

# **HOT MIX ASPHALT (HMA) TECHNICIAN TRAINING MANUAL**



Developed by  
Multi-Regional Asphalt Training and Certification Group  
Revised 2006



## **Table of Contents**

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<b>Topic</b>	<b>Chapter File</b>
Preface	INTRO
AASHTO T 40, Sampling Bituminous Materials	T40
AASHTO T 168, Sampling Bituminous Paving Mixtures	T168
AASHTO R 30, Mixture Conditioning of Hot Mix Asphalt	R30
AASHTO T 312, Standard Method for Preparing and Determining the Density of Hot Mix Asphalt Specimens by Means of the Superpave Gyratory Compactor	T312
AASHTO T 166, Bulk Specific Gravity of Compacted Hot-Mix Asphalt Mixtures Using Saturated Surface-Dry Specimens	T166
AASHTO T 209, Theoretical Maximum Specific Gravity and Density of Hot- Mix Asphalt Paving Mixtures	T209
AASHTO T 283, Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage	T283
AASHTO T 308, Determining the Asphalt Binder Content of Hot Mix Asphalt by the Ignition Method	T308

## **Preface**

This training manual was developed as part of a multi-regional effort to assist states with meeting the requirements of the Code of Federal Regulation, Part 637, for “qualified” personnel to perform material sampling and testing for quality control and quality acceptance (QC/QA).

The ultimate goal of the group is also to promote reciprocity of this “qualification” across state lines. To that end, the group recommends that each training program cover the procedures and specifications listed here as a minimum core. The core materials should include presentation of the current AASHTO procedures. Individual state requirements, if needed, should be presented in addition to, not instead of, the approved AASHTO versions.

This manual is designed to cover the Superpave systems, only those tests and specifications applicable to the Superpave systems are presented here.

AASHTO standards are listed in the Table of Contents in the recommended order of presentation. Prerequisites for the standards are listed on the first page of each one. Knowledge of certain methods and tests is necessary before proceeding to other standards.

Students are to use the mathematical rounding rules recommended by each agency in performing calculations for qualification testing.

# **SAMPLING BITUMINOUS MATERIALS**

## **AASHTO T 40**



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**NOTE**

**There are no prerequisites for this training package.**



# TABLE OF CONTENTS

---

SAMPLING OF BITUMINOUS MATERIALS ..... [Asph-T40-1](#)  
    Common Sampling Errors..... [Asph-T40-1](#)

TESTING..... [Asph-T40-2](#)  
    Apparatus..... [Asph-T40-2](#)  
    Sampling Procedure ..... [Asph-T40-2](#)  
    Sampling Procedure ..... [Asph-T40-2](#)

GLOSSARY ..... [Asph-T40-3](#)



# **SAMPLING OF BITUMINOUS MATERIALS**

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This discussion of sampling bituminous materials is limited to the sampling of asphalt binder. Asphalt binder quality is important to producing quality Hot Mix Asphalt (HMA). Using the correct grade of asphalt ensures that the HMA pavement will perform as expected under the conditions encountered in the field. The producers of asphalt binders are responsible for the quality of their product and must operate under a quality control plan. Proper sampling is a key component of any Quality Control/Quality Assurance plan.

As in sampling many products, safety is a major factor. Be sure to always wear the proper safety equipment and use extreme caution around hot asphalt binder.

Sampling locations for asphalt binders include the following:

- from the producer's storage facility
- from shipment, or
- from the Hot Mix Asphalt producer's plant

The location of the sample should be as directed by the State Highway Agency (SHA). Most Agencies specify one or more of the above sampling locations depending on the type or purpose of the sample being obtained.

There are two methods for sampling asphalt binder:

1. By the use of a sample valve attached to the line or tank.
2. Dipping a sampling device into the asphalt from above.

The use of a sample valve is the preferred method.

The asphalt binder samples need to be placed in the proper containers. Always use caution when handling containers filled with hot asphalt binder.

## **Common Sampling Errors**

- Not wasting material before taking a sample from a valve.
- Improper sample container.
- Not wearing proper safety gear.

# TESTING METHODOLOGY

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## Apparatus

- Safety apparel including - insulated gloves, face shield, long sleeve shirts, long pants, and boots.
- Dipper (when dip sampling)
- Sample containers - these containers need to be clean, tight-sealing metal cans of the proper size. **Do not use solvents to clean cans.** Use a clean dry cloth to wipe off any material from the outside of the sample cans. Do not use plastic containers or coated paper cups.

## Sampling Procedure - Sampling from a valve (tanks, lines, pipes)

When sampling asphalt binder from a valve, waste at least four liters (one gallon) of the material through the valve before taking the sample. This is done to avoid any contamination of the sample. After the material has been wasted, the sample container may be filled.

### NOTE

**Always check with the owner concerning any special safety issues in the operation of the sampling valves.**

**Safety is extremely important when sampling asphalt binder.**



### Sampling Asphalt Binder

(Note: the cup being used for the sample is an uncoated cup. Never use cups that have been coated.)

## Sampling Procedure - Dip Sampling (tanks, tankers, tank cars, barges, distributors)

Asphalt binder in storage may be sampled by lowering a sample device into the material from an access hatch in the top of the tank. A specially designed dip sampler is lowered into the material to the proper depth, opened, and allowed to fill. The sampler is then carefully withdrawn and the entire contents of the sampler is then poured into the sample container.

Properly identify all samples by marking the cans (not just the lids) with the type of material, the date, the time, and the sample location, as a minimum. Agencies often have additional requirements for identifying samples.

