

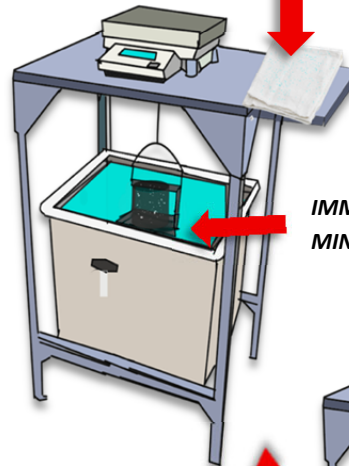
DAMP TOWEL

5

Remove the specimen from the water bath, damp dry the specimen by blotting it with a damp towel (see Note 4), and weigh and record the surface dry mass to the nearest 0.1 grams as quickly as possible (not to exceed 15 seconds). (Record this value as *B* according to the calculation in the procedure)

8.2.

IMMERSE SPECIMEN FOR  $4 \pm 1$  MINUTES THEN WEIGH & RECORD



**NOTE 4:** terry cloth has been found to work well for an absorbent cloth. Damp is considered to be when no water can be wrung from the towel. (SECTION 8.3.)

8.2.

REMOVE AND DAMP DRY THE SPECIMEN. DO NOT EXCEED 15 SECONDS

6

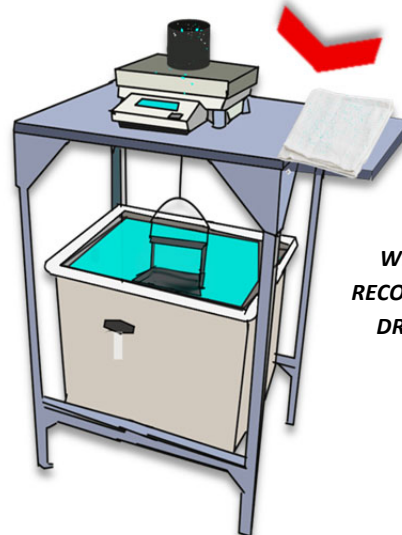
Any water that seeps from the specimen during the weighing operation is considered part of the weight to be recorded. Each specimen will be immersed and weighed individually.

8.3.

7

Perform the Bulk Specific Gravity calculations for Method A (Section 9). If the percent of water absorbed by the specimen exceeds 2.0 percent, use either AASHTO T275 (Bulk Specific Gravity Paraffin Coating) or AASHTO T331 (Bulk Specific Gravity by Vacuum Sealing) to determine the bulk specific gravity ( $G_{mb}$ ) of the specimen.

WEIGH AND RECORD SURFACE DRY SAMPLE



**CALCULATION:**

9.



The acceptable range for two results of different specimens is less than or equal to 0.006. To calculate the acceptable range for more than 2 samples multiply the appropriate deviation (1s) (or coefficient of variation (1s%)) by the appropriate factor from second column of Table 1 in ASTM C670. See ASTM C670 for additional details. (Section 18 AASHTO T166)

**ASTM C670 (MULTIPLIER)**

Number of Test Results	Multiplier of (1s) or (1s%) for Maximum Acceptable Range <sup>A</sup>
2	2.8
3	3.3
4	3.6
5	3.9
6	4.0
7	4.2
8	4.3
9	4.4
10	4.5

<sup>A</sup> Values were obtained from Table A7 of "Order Statistics and Their Use in Testing and Estimation," Vol 1, by Leon Harter, Aerospace Research Laboratories, United States Air Force.

**AASHTO T166 (SECTION 18) PRECISION TABLE**

Table 1—Precision Estimates for T 166

Condition of Test	Standard Deviation (1s) <sup>a</sup>	Acceptable Range of Two Results (d2s) <sup>a</sup>
Single-operator precision	0.002	0.006
Multilaboratory precision	0.006	0.017

<sup>a</sup> These values represent the 1s and 2ds limits described in ASTM C670.  
 Note: Based on interlaboratory study described in NCHRP Research Report 9-26 Phase 2 involving 150-mm-diameter specimens, 20 laboratories, three materials (9.5-mm, 12.5-mm, and 19.0-mm mixtures), and two replicates.

**CALCULATING THE ACCEPTABLE RANGE FOR 3 SAMPLES**

EXAMPLE: 3.3 X 0.002 = 0.007 ← THE BULK SPECIFIC GRAVITY RANGE BETWEEN 3 SPECIMENS HAS TO BE LESS THAN OR EQUAL TO 0.007

Calculate the bulk specific gravity ( $G_{mb}$ ) of the specimen from the following equation:

**BULK SPECIFIC GRAVITY (METHOD A)**

$G_{mb}$  = bulk specific gravity recorded to the nearest thousandth;

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

$A$  = mass of the specimen in air, grams;

$B$  = mass of the surface dry specimen in air, grams;

$C$  = mass of the specimen in water, grams;

**EXAMPLE:**

**SPECIMEN 1:**

$A = 1168.3g$

$B = 1171.5g$

$C = 660.9g$

$$G_{mb} = \frac{1168.3}{(1171.5 - 660.9)}$$

$G_{mb} = 2.288$

**SPECIMEN 2:**

$1165.9g$

$1170.5g$

$661.0g$

$$\frac{1165.9}{(1170.5 - 661.0)}$$

$G_{mb} = 2.288$

**SPECIMEN 3:**

$1169.9g$

$1172.7g$

$661.9g$

$$\frac{1169.9}{(1172.7 - 661.9)}$$

$G_{mb} = 2.290$

Report bulk specific gravity ( $G_{mb}$ ) to the nearest thousandth -0.001 (Section 17.)

Report absorption to the nearest hundredth- 0.01 (Section 17.)

**AVERAGE  $G_{mb} = 2.287$**  ←

RANGE (HIGHEST: 2.290 – LOWEST: 2.288) = 0.002 < 0.007. THREE SAMPLES ARE WITHIN ACCEPTABLE RANGE

Calculate the percent of water absorbed by the specimen (on a volume basis) from the following equation:

**PERCENT OF WATER ABSORBED (METHOD A)**

EXAMPLE DEMONSTRATES ONLY THE ABSORPTION OF SPECIMEN 1

$$\%W_{ABSORBED} = \frac{(B - A)}{(B - C)} \times 100$$

$$\frac{(1171.5 - 1168.3)}{(1171.5 - 660.9)} \times 100$$

$\%W_{ABSORBED} = 0.63\%$  ←

## METHOD B

### EQUIPMENT/ MATERIALS:

- **WEIGHING DEVICE** – will have sufficient capacity, be **readable to 0.1 percent** of the specimen mass or better (**weigh and record all specimens to the nearest 0.1 grams**). Balance must conform to the **requirements of M231**.
- **WATER BATH** – a **large container** filled with **water** for immersing the specimen in water.
- **THERMOMETER**- an immersion thermometer with a temperature range that includes the **test temperature range**. The thermometer's **smallest temperature** change that can be reliably detected and displayed must be **0.2 ° F (0.1 ° C)**, and **maximum permissible error of 1 ° F (0.5 ° C)**. *See procedure for additional details.*
- **VOLUMETER**- **1200 mL in capacity**, or an **appropriate capacity** depending on the size of the test specimen. The **volumeter** will have a **tapered lid with a capillary bore**.
- **OVEN (IF NEEDED)** – Of sufficient size, capable of maintaining a **uniform temperature of 126 ± 5 ° F (52 ± 3 ° C)**. The oven(s) shall be capable of operation at the temperatures required as corrected, if necessary, by standardization.
- **WATER** – **clear, potable water for filling the water bath**. The water that is used to fill the water bath shall be potable, but the **water in the bath does not need to maintain a potable condition once used**. The water shall **remain clear** at all times.
- **DISTILLED WATER** - clear, **distilled water** for filling the volumeter.

### PROCEDURE:

1

If the specimen has been **exposed to moisture**, **dry** the specimen to a **constant mass at a temperature of 126 ± 5 ° F (52 ± 3 ° C)**. Specimens saturated with water must be **initially dried overnight** and then **weighed at 2 hour drying intervals**.

12.1.