# GLOSSARY

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**Asphalt Binder:** Also referred to as Asphalt Cement. It is a product normally refined from crude petroleum. There are a few natural asphalt deposits such as Trinidad Lake. It is a black tar like material that is solid at low temperatures and liquid at high temperatures. This allows it to be used as a paving cement by mixing and placing in a liquid state then the natural cooling produces a solid but flexible pavement.

The performance grading (PG) system of classifying asphalt binders is based on the high and low temperatures expected to be found in the pavement during its life. For example: a PG 58-28 is expected to stay stiff at a temperature of 58°C and yet remain flexible at a temperature of -28°C.

The term "asphalt binder" is generally understood to include asphalt cements with and without modification. The term "asphalt cement" implies asphalt that is unmodified.



# **SAMPLING BITUMINOUS PAVING MIXTURES**

## **AASHTO T 168**



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**NOTE**

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# TABLE OF CONTENTS

---

Sampling Bituminous Paving Mixtures .....	<a href="#">Asph-T168-1</a>
Common Sampling Errors.....	<a href="#">Asph-T168-1</a>
SAMPLING METHODOLOGY .....	<a href="#">Asph-T168-2</a>
Apparatus.....	<a href="#">Asph-T168-2</a>
Roadway Sampling .....	<a href="#">Asph-T168-2</a>
Truck Sampling .....	<a href="#">Asph-T168-3</a>
Sample Identification.....	<a href="#">Asph-T168-4</a>
GLOSSARY .....	<a href="#">Asph-T168-5</a>



# **Sampling Bituminous Paving Mixtures**

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This discussion concerns obtaining samples of bituminous paving mixtures for laboratory testing. Proper sampling is a key component of any Quality Control/Quality Assurance plan. Hot mix asphalt (HMA) is best sampled at the last point, in the construction process, where loose mixture is available. This is normally behind the laydown machine before the rollers begin compacting the mixture. Some agencies, however, allow sampling at the plant or from the trucks because it is easier and more convenient.

Samples of HMA are normally analyzed for their volumetric properties, such as the percent air voids by volume. Samples obtained at the plant or from trucks immediately after production may not reflect the volumetrics of the in-place material if the aggregates in the mixture have a significant absorption, so caution should be used when these sampling methods are employed. Some agencies also require HMA to be tested for asphalt content and aggregate gradation. When sampling HMA, it is important to obtain enough material to perform all the required tests plus extra material for retesting when test results are questionable.

Safety is very important when sampling hot mix asphalt due to the temperature of the mixture. Always wear protective garments and shoes to keep the hot mix asphalt from coming in contact with the skin. As with any construction project, being alert to traffic is important.

## **Common Sampling Errors**

- Obtaining the entire sample from a single location.
- Not removing all the material from within a template.
- Contaminating the sample with underlying material.
- Segregating the material while sampling.

# **SAMPLING METHODOLOGY**

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## **Apparatus**

- Square ended shovel or scoop
- Template (roadway sampling)
- Clean sample container
- Protective clothing, insulated gloves, safety shoes

## **Roadway Sampling**

Random sampling locations should be determined. Sample the uncompacted mat by placing a template through the entire lift of HMA, or using a square pointed shovel to create a sample area with vertical faces. Remove all material from within the template or between the vertical faces and place in a clean sample container. Avoid contaminating the sample with any underlying material. At least three increments should be obtained for each sample.



**Template Placed in Asphalt Mat**



**Cleaning Asphalt Off Template Into Sample**

## Truck Sampling

Sample from the truck load by first removing approximately one foot of material from the outside of the mass. Using a square shovel or scoop, remove enough material from the sample area to provide approximately 1/3 of the sample size. Care must be taken to avoid segregating the material while sampling. There are automated devices available for sampling from the truck load that insert a tube into the mass and withdraw a sample increment. Place each increment in the clean sample container. At least three increments should be obtained for each sample.



**Sampling From A Truck**



**Scraping Sample off Shovel Into Sample Box**

## Sampling from Plant Production

There are several possible sampling points at a hot mix plant. Conveyor belts, skip conveyors and funneling devices that feed a conveyor are all possible places to obtain samples. Each of these requires a different sampling procedure.

Conveyor belts are sampled similar to the procedures for sampling aggregates from a belt, where the belt is stopped and a template that conforms to the shape of the belt is inserted into the material. All the material inside the template is then removed and placed in the sample container. At least three increments should be obtained for each sample.

Skip conveyors generally convey a large mass of material and are sampled similarly to truck loads. The conveyor is stopped and about six inches of the outside of the mass is removed with a shovel or scoop, then three increments are obtained, one each from the top, middle and bottom of the mass.

Funnel devices are sampled similarly to sampling the stream flow of aggregates. A sample catching device such as a bucket or pan is passed through the entire flow of material as it is discharged from the bottom of the funnel. At least three increments should be obtained for each sample.

## **Sample Identification**

Properly identify each sample by marking the sample container with a project identifier, the type of material, date, time, and the sample location. This is the minimum information that should be included with each sample. The agency may require additional information to identify samples.

# **GLOSSARY**

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**Hot Mix Asphalt** - a mixture of aggregate and asphalt binder, sometimes including modifiers, that is produced by mixing hot dried aggregate with heated asphalt in a plant designed for the process.

**Template** - a device used to create a sample area, often no more than a steel box without a top. If the template is inserted after the material is spread, it does not have a bottom. Templates have the advantage of avoiding any segregation during sampling.



# MIXTURE CONDITIONING OF HOT MIX ASPHALT (HMA)

## AASHTO R 30



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**NOTE**

Successful completion of the following training materials, including examination and performance evaluation, is a prerequisite for this training package.