2

**Recently compacted laboratory specimens**, which have not been exposed to moisture, **do not require drying**. As an **alternative** to oven drying to constant mass, drying the specimen according to **AASHTO R79** may be used.

12.1.

3

**Cool** the specimen to **room temperature at 77 ± 9 ° F (25 ± 5 ° C)**, and **weigh and record** the **dry mass** to the **nearest 0.1 grams** (*see Note 3*). (**Record this value as A** according to the calculation in the procedure)

12.2.

4

**Immerse** the specimen in the **water bath at 77 ± 2 ° F (25 ± 1 ° C)** and allow it to **saturate for at least 10 minutes**.

12.2.

5 After the 10 minutes, fill the volumeter with distilled water at  $77 \pm 2^\circ \text{F}$  ( $25 \pm 1^\circ \text{C}$ ), and weigh the volumeter to the nearest 0.1 grams. (Record this value as *D* according to the calculation in the procedure) 12.2.

6 Remove the saturated specimen from the water bath, damp dry the specimen by blotting it with a damp towel (see Note 4), as quickly as possible (not to exceed 15 seconds) and weigh and record the surface dry mass to the nearest 0.1 grams. Any water that seeps from the specimen during the weighing operation is considered part of the weight of the specimen. (Record this value as *B* according to the calculation in the procedure) 12.2.

7 Place the specimen into the volumeter, and let it stand for at least 60 seconds. 12.3.

8 Adjust the temperature of the water to  $77 \pm 2^\circ \text{F}$  ( $25 \pm 1^\circ \text{C}$ ) and cover the volumeter, make certain that some water escapes through the capillary bore of the tapered lid. Wipe the outside of the volumeter dry with a dry absorbent cloth, and weigh the volumeter and its contents (see Note 5). (Record this value as *E* according to the calculation in the procedure)

**NOTE 5:** if preferred, the sequence of testing operations can be changed. For example, first the mass of the saturated, damp dry specimen *B* can be taken. The volumeter containing the saturated specimen and water *E* can be weighed. The dry mass of the specimen *A* can be determined last. (SECTION 12.4.)

9 Perform the Bulk Specific Gravity calculations for Method B (Section 13). If the percent of water absorbed by the specimen exceeds 2.0 percent, use either AASHTO T275 (Bulk Specific Gravity Paraffin Coating) or AASHTO T331 (Bulk Specific Gravity by Vacuum Sealing) to determine the bulk specific gravity ( $G_{mb}$ ) of the specimen. 12.4.

**CALCULATION:**

Calculate the bulk specific gravity ( $G_{mb}$ ) of the specimen from the following equation: 13.

**EXAMPLE**  
(ONLY ONE SPECIMEN DEMONSTRATED):

**SPECIMEN 1:**  
*A* = 4833.6 g  
*B* = 4842.4 g  
*D* = 2924.4 g  
*E* = 5806.0 g

---

4833.6  
(4842.4 + 2924.4 - 5806.0)

**BULK SPECIFIC GRAVITY (METHOD B)**

$$G_{mb} = \frac{A}{(B + D - E)}$$

$G_{mb} = 2.465$  ←

*G<sub>mb</sub>* = bulk specific gravity recorded to the nearest thousandth;  
*A* = mass of the specimen in air, grams;  
*B* = mass of the surface dry specimen in air, grams;  
*D* = mass of the volumeter filled with distilled water at  $77 \pm 2^\circ \text{F}$  ( $25 \pm 1^\circ \text{C}$ );  
*E* = mass of the volumeter filled with the specimen and the distilled water at  $77 \pm 2^\circ \text{F}$  ( $25 \pm 1^\circ \text{C}$ );

Calculate the percent of water absorbed by the specimen (on a volume basis) from the following equation:

**PERCENT OF WATER ABSORBED (METHOD B)**

EXAMPLE DEMONSTRATES THE ABSORPTION OF SPECIMEN 1

$$\%WABSORBED = \frac{(B - A)}{(B + D - E)} \times 100$$

$$\frac{(4842.4 - 4833.6)}{(4842.4 + 2924.4 - 5806.0)} \times 100$$

$$\%WABSORBED = 0.45 \%$$

**METHOD C (RAPID TEST FOR METHOD A OR B)**

**EQUIPMENT/ MATERIALS:**

14.

- **PAN** – flat bottom pans large enough to spread out sample for oven drying.
- **FORCED AIR, VENTILATED, OR CONVECTION OVEN** – for drying samples, meeting the requirements of Section 6.5, and capable of maintaining the temperature surrounding the sample at  $325 \pm 25^\circ \text{F}$  ( $163 \pm 14^\circ \text{C}$ ).

For additional equipment see **METHOD A** or **METHOD B**

**PROCEDURE:**

- 1 This **METHOD** is used for test specimens that are **not required to be saved** and that **contain a substantial amount of moisture**. Specimens obtained by coring or sawing can be tested the same day by this method. 15.1.

The testing procedure is identical to **METHOD A & METHOD B** except for the following sequence of operations. The dry mass **A** of the specimen is determined as follows:

- 2 Place the specimen in a **large, flat bottom drying pan of known mass**. Then place the **pan and specimen** in an **oven** and **dry** according to **AASHTO T329**. 15.2.1.
- 3 **Leave** the **specimen** in the **oven** until it can be **easily separated**. The sample is considered easily separated when the **fine aggregate portion** of the sample is **no larger than ¼ inch**. **Break down** and **spread** the sample out over the **bottom of the pan** taking care **not to lose fines**. 15.2.1.
- 4 Place the **separated specimen** back in the **oven** **AFTER 2 hours of drying** (according to **AASHTO T329**) **reweigh**. **Continue this process** until **constant mass** is attained. 15.2.1
- 5 **Cool** the pan and specimen to **room temperature** at  $77 \pm 9^\circ \text{F}$  ( $25 \pm 5^\circ \text{C}$ ). **Weigh and record** the mass of the pan and specimen, subtract the mass of the pan, and record as the dry mass; **A**. 15.2.2.



**Constant Mass** – defined as the mass at which further drying does not alter the mass by more than 0.05 percent when weighed at 2-hour intervals when using oven drying, or by more than 0.05 percent when weighed after at least two drying cycles of the vacuum-drying apparatus required in AASHTO R79. (Section 3.1.2.)

**CALCULATION:**

Calculate the bulk specific gravity ( $G_{mb}$ ) and percent of water absorbed as given in METHOD A or METHOD B all other requirements similarly apply.

16.



**BULK DENSITY** – can be calculated by the following equations:

**BULK DENSITY** = BULK SPECIFIC GRAVITY (average) X 1 g / m<sup>3</sup> results  
ARE recorded to the nearest 0.001 grams per cubic meters

OR

**BULK DENSITY** = BULK SPECIFIC GRAVITY (average) X 62.4 lb. / ft<sup>3</sup>  
results ARE recorded to the nearest 0.1 pounds per cubic feet

**REPORT:**

17.

**REPORT**

TEST METHOD (A, B OR C)

BULK SPECIFIC GRAVITY  
REPORTED TO THE NEAREST  
THOUSANDTH

ABSORPTION REPORTED TO THE  
NEAREST HUNDREDTH

## AASHTO T245:

### RESISTANCE TO PLASTIC FLOW OF ASPHALT MIXTURES USING MARSHALL APPARATUS

#### DEFINITIONS:

**Marshall Stability**- maximum load the specimen can withstand before failure (measured in pounds or kN).

**Flow**- measures the deformation corresponding to the maximum load (measured in 0.01 inches or mm).



ASHTO T 245 evaluates the load-carrying capacity and deformation resistance (plastic flow) of asphalt mixtures by using the Marshall Stability and Flow Test. The Marshall stability and flow test provides the performance prediction measure for the Marshall mix design method. The stability portion of the test measures the maximum load supported by the test specimen at a loading rate of 2 inches/minute. Basically, the load is increased until it reaches a maximum then when the load just begins to decrease, the loading is stopped and the maximum load is recorded. During the loading, an attached dial gauge measures the specimen's plastic flow as a result of the loading. The flow value is recorded in 0.25 mm (0.01 inch) increments at the same time the maximum load is recorded. This test is important because it helps ensure that asphalt pavements are strong, stable, and durable.

#### SCOPE:

This method covers the measurement of the resistance to plastic flow of cylindrical specimens of asphalt mixture loaded on the lateral surface by means of the Marshall apparatus. This method is for use with mixtures containing asphalt binder or asphalt cutback and aggregate up to 1-inch maximum size.

1.1.

#### EQUIPMENT:

3.

- **BREAKING HEAD** – shall consist of upper and lower cylindrical segments or test heads having an inside radius machined to a curvature of 2 inches. The lower segment must be mounted on a base having 2 perpendicular guide rods or posts extending upward. Guide sleeves in the upper segment must be positioned to allow the guide rods to slide in connecting two segments together without appreciable binding or loose motion. See procedure for additional details and critical dimensions.
- **LOADING JACK** – the loading jack must consist of a screw jack mounted in a testing frame and shall produce a uniform vertical movement of 2 inch per minute. An electric motor may be attached to the jacking mechanism.
- **RING DYNAMOMETER ASSEMBLY** – one ring dynamometer (figure 2 in the procedure) of 22.2 kN (5000-lb) capacity and SENSITIVITY of 44.5 N (10lb) up to 4.45 kN (1000lb) AND 111.2 N (25lb) between 4.45 and 22.2 kN (1000 and 5000lb) shall be equipped with a micrometer dial. The micrometer dial shall be graduated in 0.0025mm (0.0001 inches) increments. Upper and lower ring dynamometer attachments are required for fastening the ring dynamometer to the testing frame and transmitting the load to the breaking head. Instead of the ring dynamometer assembly, any suitable load measuring device may be used, provided the capacity and sensitivity satisfy the above requirements.
- **FLOWMETER** – will consist of a guide sleeve and a gauge. The activating pin of the gauge will slide inside the guide sleeve with a slight amount of frictional resistance. The guide sleeve will slide freely over the guide rod of the breaking head. The flowmeter gauge will be adjusted to zero when placed in position on the breaking head when each individual test specimen is inserted between the breaking head segments. Graduations of the flowmeter gauge shall be in 0.01-inch divisions. Instead of the flowmeter, a micrometer dial or stress-strain recorder graduated in 0.01-inch divisions.

- **WATER BATH** – will be at least 6 inches deep and will be thermostatically controlled so as to maintain the bath at  $140 \pm 2^\circ \text{F}$  ( $60 \pm 1^\circ \text{C}$ ). The tank will have a **perforated false bottom** or be equipped with a **shelf** for supporting specimens 2 inches above the bottom of the bath.
- **AIR BATH** – for asphalt cutback mixtures refer to the procedure for details on this equipment will not be tested on during ATTI ASPHALT or discussed in this manual.
- **THERMOMETER (WATER/AIRBATHS/BREAKING HEADS)**- with a temperature range of at least  $59^\circ\text{F}$  and  $149^\circ\text{F}$  ( $15^\circ \text{C}$  and  $65^\circ \text{C}$ ) and an accuracy of  $\pm 0.45^\circ \text{F}$  ( $\pm 0.25^\circ \text{C}$ ). See procedure for additional details.
- **CALIPERS** – calipers readable to 0.004 inches (0.1 mm).
- **GLOVES** – for removing specimens from water bath or handling any hot equipment.

## TEST SPECIMENS:

- **NUMBER & DIMENSIONS OF SPECIMENS** – Three cylindrical specimens,  $4.0 \pm 0.05$  inch ( $101.6 \pm 0.1$  mm) in diameter and ranging from 1.0 inches (25.4 mm) to 3.0 inches (76.2 mm) tall, are recommended. Prepare specimens according to AASHTO R68. 4.1.
- **ROADWAY CORE SPECIMENS** – cylindrical specimens must meet the dimensional requirements of the NUMBER & DIMENSIONS OF SPECIMENS (Section 4.1) may be collected according to AASHTO R67. 4.2.

## 5.1.

## PROCEDURE:

1

## Measure specimen height according to ASTM D3549:

1. **METHOD A:** Determined by direct measurement (using a ruler, calipers, measurement jig, or other suitable device)
  - a. Measure the thickness of the specimen or layer using a suitable device.
  - b. Make thickness measurements approximately perpendicular to the upper plane. Measuring between upper and lower surfaces.
  - c. Make 4 measurements at approximately quarter points on the periphery of the cylindrical specimens and average.
2. **METHOD B:** Determined through a combination of measurements of surface area and calculations using density as determined according to AASHTO T166.
  - a. Specimens of dense-graded asphalt mixtures (less than 10% air voids) with uniform vertical boundaries may be tested.
  - b. Refer to the procedure for additional details about this method.

$$\text{Volume cm}^3 = \frac{D - E - (D - A)/F}{1} \text{ or } \frac{B - C}{1} \quad (1)$$

where:

*A* = mass of the dry specimen in air, g,  
*B* = mass of the saturated surface-dry specimen in air, g,  
*C* = mass of the specimen in water, g,  
*D* = mass of dry, coated specimen, g,  
*E* = mass of coated specimen under water, g, and  
*F* = specific gravity of coating determined at  $25 \pm 1^\circ \text{C}$  ( $77 \pm 2^\circ \text{F}$ ).  
 The denominator is the density of water in  $\text{g/cm}^3$  or  $\text{kg/m}^3$ , which for the purpose of this test is considered to be unity.

7.4.3 Calculate the average thickness of the specimen as follows using the area determination from 7.4.1 and the volume determination from 7.4.2:

$$\text{Thickness, cm} = \frac{\text{Volume (cm}^3\text{)}}{\text{Area (cm}^2\text{)}} \quad (2)$$

**CALCULATION FOR METHOD B**  
(SEE ASTM D3549):



**RECORD ALL MEASUREMENTS TO THE NEAREST 0.001 OF AN INCH. REPORT THE AVERAGE OF THE HEIGHTS OF ALL THREE SPECIMENS.**



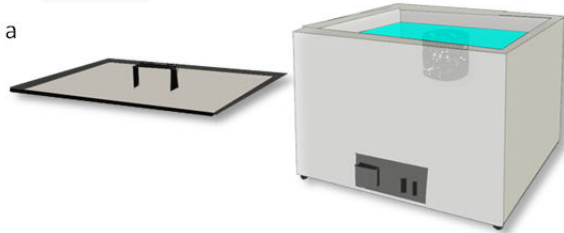
**MEASURE SPECIMEN**

2

Bring the **specimens** (asphalt binder) to the specified temperature by **immersing** in the **water bath 30 to 40 minutes** that maintains a **temperature of  $140 \pm 2^\circ \text{F}$  ( $60 \pm 1^\circ \text{C}$ )** OR placing in the **oven for 2 hours** at a **temperature of  $140 \pm 2^\circ \text{F}$  ( $60 \pm 1^\circ \text{C}$ )**. *For asphalt cutback material please refer to the procedure.*

5.2.

**PLACE SPECIMEN IN WATER BATH 30 TO 40 MINUTES AT A TEMPERATURE  $140 \pm 2^\circ \text{F}$**

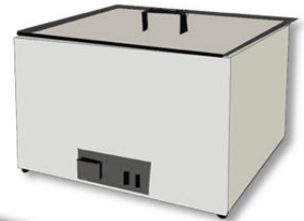


3

**Thoroughly clean** the guide rods and the inside surfaces of the breaking heads before testing, **and lubricate the guide rods** so that the upper test head slides freely over them.

5.2.

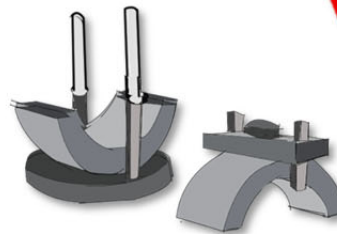
**CLEAN BREAKING HEAD AND LUBRICATE GUIDE RODS**



4

The breaking head temperature will be maintained between  **$70^\circ \text{F}$  ( $21.1^\circ \text{C}$ )** and  **$100^\circ \text{F}$  ( $37.8^\circ \text{C}$ )** using a water bath if necessary.

5.2.



**REMOVE SPECIMEN FROM WATERBATH. SLIGHTLY DAMP DRY AND PLACE ON LOWER BREAKING HEAD**

5

**Remove the specimen from the water bath, or oven, and place it in the lower segment** of the breaking head.

5.2.