AASHTO T168, Sampling Bituminous Paving Mixtures



# TABLE OF CONTENTS

---

Mixture Conditioning of Hot Mix Asphalt (HMA) .....	<a href="#">Asph-R30-1</a>
Common Testing Errors.....	<a href="#">Asph-R30-1</a>
TEST METHODOLOGY .....	<a href="#">Asph-R30-2</a>
Apparatus.....	<a href="#">Asph-R30-2</a>
Mixture Conditioning for Volumetric Mix Design.....	<a href="#">Asph-R30-2</a>
Sample Preparation .....	<a href="#">Asph-R30-2</a>
Procedure.....	<a href="#">Asph-R30-2</a>
Long Term Conditioning for Mechanical Property Testing.....	<a href="#">Asph-R30-3</a>
Sample Preparation .....	<a href="#">Asph-R30-3</a>
Procedure.....	<a href="#">Asph-R30-3</a>
GLOSSARY.....	<a href="#">Asph-R30-4</a>



## **Mixture Conditioning of Hot Mix Asphalt (HMA)**

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Samples of bituminous mixtures prepared in the laboratory have different properties from mixtures produced in a hot mix asphalt plant for a number of reasons. One of these reasons is that the hot mix ages as it goes through the plant, and during storage and transportation, until it cools down. The asphalt binder reacts with oxygen in the air and becomes harder and more brittle. Some volatile fractions of the binder may also be driven off at the high temperatures encountered during construction. Absorption of some of the asphalt into the aggregate can also occur at high temperatures during construction while the binder is still fluid enough to be absorbed into the pores of the aggregate. Aging continues at a slower rate throughout the service life of the pavement. The aging (or oxidation) reaction proceeds at a higher rate in hot climates or during the summer months when the temperatures are higher.

It is important to account for these changes in the mixture properties when preparing mixtures in the lab. One way to account for these changes is to condition the laboratory mixtures in such a way as to simulate the aging that happens during construction and service. The short term conditioning procedure is used to simulate the aging that occurs during construction (up to the point of compaction) and is used during the volumetric mix design procedure. Long term mixture conditioning is used to simulate the aging that occurs over the many years the pavement is in service. Consequently, long term aging is used when performing tests to simulate mixture mechanical properties late in the life of the pavement, such as when analyzing the resistance of a mixture to low temperature or fatigue cracking.

This text will outline the procedures used for short and long term mixture conditioning of bituminous mixtures. Short term aging is routinely used for mix design and other purposes, while long term aging is less commonly used.

### **Common Testing Errors**

- Failure to calibrate the oven temperature resulting in aging at an improper temperature.
- Not spreading the mixture uniformly across a pan of sufficient size.
- Failing to record the start time for the aging procedures.
- Short term aging plant mixed material when not required.
- Failing to stir the mix every  $60 \pm 5$  minutes to ensure uniform aging.

# TEST METHODOLOGY

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## Apparatus

- Oven capable of maintaining temperatures from room temperature up to  $176^{\circ} \pm 3^{\circ}\text{C}$  ( $349^{\circ} \pm 5.4^{\circ}\text{F}$ ).
- Thermometers covering the range from  $50^{\circ}\text{C}$  ( $122^{\circ}\text{F}$ ) to  $260^{\circ}\text{C}$  ( $500^{\circ}\text{F}$ ) readable to the nearest  $1^{\circ}\text{C}$  ( $2^{\circ}\text{F}$ ).
- Miscellaneous: shallow metal cake pan for aging loose mix, metal spatula or spoon for stirring, oven gloves.

## Short Term Mixture Conditioning

### Sample Preparation

Short term mixture conditioning is applicable to laboratory prepared mixtures. Short term conditioning is only used for plant produced mixtures when called for by the Agency to account for special conditions such as the presence of absorptive aggregates, which have not had time to absorb asphalt binder.

After mixing at the proper mixing temperature for the binder used, the loose mix is spread evenly in a pan to an even thickness of 25 to 50mm (1 to 2 in.).

### Procedure

Place the pan containing the mixture in an oven. Age for 2 hours  $\pm$  5 minutes at the binder compaction temperature  $\pm$   $3^{\circ}\text{C}$  ( $\pm$   $5.4^{\circ}\text{F}$ ).

Stir the mixture after  $60 \pm 5$  minutes to ensure uniform aging.

At the end of the aging period, remove the mixture from the oven and complete sample preparation as required for the tests to be conducted. If the mixture will be used for mechanical testing, condition for 4 hours  $\pm$  5 minutes at  $135^{\circ}\text{C}$ . Stir every  $60 \pm 5$  minutes.

Report the mixture properties and aging conditions. Specifically, report the binder grade and content (to the nearest 0.1%) and the aggregate type and gradation, if possible. For the aging conditions, report the laboratory mixing temperature and short term aging temperature to the nearest  $1^{\circ}\text{C}$  ( $2^{\circ}\text{F}$ ) and the short term aging duration to the nearest 1 minute.

# **Long Term Conditioning for Mechanical Property Testing**

## **Sample Preparation**

The long term conditioning procedure can be applied to laboratory prepared samples following short term aging, to plant-mixed HMA or to compacted roadway samples when needed to simulate long term aging effects.

### Loose Mix (Laboratory prepared or Plant-mix)

Compact the HMA sample according to T 312 to the level of compaction required for the tests to be conducted. Do not extrude the specimen from the mold.

Cool the specimens in the mold for 2 to 3 hours. Extract the specimen and continue cooling at room temperature for a total of 16 +/- 1 hour.

### Compacted Roadway Specimens

Cool the specimen at room temperature for approximately 16 ± 1 hours.