**PLACE ON UPPER SEGMENT THEN PLACE COMPLETED ASSEMBLY IN TESTING MACHINE CORRECTLY**



6

Place the **upper segment** of the breaking head on the **specimen**; and **place the complete assembly in position** on the testing machine. Place the **flowmeter**, where used, in **position over one of the guide rods** and **adjust the flowmeter to zero** while **holding the sleeve firmly against the upper segment of the breaking head** (refer to manufacturer's instructions)

5.2.



7

**Hold the flowmeter sleeve firmly against the upper segment** of the breaking head while the **test load is being applied**. *(Refer to manufacturer's instructions)*

5.2.

8

Apply the load to the specimen by means of the constant rate of movement of the loading jack or testing machine head of **2 inches per minute** until the **maximum load is reached** and the load **decreases as indicated by the dial**.

5.3.

**APPLY LOAD ON SPECIMEN AT CONSTANT RATE OF 2 INCHES PER MINUTE UNTIL MAX LOAD IS REACHED**



9

Record the maximum load noted on the testing machine or converted from the maximum micrometer dial readings.

5.3.

10

Release the flowmeter sleeve or record the micrometer dial reading where the instant the maximum load begins to decrease. Record the indicated flow value displayed or equivalent units in twenty-five hundredths of a millimeter (hundredths of an inch) if a micrometer dial is used.

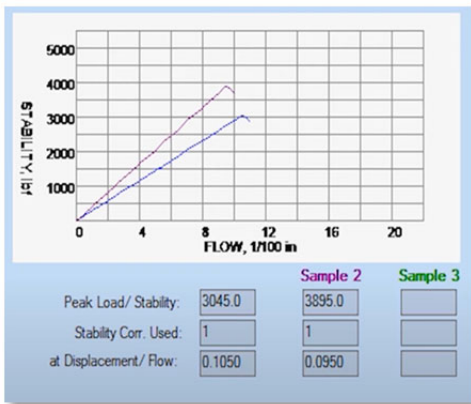
5.3.

11

The elapsed time for the test from removal of the test specimen from the water bath to the maximum load determination must not exceed 30 seconds.

5.3.

EXAMPLE OF STAB & FLOW DISPLAY (GILSON)



**STABILITY** – results are recorded to the nearest 10 lbs. Final result is the average maximum load of the three readings.

**Example:** if measured peak load is 1387 lbs, it is recorded at: 1390.



**NOTE 4:** for core specimens, correct the load when thickness is other than 2 1/2 inches (63.5mm) by using the proper multiplying factor from Table 2. (SECTION 53.)



**FLOW** – an average flow value shall be reported in units of 0.01 inch, rounded to the nearest whole number.

Table 2—Stability Correlation Ratios<sup>a,b</sup>

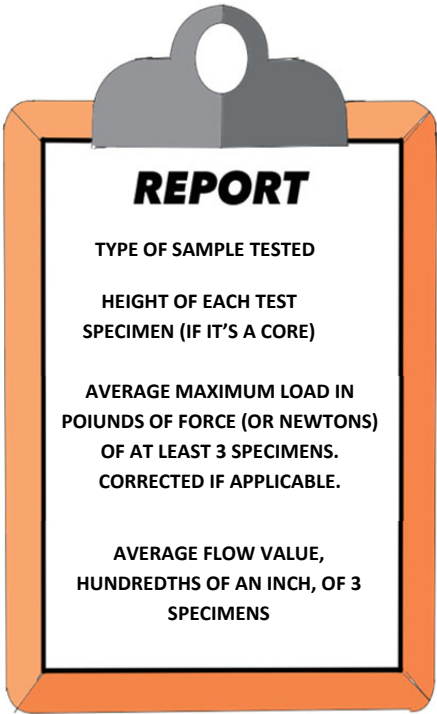
Volume of Specimen, cm <sup>3</sup>	Approximate Thickness of Specimen,		Correlation Ratio
	in.	mm	
200 to 213	1	25.4	5.56
214 to 225	1 1/16	27.0	5.00
226 to 237	1 1/8	28.6	4.55
238 to 250	1 1/4	30.2	4.17
251 to 264	1 1/2	31.8	3.85
265 to 276	1 5/8	33.3	3.57
277 to 289	1 3/4	34.9	3.33
290 to 301	1 7/8	36.5	3.03
302 to 316	1 1/2	38.1	2.78
317 to 328	1 1/8	39.7	2.50
329 to 340	1 1/4	41.3	2.27
341 to 353	1 1/2	42.9	2.08
354 to 367	1 3/4	44.4	1.92
368 to 379	1 7/8	46.0	1.79
380 to 392	1 7/8	47.6	1.67
393 to 405	1 15/16	49.2	1.56
406 to 420	2	50.8	1.47
421 to 431	2 1/16	52.4	1.39
432 to 443	2 1/8	54.0	1.32
444 to 456	2 1/4	55.6	1.25
457 to 470	2 1/4	57.2	1.19
471 to 482	2 1/2	58.7	1.14
483 to 495	2 1/2	60.3	1.09
496 to 508	2 1/2	61.9	1.04
509 to 522	2 1/2	63.5	1.00
523 to 535	2 1/4	65.1	0.96
536 to 546	2 1/8	66.7	0.93
547 to 559	2 1/8	68.3	0.89
560 to 573	2 1/4	69.9	0.86
574 to 585	2 1/2	71.4	0.83
586 to 598	2 1/4	73.0	0.81
599 to 610	2 1/2	74.6	0.78
611 to 625	3	76.2	0.76

<sup>a</sup> The measured stability of a specimen multiplied by the ratio for the thickness of the specimen equals the corrected stability for a 63.5 mm (2 1/2-in.) specimen.

<sup>b</sup> Volume-thickness relationship is based on a specimen diameter of 101.6 mm (4 in.).

**REPORT:**

6.



# AASHTO T269:

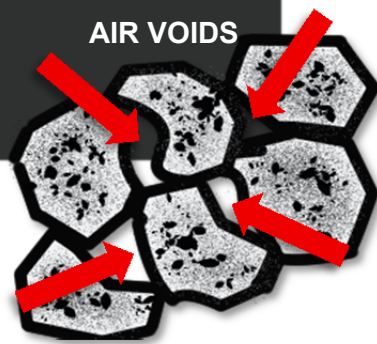
## PERCENT AIR VOIDS IN COMPACTED DENSE AND OPEN ASPHALT MIXTURES

### DEFINITIONS:

**Air Voids** – the pockets of air between the asphalt-coated aggregate particles in a compacted asphalt mixture.

**Dense Asphalt Mixtures** – asphalt mixtures where the air voids are less than 10 percent when compacted.

**Open Asphalt Mixtures** – asphalt mixtures where the air voids are 10 percent or more when compacted.



The percent Air voids in an asphalt mixture are used as one of the criteria in the design methods and for evaluation of the compaction achieved on asphalt paving projects. Air voids are small airspaces or pockets of air that occur between the coated aggregate particles in the final compacted mix. A certain percentage of air voids is necessary to allow for some additional pavement compaction under traffic and to provide spaces into which small amounts of asphalt can flow during this subsequent compaction.

### SCOPE:

This method covers the determination of the percent air voids ( $P_a$ ) in compacted dense and open asphalt mixtures.

1.1.

### SAMPLING:

- **Test samples** are specimens from **laboratory-molded mixtures** (ex: Marshalls, Gyros...) **OR cores** from field-compacted mixtures.

5.1

### PROCEDURE:

1

For dense asphalt mixtures, determine the **bulk specific gravity ( $G_{mb}$ )** of the compacted mixture according to **AASHTO T166**. *For other methods of obtaining bulk specific gravity please refer to the procedure.*

6.1.

2

Determine the **theoretical maximum specific gravity ( $G_{mm}$ )** according to **AASHTO T209** on an **equivalent asphalt mixture** to avoid the influence of differences in gradation, asphalt content, etc.

6.1.

**FOR OPEN ASPHALT MIXTURES, USE EITHER OF THE FOLLOWING METHODS:**

3

**Automatic Vacuum Sealing Method** – determine the **bulk specific gravity ( $G_{mb}$ )** of the compacted mixture by **AASHTO T331 BULK SPECIFIC GRAVITY (VACUUM SEALING)**. Determine the **theoretical maximum specific gravity ( $G_{mm}$ )** according to **AASHTO T209** on an equivalent asphalt mixture.

6.2.1.

**OR**

3

**Volume Method** – determine the **density** of a compacted specimen (only cylindrical) from its **dry mass (in grams)** and its **volume (in cubic centimeters)**. Obtain the **height** of the specimen according to **ASTM 3549 (see AASHTO T245 in the manual)** Then measure the **diameter** of the specimen at **4 locations** and **averaging** the measurements. **Calculate the volume** of the specimen based on the average height and diameter measurements. Convert the density to **bulk specific gravity ( $G_{mb}$ )** by dividing by **0.99707 g / cm<sup>3</sup>** or **997 kg / m<sup>3</sup>**, the density of water at 77 °F (25 °C). Determine the **theoretical maximum specific gravity ( $G_{mm}$ )** according to **AASHTO T209** on an equivalent asphalt mixture.

6.2.2.

**CALCULATION:**

Calculation for the percent air voids in a compacted asphalt mixture:

**PERCENT AIR VOIDS**

$$P_a = 100 X \left( 1 - \left( \frac{G_{mb}}{G_{mm}} \right) \right)$$

**OR**

$$P_a = 100 X \left( \frac{G_{mm} - G_{mb}}{G_{mm}} \right)$$



**NOTE 1** – Test results should not be reported to a greater number of significant digits than the specified air voids limits that is generally to the nearest **0.1 percent**. (Section 7.1.)



**For reference purposes**, determine both the bulk specific gravity and the theoretical maximum specific gravity on portion of **the same sample** of compacted asphalt mixture. (Section 6.2.2.)

$P_a$  = percent air voids recorded to the nearest 0.1 percent;

$G_{mb}$  = bulk specific gravity recorded to the nearest thousandth;

$G_{mm}$  = the theoretical maximum specific gravity recorded to the nearest thousandth;

**EXAMPLE**

**AASHTO T166** (different example results not from section in manual):  $G_{mb} = 2.289$

**ASSHTO T209**(different example results not from section in manual):  $G_{mm} = 2.397$

$$P_a = 100 X \left( 1 - \left( \frac{2.289}{2.397} \right) \right)$$

**OR**

$$P_a = 100 X \left( \frac{2.397 - 2.289}{2.397} \right)$$

**ANSWER:  $P_a = 4.5\%$**  ←

# AASHTO T304:

## UNCOMPACTED VOID CONTENT OF FINE AGGREGATE

### DEFINITIONS:

**Angularity** - is a description of the degree of roughness, surface irregularities or sharp angles of the aggregate particles.

**Void Content** - the volume of empty space (voids) between individual aggregate particles, expressed as a percentage of the total volume.

**Grading (aggregates)** - refers to the particle size distribution within a sample of aggregate materials. It describes how well the aggregate particles are mixed and how many of each size are present.

### SCOPE:

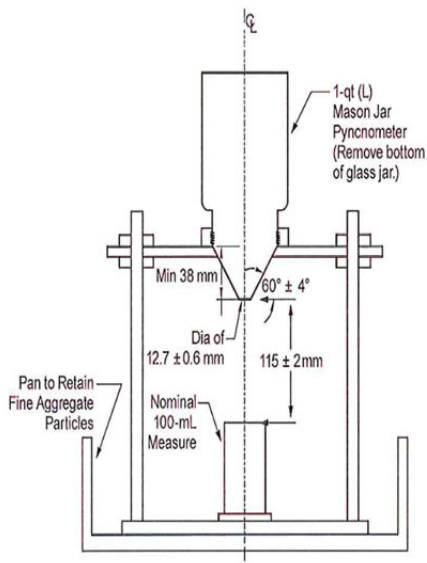
1.1.

This test method describes the determination of the loose uncompact void content of a sample of fine aggregate. When measured on any aggregate of known grading, void content provides an indication of that aggregate's angularity, sphericity, and surface texture compared with other fine aggregates tested in the same grading.

### EQUIPMENT:

6.

- **CYLINDRICAL MEASURE** – a cylinder of approximately 100 mL capacity having an inside diameter of approximately 39mm and an inside height of approximately 86 mm. (See procedure for more detail and all critical dimensions)
- **FUNNEL** – a metal funnel with an opening  $12.7 \pm 0.6$  mm diameter. It shall be at least 38mm high with a volume of at least 200 mL. (See procedure for more detail and all critical dimensions)
- **FUNNEL STAND** – three- or four-legged support capable of holding the funnel firmly in position. The funnel opening must be  $115 \pm 2$  mm above the top of the cylinder measure. (See procedure for more detail and all critical dimensions)
- **GLASS PLATE**– a square glass plate approximately 60 mm by 60 mm with a minimum 4 mm thickness.
- **PAN** – a flat metal or plastic pan of sufficient size to contain the funnel stand and to prevent loss of material. Must not be warped to prevent rocking of the device during testing.
- **METAL SPATULA** – with a blade approximately 100 mm long and at least 20 mm wide. The blade will have straight edges and the end will be cut at a right angle to the edges. The straight edges
- **BALANCE** – accurate and readable to  $\pm 0.1$  grams.
- **THERMOMETER (MEASURING LIQUID)** - with a temperature range of at least 60.8 F to 78.8 °F (16 °C to 26 °C) with an accuracy of an accuracy of  $\pm 0.9^\circ\text{F}$ .



There are 3 methods within this procedure that provide percent void content determined under standardized conditions. An increase in void content determined by these methods indicates greater angularity, less sphericity, or rougher surface texture or some combination of these. A decrease in void content is associated with more rounded, spherical, smooth surfaced fine aggregate, or any combination of these. Each method has its own strengths and weaknesses and should be applied according to agency requirements or procedures.

**SAMPLE:**

- The sample used for this test will be obtained **according to AASHTO R90** and brought to testing size **according to AASHTO R76 OR** from **sieve analysis** samples used for **AASHTO T27, OR aggregate extracted** from a **bituminous concrete specimen**. 7.1
- For **METHODS A & B**, the sample is **washed over a #100 or #200 sieve** according to AASHTO T11 and then dried and **sieved into separate size fractions** according to **AASHTO T27**. 7.1
- Place the required **different size fractions** obtained from one (or more) sieve analysis in a **dry condition in separate containers for each size**. 7.1
- For **METHOD C**, dry a **split of the as received sample** according to the drying procedures from **AASHTO T27**. 7.1

**CALIBRATION OF CYLINDRICAL MEASURE:**

**1** Apply a **light coat of grease** to the **top edge** of the dry, empty cylindrical measure. **Weigh the measure, (with grease on it) and glass plate** to the nearest **0.1 grams**. 8.1

**2** Fill the measure with **freshly boiled, deionized OR distilled water** at a temperature of **18 °C to 24 °C**. **Remove any air bubbles** seen using appropriate equipment. **Record the temperature of the water**. 8.1

**3** **Top off the measure** so that the **water is slightly over the rim**. Cover the **measure with the glass plate** in a way so as **not to entrap air bubbles**. Dry the outer surfaces of the measure carefully and **weigh the combined mass of measure glass plate grease, and water** to the nearest **0.1 grams**. 8.1

**4** Following the final weighing **remove the grease and determine the mass of the clean, dry, empty measure** for subsequent tests. Alternatively, the **clean, dry, empty measure can be weighed first before the calibration procedure begins**. 8.1

*FILL THE MEASURE (WITH APPROPRIATE WATER) AND TAKE TEMPERATURE AND RECORD*

*APPLY GREASE TO RIM*

*WEIGH & RECORD MEASURE (WITH GREASE) AND PLATE*

*WEIGH & RECORD COMBINED MASS*



Determine the volume to the nearest 0.1 mL. (Section 8.2.)