## **Procedure**

Place the prepared specimen(s) on a rack in an oven set to 85° ± 3°C (185° ± 5.4°F). Long term age the specimen(s) for 120 ± 0.5 hours. After that time period, turn off the oven and open the door. Allow the oven and specimen(s) to cool to room temperature. This typically takes about 16 hours. Do not touch or remove the specimen(s) from the oven until the end of this cooling period.

Remove the specimen(s) from the oven and test as required.

## **GLOSSARY**

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**Long term conditioning** - a laboratory conditioning procedure used to simulate the effects of bituminous mixture aging that occur over the service life of a pavement.

**Oxidation** - a type of chemical reaction that occurs between asphalt and oxygen that increases the stiffness of the asphalt.

**Short term conditioning** - a laboratory conditioning procedure used to simulate the effects of bituminous mixture aging that occur during production of hot mix asphalt in a hot mix plant and during placement.

# **STANDARD METHOD FOR PREPARING AND DETERMINING THE DENSITY OF HOT MIX ASPHALT (HMA) SPECIMENS BY MEANS OF THE SUPERPAVE GYRATORY COMPACTOR**

## **AASHTO T 312**



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**NOTE**

**Successful completion of the following training materials, including examination and performance evaluation, is a prerequisite for this training package.**

- AASHTO T 168, Sampling Bituminous Paving Mixtures
- AASHTO R 30, Mixture Conditioning of Hot Mix Asphalt



# TABLE OF CONTENTS

---

PREPARING AND DETERMINING THE DENSITY OF HMA SPECIMENS BY MEANS OF THE  
SUPERPAVE GYRATORY COMPACTOR..... [Asph-T312-1](#)  
Common Testing Errors ..... [Asph-T312-1](#)

TEST METHODOLOGY..... [Asph-T312-2](#)  
Apparatus..... [Asph-T312-2](#)  
Calibration ..... [Asph-T312-2](#)  
Sample Preparation..... [Asph-T312-3](#)  
Laboratory Prepared Materials ..... [Asph-T312-3](#)  
Plant-Mixed Materials ..... [Asph-T312-4](#)  
Procedure..... [Asph-T312-4](#)  
Density Procedure..... [Asph-T312-5](#)  
Calculations..... [Asph-T312-6](#)  
    Example..... [Asph-T312-7](#)

GLOSSARY ..... [Asph-T312-8](#)



# **PREPARING AND DETERMINING THE DENSITY OF HMA SPECIMENS BY MEANS OF THE SUPERPAVE GYRATORY COMPACTOR**

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Compacted samples of hot mix asphalt (HMA) are used to determine the volumetric and mechanical properties of the mixture during the mix design phase and for quality control/quality assurance during construction. These volumetric and/or mechanical properties are then evaluated to select a mix design or control the mixture during production. The specimens produced with the gyratory compactor simulate the density, aggregate orientation and structural characteristics of this mixture in the actual roadway.

The gyratory compactor is used to prepare specimens for later analysis of the volumetric properties of the mixture, evaluation of mixture densification properties, evaluation of moisture sensitivity, field quality control, or other testing purposes.

This text will explain the method of compacting samples of hot mix asphalt and determining their percent compaction using the Superpave gyratory compactor. This method may be used with laboratory fabricated mixture, as in the mix design process, or with plant-mixed material during construction.

## **Common Testing Errors**

- Not placing a paper protection disk on the bottom or top of the specimen.
- Not compacting the mixture at the proper temperature.
- Not properly verifying the calibration of the compactor prior to use.
- Not removing the paper disks while specimen is still warm.
- Not preheating the mold and base plate.
- Not charging the mold with mix quickly, in one lift without spading or rodding.
- Not properly maintaining the gyratory compactor.

# TEST METHODOLOGY

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## Apparatus

- Superpave Gyratory Compactor, including a device for measuring and recording the height of the specimen throughout the compaction process. The compactor may also include a printer or a computer and software for collecting and printing the data.
- Specimen molds
- Thermometer
- Balance readable to 1 gram
- Oven
- Calibration equipment recommended by compactor manufacturer
- Safety equipment: insulated gloves, long sleeves, etc.
- Miscellaneous equipment: paper disks, lubricating materials recommended by compactor manufacturer, scoop or trowel for moving mixture, funnel or other device for ease of loading mixture into mold (optional).

## Calibration

The means of calibrating the gyratory vary with different manufacturers. Refer to the operation manual of the particular brand and model of gyratory available for use. Calibration of the following items should be verified at the noted intervals or according to manufacturer's recommendations:

Item	Tolerance	Calibration Interval
Height	Record to nearest 0.1mm, Compact to $115 \pm 5$ mm	Daily
External Angle or Internal Angle	$1.25^\circ \pm 0.02^\circ$ External $1.16^\circ \pm 0.02^\circ$ Internal	Every 6 months
Pressure	$600 \pm 18$ kPa	Every 6 months
Speed of Rotation	$30.0 \pm 0.5$ gyrations per minute	After mechanical changes or every 6 months

Mold and platen dimensions, hardness and smoothness should also be verified on a yearly basis. Oven temperature should be verified; oven must be capable of maintaining the temperature as required for R 30, *Mixture Conditioning of Hot Mix Asphalt (HMA)*.

There is an optional method for verifying the angle calibration (method B) that measures the internal angle within the mold. The procedure for internal angle calibration is found in AASHTO PP 48. The agency may specify which method will be used. The two methods are not interchangeable.

Samples for compaction in the gyratory may be obtained in one of two ways; mixture may be prepared in the laboratory or plant-mixed material may be obtained from roadway, plant or truck samples.