**VOLUME OF MEASURE**

$$V = 1000 \left( \frac{M}{D} \right)$$

**V** = volume of cylinder, mL;  
**M** = net mass of water, g;  
**D** = density of water (see Table 3 in AASHTO T19 SECTION 8), kg/m<sup>3</sup>;

**EXAMPLE:**

**Mass of empty measure AND glass plate: 187.1 grams**  
**TOTAL mass water AND measure AND glass plate: 285.2 grams**  
**Net mass water (285.2 – 187.1) = 98.1 grams**  
**Density of water: (see AASHTO T19 calibration of measure for density of water table)**  
**Temperature of the water for this example: 23.9°C**  
**Density of water from table: 997.32 kg / m<sup>3</sup>**  
 $1000 \left( \frac{98.1}{997.32} \right) = 98.36361449 = 98.4 \text{ mL}$   
**V = 98.4 mL**

**PREPARATION OF SAMPLES:**



**METHOD A- STANDARD GRADED SAMPLE:** Weigh out and combine the following quantities of fine aggregate which has been dried and sieved in accordance with AASHTO T27.

**METHOD A WILL BE DEMONSTRATED & TESTED ON DURING ATTII**

**INDIVIDUAL SIZE FRACTION:**

9.1

Passing #8 screen and retained on #16 screen **44 ± 0.2 grams**  
 Passing #16 screen and retained on #30 screen **57 ± 0.2 grams**  
 Passing #30 screen to retained on #50 screen **72 ± 0.2 grams**  
 Passing #50 screen to retained on #100 screen **17 ± 0.2 grams**  
**190 ± 0.2 grams**

**METHOD B- INDIVIDUAL SIZE FRACTIONS:** Prepare a separate 190-gram sample of fine aggregate, dried and sieved in accordance with AASHTO T27 in the following table:

**INDIVIDUAL SIZE FRACTION:**

9.2

Passing #8 screen and retained on #16 screen **190 ± 0.1 grams**  
 Passing #16 screen and retained on #30 screen **190 ± 0.1 grams**  
 Passing #30 screen to retained on #50 screen **190 ± 0.1 grams**

**DO NOT mix these samples together. Each size is tested separately.**

- METHOD C- AS RECEIVED GRADING:** Pass the **sample** (dried in accordance with AASHTO T27) through a **#4 sieve**. Obtain a  $190 \pm 1$  gram sample of the material passing the #4 screen for testing.

9.3



**SPECIFIC GRAVITY OF FINE AGGREGATE:**

If the bulk dry specific gravity of fine aggregate from the source is unknown, determine it on the material passing the #4 sieve according to AASHTO T84. The bulk dry specific gravity of fine aggregate is used to calculate uncompacted voids. See the procedure for additional details (Section 9.4.).

1

Mix each **test sample** with the spatula until it appears to be **homogenous**. Position the cylinder centered under the funnel. See procedure for more detail on equipment set up.

10.1

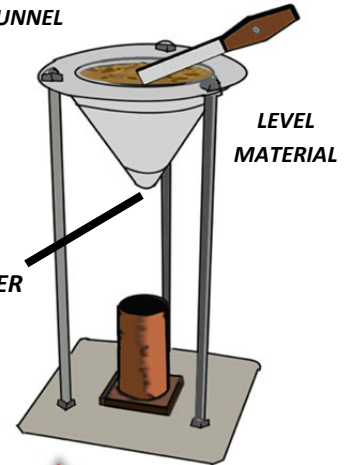
**PROCEDURE:**

2

Use a **finger** to **block the opening** of the **funnel** then **pour the test sample into the funnel**. Level the material in the funnel with the spatula.

10.1

POUR SAMPLE INTO FUNNEL



3

Remove the **finger** and allow the sample to fall **freely** into the cylindrical measure.

10.1

FINGER

4

After the funnel empties, **strike off excess** heaped fine aggregate from the cylindrical measure by a **rapid single pass** of the spatula. While striking off keep the **width of the blade vertical**, keeping the **straight part of its edge horizontal** and in **light contact with top of the measure**.

10.2



Until this operation is complete avoid vibration or any disturbance that could cause compaction of the fine aggregate in the measure. (SECTION 10.2.)



**NOTE 3:** After strike off, the cylindrical measure may be tapped lightly to compact the sample to make it easier to transfer the container to the balance without spilling. (SECTION 10.2.)

5

Brush adhering grains from the outside of the container and **weigh the mass of the cylinder measure and contents** to the nearest 0.1 grams. **Retain all fine aggregate particles for a second run.**

10.2

6

Recombine the material from the retaining pan and cylinder measure and repeat the procedure. The results of the 2 runs are averaged.

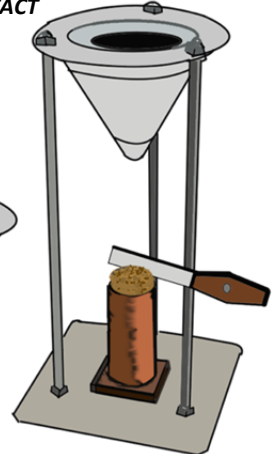
7

Record the mass of the empty measure. (THIS CAN ALSO BE DONE BEFORE THE PROCEDURE IS PERFORMED)

STRIKE OFF WITH A SINGLE PASS WHILE MAKING LIGHT CONTACT

10.3

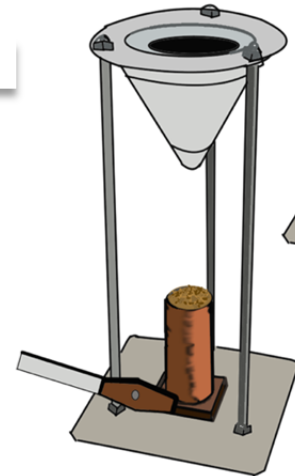
10.3



WEIGH EMPTIED CYLINDRICAL MEASURE



WEIGH FILLED CYLINDRICAL MEASURE



CALCULATIONS:

UNCOMPACTED VOIDS

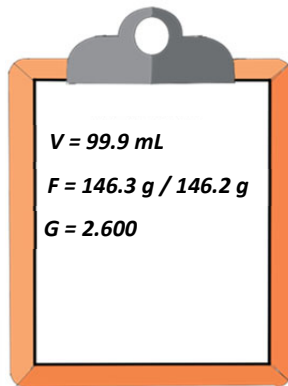
$$U = \left( \frac{V - \left(\frac{F}{G}\right)}{V} \right) \times 100$$

V = volume of cylinder, mL;

F = net mass, g, of fine aggregate in measure (Weight of measure with material - Weight of measure empty);

G = bulk dry specific gravity of fine aggregate;

U = uncompact voids, percent, in material;



METHOD A: • For the standard graded sample (Method A) calculate the average uncompact voids for the two determinations and report the result.

EXAMPLE:

WEIGHT OF EMPTY MEASURE = 187.1 grams

1 FIRST RUN

FIRST RUN = 333.4 grams (measure & material)

333.4 grams - 187.1 grams = 146.3 grams

Net Mass (F) = 146.3 grams

$$U = \left( \frac{99.9 - \left(\frac{146.3}{2.600}\right)}{99.9} \right) \times 100$$

UNCOMPACTED VOID CONTENT (U<sub>1</sub>) = 43.7% (rounded)

SECOND RUN = 333.3 grams (measure & material)

333.3 grams - 187.1 grams =

Net Mass (F) = 146.2 grams

2 SECOND RUN

$$U = \left( \frac{99.9 - \left(\frac{146.2}{2.600}\right)}{99.9} \right) \times 100$$

UNCOMPACTED VOID CONTENT (U<sub>2</sub>) = 43.7% (rounded)

AVERAGE BOTH UNCOMPACTED VOID RESULTS

$$3 \text{ AVERAGE} = \left( \frac{43.7 + 43.7}{2} \right)$$

AVERAGE RESULT = 43.7%

**METHOD B:** • For the individual size fractions (Method B) calculate:

First, the average uncompact voids for the determination made on each of the 3 size fraction samples: EXAMPLE:

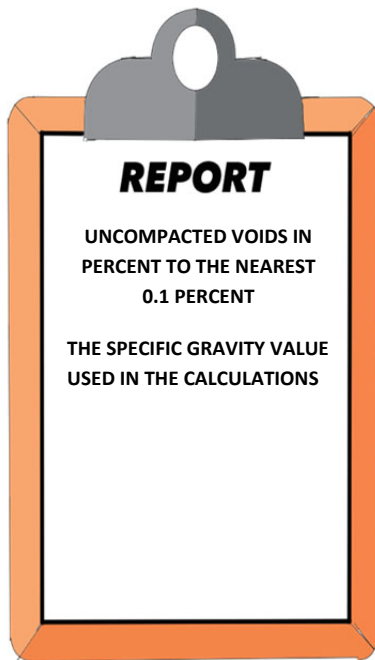
$U_1$  = uncompact voids #8 to #16 screen, percent;

$U_2$  = uncompact voids #16 to #30 screen, percent;

$U_3$  = uncompact voids #30 to #50 screen, percent;

$$\text{AVERAGE } (U) = \left( \frac{U_1 + U_2 + U_3}{3} \right)$$

**METHOD C:** • For METHOD C, calculate the average uncompact voids for the two determinations and report the result.



12.