## Sample Preparation

For the determination of volumetric properties for mix design or quality control, a finished specimen height of  $115 \pm 5$  mm is desired. When producing specimens for testing under AASHTO T283, *Resistance of Compacted Bituminous Mixture to Moisture Induced Damage*, a finished specimen height of 95 mm is required and for other mechanical tests, such as dynamic modulus, specimen heights of 140mm to 170mm are desired. In these two cases, the batch weights must be varied to provide the desired specimen height at a specified air void content; samples are then compacted to the specified height rather than a fixed number of gyrations. (See AASHTO T283 for more details.)

### Laboratory Prepared Materials

Preparing samples of mixture in the laboratory requires batching out the aggregates, mixing in the proper amount of asphalt binder, aging the prepared mixture, heating the mixture to compaction temperature and compacting the specimen. The steps involved in preparing the mixture in the laboratory are as follows:

1. Weigh out the appropriate amounts of the required aggregate size fractions and combine in a bowl to the proper batch weight. Typically, a batch weight of 4500 - 4700 grams of aggregate will provide enough material for a finished specimen height of  $115 \pm 5$ mm, if the combined aggregate specific gravity is between 2.55 - 2.70.
2. Heat the asphalt binder and the combined aggregate in an oven to the appropriate mixing temperature for the binder to be used. This temperature can be determined from an equi-viscous temperature chart or may be provided by the binder supplier or agency. The appropriate temperature range for mixing is defined as the range of temperatures that produces a viscosity of  $0.17 \pm 0.02$  Pa•s for the unaged binder. This ensures that the binder is fluid enough to coat the aggregate particles. Some modified binders do not follow these temperature-viscosity relationships; the manufacturer's recommendations or agency's protocols should be followed.
3. The heated aggregate should be placed in the mixing bowl and thoroughly dry mixed. Make a crater in the center of the aggregate in the bowl and weigh in the required amount of asphalt binder. Begin mixing immediately.
4. A mechanical mixer is recommended for preparing laboratory mixtures because mixing such a large quantity of material by hand is difficult. Mixing should continue until the asphalt binder is uniformly distributed over the aggregate particles.
5. After mixing, spread the loose mixture in a flat, shallow pan and short-term age the mixture as detailed in R 30, *Mixture Conditioning of Hot Mix Asphalt (HMA)*.
6. Determine the proper compaction temperature range for the asphalt binder used. This is defined as the range of temperatures that yield a binder viscosity of approximately  $0.28 \pm 0.03$  Pa•s. Modified binders may not conform to these mixing and compaction temperatures, so the manufacturer's recommendations or agency's protocols should be followed.
7. Place the compaction mold and base plate in an oven to preheat at the required compaction temperature for a minimum of 30 minutes prior to the start of compaction.

8. Following the short-term mixture conditioning period, bring the mixture to the proper compaction temperature, if different from 135°C (275°F), by placing it in another oven at the compaction temperature for up to 30 minutes. If the mixture was conditioned at 135°C, samples can be compacted immediately.
9. After the mixture comes to the proper compaction temperature, proceed with compaction in the gyratory as outlined below.

### **Plant-Mixed Materials**

When plant-mixed materials are sampled from the roadway or truck, no short-term aging is required. The mixture must be brought to the proper compaction temperature then compacted and analyzed as described below. Place the material in an oven at the compaction temperature and bring the mixture to the proper temperature by careful, uniform heating. The mix should be stirred periodically to help assure uniform heating. In general, the shortest heating time that will bring the mixture to the compaction temperature is preferred. Avoid over-heating the mix. When the compaction temperature has been reached, proceed with specimen compaction as outlined below.

### **Procedure**

Once the mixture sample has reached the proper compaction temperature, it is compacted in the gyratory. For most purposes, the finished specimens will be used to calculate volumetric properties and the specimens will be compacted to a fixed number of gyrations. When preparing specimens for testing under AASHTO T283, *Resistance of Compacted Bituminous Mixture to Moisture Induced Damage*, or in other mechanical tests, specimens may be compacted to a fixed height to produce a specified air void content.

The procedure to compact to a fixed number of gyrations is as follows:

1. Ensure that the gyratory compactor has been turned on and allowed to warm up for the time recommended by the manufacturer. Verify all settings for angle, pressure and number of gyrations.
2. Verify that height recording device is turned on and is reading in the proper units. Height calibration should be verified daily.
3. When the compaction temperature has been reached, remove the mold and base plate from the oven. Put the base plate in position in the mold and place a paper disk in the bottom of the mold.
4. Place the mixture into the mold in one lift. Take care to avoid segregating the mix in the mold, but work quickly so that the mixture does not cool excessively during loading. Level the mix in the mold and place a paper disk on top.
5. Place the mold in the gyratory as per manufacturer's recommendations. (Some gyratories

allow charging the mold with mix after the mold has been positioned in the compactor.) Lubricate the mold or gyratory parts as recommended by the manufacturer.

6. Apply the load to the mixture in the mold according to manufacturer's recommendations. The pressure applied should be  $600 \pm 18$  kPa.
7. Apply the gyratory external angle of  $1.25^\circ \pm 0.02^\circ$  to the specimen or internal angle of  $1.16^\circ \pm 0.02^\circ$  as required by the Agency.
8. Start the compaction process and compact to the required number of gyrations. The number of gyrations to apply is usually provided by the Agency in the contract documents or can be determined from AASHTO R 35. Compact to  $N_{des}$  or  $N_{max}$  as specified by the Agency. Volumetric properties are normally determined at  $N_{des}$ , but are also determined at  $N_{ini}$  and at  $N_{max}$  during mix design and when specified, as described in the following section on calculations.
9. The gyratory will stop automatically when the specified number of gyrations has been reached. Remove the angle from the specimen and raise the loading ram if needed (this is done automatically on some gyratories).
10. Remove the mold from the compactor, if required, and extrude the specimen from the mold. Take care not to distort the specimen when removing the specimen from the mold. A cooling period of 5 to 10 minutes may be necessary with some mixtures; a fan may help speed the cooling process. Remove the paper disks while the specimen is still warm to avoid excessive sticking.