**REPORT:**

- Example only demonstrates what is to be reported for METHOD A. Refer to the procedure on what is to be reported for METHOD B & METHOD C.

**AASHTO T255:  
STANDARD METHOD OF TEST  
FOR TOTAL EVAPORABLE  
MOISTURE CONTENT OF  
AGGREGATE BY DRYING.**

**SCOPE:**

This test method covers the determination of the percentage of evaporable moisture in a sample of aggregate by drying both surface moisture and moisture in the pores of the aggregate. Drying procedure to achieve constant mass for aggregate.

1.1.

**EQUIPMENT:**

5.

This test method determines the total moisture content in aggregates, including those used in asphalt and concrete mixtures. This test has many applications. An example of the significance for this test is that both batch and drum asphalt plants, aggregate is weighed before mixing. If moisture is not measured and adjusted for, the plant may add too much water (by weight), resulting in under-dosing of asphalt binder and other ingredients.



**SAMPLE:**

- Sampling will generally be according to AASHTO R90 except the sample size may conform to Table 1 in the procedure.
- Obtain the representative aggregate sample. The sample must have a mass that is at least minimum amount that is outlined in the table.
- Protect the sample from a loss of moisture before determining the mass of the sample.

6.1

6.2.

6.2.

- **SOURCE OF HEAT** – Thermostatically controlled oven capable of being heated continuously at a temperature of 230 ± 9°F (110 ± 5°C). The oven must be capable of operation at the temperatures required, between 212°F to 248°F (100°C to 120°C). Other sources of heating can be used such as a hot plate, electric heat lamps and a ventilated microwave oven.
- **BALANCE** – Readable to at least 0.1 % of the sample mass, record to the nearest 0.1 grams.
- **CONTAINERS (FOR CONSTANT MASS)** – Made of material not effected by heat and volume enough to contain the sample without spilling and a size where the sample depth will not exceed one-fifth of the least lateral dimension.
- **CONTAINERS (FOR TRANSPORT/ OBTAINING)** – That can adequately protect the sample against loss of moisture.
- **STIRRER**
- **THERMOMETER (OVEN VERIFICATION)**- with a temperature range of at least 194°F and 266 °F (90 °C and 130 °C) and an accuracy of ± 2.25 °F (± 1.25 °C). See procedure for additional details.

Nominal Maximum Size of Aggregate, mm (in.) <sup>a</sup>	Mass of Normal Weight Aggregate Sample, Min., kg <sup>b</sup>
4.75 (0.187) (No. 4)	0.5
9.5 (3/8)	1.5
12.5 (1/2)	2
19.0 (3/4)	3
25.0 (1)	4
37.5 (1 1/2)	6
50 (2)	8
63 (2 1/2)	10
75 (3)	13
90 (3 1/2)	16
100 (4)	25
150 (6)	50

<sup>a</sup> Based on sieves meeting ASTM E11.

<sup>b</sup> Determine the minimum sample mass for lightweight aggregate by multiplying the value listed by the dry-loose unit mass of the aggregate in kg/m<sup>3</sup> (determined using T 19M/T 19) and dividing by 1600.

**PROCEDURE:**

**1** Weigh and record the mass of the moisture sample to the nearest **0.1%** or to the nearest **0.1 grams**. Obtain weight of container empty to subtract from total mass of sample and container. Record the mass of the sample.

7.1.

**EXAMPLE OF WAY TO PROTECT SAMPLE FROM LOSS OF MOISTURE FROM THE FIELD**



**2** Dry the sample thoroughly in the **sample container** by means of the selected **source of heating**. Avoid loss of particles.

7.2.

**Rapid heating may make particles explode losing material. IF not using the oven stir constantly to avoid over localized heating. (SECTION 7.2.)**

**3** Use an **oven** when it is determined that **excessive heat will alter the character** of the aggregate, or where **more precise measurement is required**.

7.2.

**Contant Mass:** Sample is dry when further heating causes less than 0.1% additional loss in mass. (SECTION 7.4.).



**4**

Remove the moisture sample from the **oven** and **reweigh** and record the mass to the nearest **0.1 %** or to the nearest **0.1 grams**. Calculate whether the **sample has lost 0.1% from the previously recorded weight**. If not repeat the process until constant mass has been attained.

7.2.



**5**

Once **dried weigh** and record the mass of the dried sample to the nearest **0.1%** or nearest **0.1 grams** after it has cooled to the point where it won't damage the balance.

7.4.



**CALCULATION:**

**TOTAL EVAPORABLE MOISTURE CONTENT CALCULATION**

$$P = \frac{100*(W-D)}{D}$$

P = total evaporable moisture content of sample (percent);

W = mass of original sample (grams);

D = mass of dried sample (grams)

**EXAMPLE:**

Mass of original sample:

**688.1 grams.**

Mass of dried sample:

**663.2 grams.**

$$\frac{100*(688.1-663.2)}{663.2} = 3.754523522 = \text{Answer: } \mathbf{3.8\%}$$



**WHAT IS THE SURFACE MOISTURE CONTENT?**

*It's the difference between the total evaporable moisture content result and the absorption. All values are based on the mass of a dry sample. Absorption can be determined by T85 or T84*

# AASHTO T355:

## DENSITY OF COMPACTED BITUMINOUS MIXTURES BY NUCLEAR METHOD

### DEFINITIONS:

**Back Scatter Mode** – when in back scatter mode the source is in the same plane as the sensor. The shielding within the gauge means that radiation given off the source must first be deflected by the material before reaching the sensor. The more radiation detected by the sensor the higher the material's density.

### SCOPE:

This method describes the procedure for determining the in-place density of ASPHALT MIXTURES by use of the nuclear gauge. The density is determined by the back scatter method.

1.1.

### EQUIPMENT:

5.

- **NUCLEAR DENSITY/ MOISTURE GAUGE with instruction manual**
  - **SEALED RADIATION SOURCE** – high energy gamma radiation such as cesium or radium.
  - **GAMMA DETECTOR** – any type of detector such as a Geiger-Mueller tube.

*see procedure for more details.*
- **TRANSPORT CASE-** for properly shipping and housing the gauge and tools.
- **REFERENCE STANDARD / BLOCK** – a block of material used for checking gauge operations.
- **SITE PREPARATION APPARATUS** – a straight edge / plate / leveling tool.
- **FILLER MATERIAL-** fine graded sand from a source that is used to produce the asphalt pavement or other acceptable material.
- **RADIOACTIVE MATERIAL & CALIBRATION PACKET** – CONTAINS: daily standard count log, factory & laboratory calibration data sheet, Leak test cert, Procedure for handling, Shipper's declaration for dangerous goods, anything else required by local agencies.

### STANDARDIZE:

- **Standardization** of the gauge on the reference standard / block is required **every day** and a **permanent record must be maintained.**

8.2.

- Perform the standardization at least **30 feet** from any **other gauge** or other radioactive sources and **10 feet** away from **large masses.**

8.2.



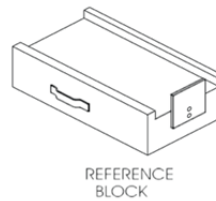
Take the standard counts in the same environment as the actual measurement counts. (SECTION 8.2.)

- Follow **instruction manual** on how to turn on and **stabilize** the gauge. If the gauge is used continuously or intermittently its best to leave the gauge on.

8.2.1.



**NOTE 2:** *The nuclear gauge density measurements are somewhat biased to the surface layers of the material being tested. This method is more sensitive to the material within the first several inches from the surface (SECTION 4.1. 2..)*



*When gauge is seated on the reference block make sure the gauge is butted up against the plate on the block.*

- While on the standardization block take at least **four repetitive readings** and obtain the **mean**. This is considered one standardization check. *Note: Some gauges will do this automatically.*

8.2.2.

- If the **mean of the 4 repetitive readings** is outside the limits set by the procedure's equation repeat the standardization check. If the second check is still outside, refer to the **annex** from the procedure. **You are determining that the standard counts are within the limit for normal operation in accordance with the gauge manufacturer's manual.**

8.2.3.

#### PROCEDURE:

*The nuclear density gauge works by using a small source of gamma radiation (usually Cesium-137 or Americium-241) to send gamma rays into the compacted asphalt mixture. When the gamma rays interact with the material, some of the rays are scattered back to the detector, while others are absorbed by the material. The density of the material is then determined by the backscatter/air gap ratio method. See the procedure for more details.*

### Alternate Method 1 – 90 Degree Rotation

1

Select a relatively **flat test location**. Make sure the gauge is at least **10 feet away** from any **large object and 30 feet from any other radioactive sources**. *If closer than 24 inches to a vertical mass or less than 12 inches from a vertical pavement edge follow the manufacturer's guide for the correction procedure.*

9.1.

2

The gauge must maintain **full contact** between its base and the **surface** of material. If there are surface **voids** use filler material to **fill them in**. Spread a **small amount of filler** over the **voids** and **distribute evenly**. Strike off with a straight edge to remove excess material.

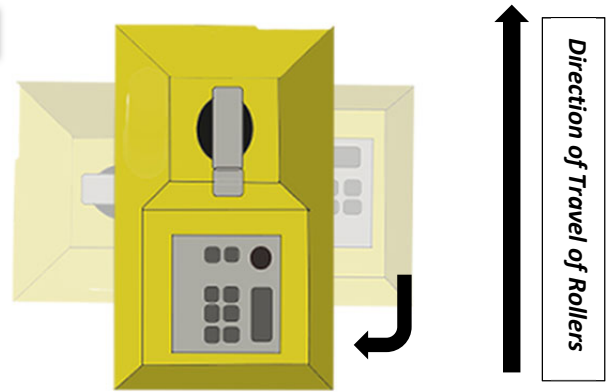
9.2.1.

3

Place the gauge on the test site **perpendicular** to the **direction of travel of the rollers**. Mark the **outline** of the foot print of the **gauge with crayon or chalk (or other suitable material)**.

9.3.1.1.

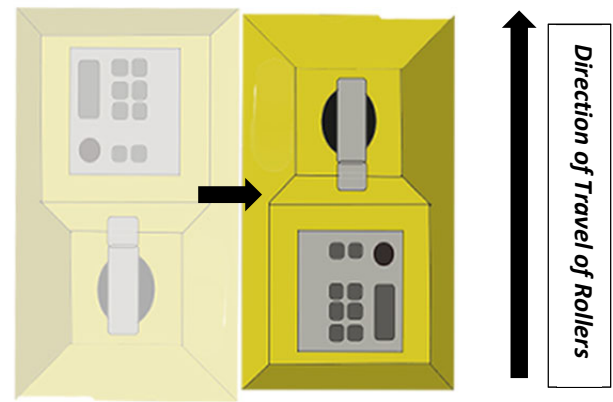
- 4 Place the gauge in the **back scatter** position. 9.3.1.1.
- 5 Take a **1-minute test** and record the **wet density** reading. Record to **0.1 lb/ft<sup>3</sup>** 9.3.1.2.
- 6 **Rotate** the gauge **90 degrees** centered **over the original outline**. Mark the outline of the new position. 9.3.1.3.
- 7 Take a **1-minute test** and record the **new wet density** reading. Record to **0.1 lb/ft<sup>3</sup>**. 9.3.1.4.
- 8 If the **difference** between the **2 readings** is **greater than 2.5 lb/ft<sup>3</sup>** then **retest in BOTH directions**. 9.3.1.6.
- 9 If the difference between the retests is still higher then **repeat the test at 180° & 270°**. 9.3.1.6.



Report the **AVERAGE** of the two individual 1-minute wet density readings. (SECTION 9.3.1.)

**Alternate Method 2 – 180 Degree Rotation**

- 1 Prepare your test area the same as SECTION 9.2.1.
- 2 Place the gauge on the test site **parallel to the direction of travel of the rollers**. Mark the outline of the foot print of the gauge. 9.3.2.1.
- 3 Take a **1-minute reading** & record the **wet density**. Record all densities to **0.1 lb/ft<sup>3</sup>**. 9.3.2.2.
- 4 **Rotate** the gauge **180 degrees** centered over the original outline. 9.3.2.3.
- 5 Take another **1-minute reading** & record the **wet density**. 9.3.2.4.



Report the **AVERAGE** of the two 1-minute wet density readings. (SECTION 9.3.2.6.)

6

If the **difference** between the **2 readings** is **greater** than **2.5 lb/ft<sup>3</sup>** then **retest** in **BOTH directions**.

9.3.2.5.

*Alternate Method 3*

1

Place the **gauge** on the test site **parallel** to the direction of travel of the rollers. **Mark the outline** of the foot print of the gauge.

9.3.3.1.

2

Take a **4-minute test** and record the **wet density**. Record all densities to **0.1 lb/ft<sup>3</sup>**.

9.3.3.2.

**CALCULATION:**



**WHAT IS THE CALCULATION FOR PERCENT COMPACTION:**

$$\% \text{ Compaction} = \frac{\text{In Place Density}}{\text{Maximum Density}} \times 100$$

**REPORT:**

11.

**REPORT**

STANDARDIZATION & ADJUSTMENT DATA FOR THE DATE OF TESTS

MAKE, MODE, SERIAL # OF GAUGE

NAME OF TECHNICIAN

DATE OF LAST CALIBRATION / VERIFICATION

TEST SITE IDENTIFICATION

THICKNESS OF LAYER TESTED

DENSITY

% COMPACTION (CORRECTED WITH CORES IF APPLICABLE)



**PRACTICE QUESTIONS:**

ANSWERS:

1. c
2. b
3. a
4. b
5. d
6. b
7. a

1. Take a **1-minute reading** & record the **wet density**. Record all densities to \_\_\_\_\_ (according to AASHTO T355)?
  - a.  $0.5 \text{ lb/ft}^3$
  - b.  $1.0 \text{ lb/ft}^3$
  - c.  $0.1 \text{ lb/ft}^3$
2. It is not necessary to protect the sample from a **loss of moisture before** determining the mass of the sample. (according to AASHTO T255)?
  - a. TRUE
  - b. FALSE
3. Fill the measure with **freshly boiled, deionized OR distilled water** at a temperature of \_\_\_\_\_. (according to AASHTO T304)?
  - a. 18 °C to 24 °C
  - b. 19 °C to 25 °C
  - c. 28 °C to 34 °C
4. Test samples for this procedure are **ONLY** cores (according to AASHTO T269)?
  - a. TRUE
  - b. FALSE
5. Apply the load to the specimen by means of the constant rate of movement of the testing machine head of \_\_\_\_\_ **per minute until the maximum load is reached** (according to AASHTO T245)?
  - a. 2.5 inches
  - b. 1 inch
  - c. 0.2 inches
  - d. 2 inches
6. Remove the specimen from the **water bath, damp dry** the specimen by **blotting it with a damp towel**, and **weigh and record** to the nearest \_\_\_\_\_ **grams** as quickly as possible (**not to exceed \_\_\_\_\_seconds**) (AASHTO T166)?
  - a. 0.2, 15
  - b. 0.1, 15
  - c. 0.2, 10
7. Select a relatively **flat test location**. Make sure the gauge is at least \_\_\_\_\_ **feet** away from any **large object** and \_\_\_\_\_ **feet** from any other **radioactive sources**. (AASHTO T11)?
  - a. 10, 30
  - b. 12, 32
  - c. 10, 60