### Density Procedure

When compacting specimens for the determination of volumetric properties for mix design or quality control/quality assurance, it is necessary to determine the specimen height and bulk specific gravity and mixture maximum theoretical specific gravity. This requires the following additional steps:

1. Prepare a loose sample of the same mixture and determine the maximum theoretical specific gravity ( $G_{mm}$ ) in accordance with AASHTO T 209, *Maximum Specific Gravity of Bituminous Paving Mixtures*.
2. Using the gyratory's height recording system, record the height of the specimen to the nearest 0.1 mm after each gyration.
3. Measure and record the mass of the compacted specimen to the nearest 1 g. Determine the bulk specific gravity ( $G_{mb}$ ) of the compacted specimen in accordance with AASHTO T 166, *Bulk Specific Gravity of Compacted Bituminous Paving Mixtures Using Saturated Surface Dry Specimens* or T275, *Bulk Specific Gravity of Compacted Bituminous Paving Mixtures Using Paraffin-Coated Specimens*, as appropriate.

## Calculations

Using the measured bulk specific gravity of the final compacted specimen and the measured maximum specific gravity of a loose sample of the mixture, and knowing the height of the specimen at different numbers of gyrations, it is possible to calculate the corrected relative density of the specimen. The corrected relative density (%G<sub>mm</sub>) at any number of gyrations is expressed as a percentage of the maximum theoretical specific gravity for the mix. This allows a determination of the air void content of the specimen at any number of gyrations (as 100% - %G<sub>mm</sub>). Calculate the corrected relative density of the specimen at any number of gyrations as follows:

$$\%G_{\text{mmx}} = (G_{\text{mb}}h_{\text{m}}/G_{\text{mm}}h_{\text{x}}) \times 100\%$$

Where: %G<sub>mmx</sub> = Corrected relative density expressed as a percentage of the maximum theoretical specific gravity  
G<sub>mb</sub> = Bulk specific gravity of the extruded specimen (determined using T166)  
G<sub>mm</sub> = Maximum theoretical specific gravity of the mixture (determined according to T209)  
h<sub>m</sub> = Height of the extruded specimen in millimeters  
h<sub>x</sub> = Height of the specimen during compaction at x gyrations, in millimeters

When only the relative density at N<sub>des</sub> is desired and the compaction is stopped at N<sub>des</sub>, the terms h<sub>m</sub> and h<sub>x</sub> may be omitted from the above equation. Report the relative density, %G<sub>mmx</sub>, to the nearest 0.1 percent.

[Note: the relative density is described as “corrected” because of the assumptions that underlie the calculations. The calculation of the volumetric properties of the compacted specimen at any point in the compaction process begins with the assumption that the specimen is a smooth sided cylinder 150mm in diameter with a height equal to the specimen height at the number of gyrations of interest, typically N<sub>ini</sub>, N<sub>des</sub> or N<sub>max</sub>. The uncorrected bulk specific gravity of the specimen can then be calculated based on the measured mass of the specimen and the volume of a smooth sided cylinder. The actual bulk specific gravity of the specimen is measured at N<sub>des</sub> or N<sub>max</sub> according to AASHTO T166. The uncorrected bulk specific gravity of the specimen is also calculated at N<sub>des</sub> or N<sub>max</sub>. The ratio of the measured bulk specific gravity to the uncorrected bulk specific gravity at N<sub>des</sub> or N<sub>max</sub> can be used as a correction factor to backcalculate the corrected bulk specific gravity at any number of gyrations. Using the correction factor corrects for the fact that the compacted specimen is not a smooth sided cylinder but does in fact have some surface irregularities and open texture. In other words, the actual volume of the specimen is less than the volume of a smooth sided cylinder due to this surface texture. The corrected bulk specific gravity of the specimen, then, is actually greater than the uncorrected bulk specific gravity because the volume is smaller. These assumptions and calculations are implicitly included in the calculations as described here.]

**Example:**

The gyration levels for this traffic volume are  $N_{ini} = 8$ ,  $N_{des} = 100$ ,  $N_{max} = 160$ . A sample of a mixture is compacted to  $N_{des}$ .

Given:  $G_{mb}$ , measured bulk specific gravity = 2.300  
 $G_{mm}$ , maximum theoretical specific gravity = 2.398  
 $h_m$ , height of extruded specimen = 114.5mm  
 $h_8$ , height at  $N_{ini}$  = 124.6mm

Calculate % $G_{mm}$  at  $N_{ini}$

$$\% G_{mm} = (2.300 \times 114.5 / 2.398 \times 124.6) \times 100\% = 88.1\%$$

Another sample of the same mix was compacted to  $N_{max}$ .

Given:  $G_{mb}$ , measured bulk specific gravity = 2.343  
 $G_{mm}$ , maximum theoretical specific gravity = 2.398  
 $h_m$ , height of extruded specimen = 112.3mm

Calculate the %  $G_{mm}$  at  $N_{max}$ . In this case, the height of the extruded sample will be the same as the height at  $N_{max}(h_x)$ .

$$\% G_{mm} = (2.343 \times 112.3 / 2.398 \times 112.3) \times 100\% = 97.7\%$$

## **GLOSSARY**

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Corrected relative density ( $G_{mmx}$ ) = the density of a specimen determined at x number of gyrations and expressed as a percentage of the maximum theoretical specific gravity of the mixture, corrected for the fact that the cylinder is not a smooth sided cylinder.

N-initial ( $N_{ini}$ ) = the initial number of gyrations, a relatively low number of gyrations determined based on traffic volume and used to analyze the early densification properties of the hot mix asphalt during construction

N-design ( $N_{des}$ ) = the design number of gyrations, also determined based on design traffic level and used for design of the asphalt mixture.

N-maximum ( $N_{max}$ ) = the maximum number of gyrations applied to a specimen, determined based on the design traffic volume and used to estimate the densification properties of the mixture after many years in service.

# **BULK SPECIFIC GRAVITY OF COMPACTED HOT MIX ASPHALT USING SATURATED SURFACE-DRY SPECIMENS**

## **AASHTO T 166**



Developed by  
Multi-Regional Asphalt Training & Certification Group  
Revised 2006



### **NOTE**

Successful completion of the following training materials, including examination and performance evaluation is a prerequisite for this training package.

- AASHTO T 168, Sampling Bituminous Paving Mixtures
- AASHTO T 312, Method of Preparing and Determining the Density of Hot Mix Asphalt (HMA) Specimens by Means of a Superpave Gyrotory Compactor.



# TABLE OF CONTENTS

---

Bulk Specific Gravity of Compacted Hot Mix Asphalt Mixtures Using Saturated Surface-Dry Specimens .....	<a href="#">Asph-T166-1</a>
Common Testing Errors.....	<a href="#">Asph-T166-1</a>
TEST METHODOLOGY .....	<a href="#">Asph-T166-2</a>
Apparatus.....	<a href="#">Asph-T166-2</a>
Sample Preparation .....	<a href="#">Asph-T166-2</a>
Testing Procedure.....	<a href="#">Asph-T166-2</a>
Calculations.....	<a href="#">Asph-T166-3</a>
Example .....	<a href="#">Asph-T166-3</a>
GLOSSARY .....	<a href="#">Asph-T166-4</a>



# **Bulk Specific Gravity of Compacted Hot Mix Asphalt Mixtures Using Saturated Surface-Dry Specimens**

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The compaction of Hot Mix Asphalt (HMA) both in the field and in the laboratory is an important characteristic to be determined for mixture quality control. The bulk specific gravity of compacted specimens can be determined on pavement cores or laboratory compacted specimens. The bulk specific gravity of compacted hot mix asphalt mixtures ( $G_{mb}$ ), using a saturated surface-dry specimen, is used to determine air voids ( $P_a$ ) and may be used for comparison between roadway compaction tests and laboratory compacted specimens.

The  $G_{mb}$  is determined by measuring the volume of the specimen by displacement when submerged in water. The dry mass and the saturated surface dry (SSD) mass after submerging in water are also measured.

The submerged mass is subtracted from the SSD mass to determine the volume of displaced water, which is the same as the volume of the specimen. Dividing the dry mass of the specimen by the volume of the specimen yields the  $G_{mb}$ .

This text addresses only method A of AASHTO T 166 which is the most commonly used method.

## **Common Testing Errors**

- Submerged specimen touches the side or bottom of the water container.
- Water temperature is not  $25^{\circ}\pm 1^{\circ}\text{C}$  ( $77^{\circ}\pm 1.8^{\circ}\text{F}$ ).
- Air bubbles trapped under the specimen.
- Specimens with high voids (>10%) may absorb excess water. (Use AASHTO T 275)
- Dirty water used.
- Specimens not cooled to  $25^{\circ}\pm 5^{\circ}\text{C}$  ( $77^{\circ}\pm 9^{\circ}\text{F}$ ).

# TEST METHODOLOGY

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## Apparatus

- Balance (readable to 0.1% of the sample mass or better).
- Oven for heating specimen
- Submersion basket
- Container for water
- Damp towel

## Sample Preparation

The sample should be secured according to AASHTO T 168. The mixture should then be prepared for testing using AASHTO T 312, AASHTO T 245, or another suitable compaction method. The procedure may also be conducted on pavement cores.

## Testing Procedure

Once the specimen has been compacted using one of the above methods, it must be cooled to  $25^{\circ}\pm 5^{\circ}\text{C}$  ( $77^{\circ}\pm 9^{\circ}\text{F}$ ). Weigh the dry specimen and record the dry mass (A) to the nearest 0.1g.

Submerge the specimen in water that is at a temperature of  $25^{\circ}\pm 1^{\circ}\text{C}$  ( $77^{\circ}\pm 1.8^{\circ}\text{F}$ ) and suspend it from the scale being careful not to trap any air bubbles under the specimen. Record the submerged mass (C) to the nearest 0.1g after the specimen has stabilized in the water for 3 to 5 minutes.



**Weighing specimen to  
Determine  $G_{mb}$**

Remove the specimen from the water and quickly blot the specimen surface dry with the damp towel. Weigh the specimen and record the SSD mass (B) to the nearest 0.1g. If water seeps out of the specimen during weighing, its mass is included in the SSD mass.

To save time, especially with roadway cores that may include some moisture, the sequence of weighing can be changed. Determine weight C, then B, as described above. Dry the specimen to constant weight and determine A.



**Blotting Sample Dry**

## Calculations

Calculate the bulk specific gravity of the specimen ( $G_{mb}$ ) as follows:

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

where:

A = dry mass

B = SSD mass

C = submerged mass

Report bulk specific gravity to three decimal places. The percent water absorbed by volume can be calculated as

$$\% \text{ water absorbed} = [(B - A)/(B - C)] \times 100\%$$

## Example

Given: Dry mass of the specimen ( A ) = 4799.0 g

SSD mass of the specimen ( B ) = 4801.0 g

Submerged mass of the specimen ( C ) = 2799.0 g

$$\frac{4799.0}{4801.0 - 2799.0} = 2.397$$

$$\% \text{ water absorbed} = [(4801.0 - 4799.0)/(4801.0 - 2799.0)] \times 100\% = 0.10\%$$

## **GLOSSARY**

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- Specific gravity** - the ratio of the mass in air of a volume of material to the mass in air of an equal volume of water.
- Saturated surface dry** - the condition of a material when it has absorbed as much water as it can and the outside of the material has no free water.

# **THEORETICAL MAXIMUM SPECIFIC GRAVITY and DENSITY of HOT-MIX ASPHALT PAVING MIXTURES**

## **AASHTO T 209**



Developed by  
Multi-Regional Asphalt Training & Certification Group  
Revised 2006



**NOTE**

Successful completion of the following training materials, including examination and performance evaluation is a prerequisite for this training package.

- AASHTO T 168, Sampling Bituminous Paving Mixtures



# TABLE OF CONTENTS

---

Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures .....	<a href="#">Asph-T209-1</a>
Common Testing Errors.....	<a href="#">Asph-T209-1</a>
TEST METHODOLOGY - FLASK METHOD.....	<a href="#">Asph-T209-2</a>
Apparatus.....	<a href="#">Asph-T209-2</a>
Sample Preparation .....	<a href="#">Asph-T209-2</a>
Calibration of Pycnometer.....	<a href="#">Asph-T209-3</a>
Procedure.....	<a href="#">Asph-T209-3</a>
Calculations.....	<a href="#">Asph-T209-5</a>
Example .....	<a href="#">Asph-T209-5</a>
GLOSSARY .....	<a href="#">Asph-T209-6</a>



# Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures

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The volumetric properties of Hot Mix Asphalt (HMA) must be controlled during design and production in order to produce durable pavements. James Rice invented a test to measure the volume of a mixture with all the air voids removed. The theoretical maximum specific gravity ( $G_{mm}$ ) of a bituminous mixture is the ratio of the mass of the loose sample to the mass of an equal volume of water at the standard temperature of 25°C (77°F). (The test is sometimes referred to as the "Rice test" after its inventor.)

$G_{mm}$  is used along with the bulk specific gravity ( $G_{mb}$ ) of the compacted mixture to determine air voids ( $P_a$ ). It is often used also for determining the percent of compaction in laboratory specimens or during roadway compaction.

This text will explain the flask method for determining the maximum specific gravity. The flask method is the most commonly used test method due to the lower variability of the method and ease of use.

## Common Testing Errors

- Not breaking up the sample completely.
- Not maintaining  $27.5 \pm 2.5$ mm absolute pressure, which could be attributed to one of the following:
  - a. Air bubble in mercury manometer,
  - b. Manometer not connected directly to pycnometer,
  - c. Clogged vacuum lines, or
  - d. Moisture or foreign material getting into the vacuum pump
- Not agitating the sample enough.
- Air bubbles trapped in the pycnometer when the cover is placed on it.
- Temperatures of water not checked.
- Uncoated particles or particles that rupture under vacuum and absorb water.
- Overheating absorptive materials.

# TEST METHODOLOGY - FLASK METHOD

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## Apparatus

- Pycnometer or flask
- Thermometer
- Mercury Manometer or NIST traceable gauge
- Vibrating Table (optional)
- Pycnometer top or cover glass
- Scale
- Vacuum pump, tubing and connectors



**Pycnometer and flask**

## Sample Preparation

If the sample is not tested soon after it has been sampled, it will cool down and need to be reheated in the oven before the  $G_{mm}$  test can be run. If necessary, heat the sample only enough to soften it. Reduce the sample to the proper size, if necessary, by quartering or other suitable means that will ensure a representative sample. See Table 1 below.

**Table 1**

<u>Maximum Aggregate Size</u>	<u>Minimum Sample Size</u>
50.0mm (2 in.)	6000 g
37.5mm (1 ½ in.)	4000g
25.0mm (1in.)	2500g
19.0mm (¾ in.)	2000g
12.5mm (½ in.)	1500g
9.5mm (¾ in.)	1000g
4.75mm (#4)	500g

Separate the particles of coarse aggregate. Break up any clumps of fine aggregate so that no clump is larger than 6.5mm (¼ in.). Stirring or spading the mixture as it cools will prevent clumps. If the clumps are difficult to break up, warming the mixture for a few minutes will be helpful.



### **Stirring Sample and Breaking Clumps**

Allow the mixture to cool to room temperature before proceeding with the test.

## **Calibration of Pycnometer**

The flask or pycnometer is calibrated by filling the vessel with water. The water temperature must be 25°C (77°F). Place the cover or a glass cover plate on the vessel, being sure that no air bubbles are trapped. Dry the outside of the vessel and cover, then weigh it. Record the mass to the nearest 0.1 gram. This is mass (D), the mass of the pycnometer filled with water at the test temperature. If temperatures other than 25°C (77°F) are encountered during testing, the vessel should be calibrated at a higher and a lower temperature. A calibration curve will then need to be developed for the pycnometer.

## **Procedure**

Tare the calibrated pycnometer on a scale and add the sample. Record the mass of the sample to the nearest 0.1 gram. This mass is the dry sample in air (A).

Add enough water to completely cover the sample. The water temperature should be approximately 25°C (77°F).

Connect the pycnometer to the vacuum system and remove the entrapped air. Maintain a vacuum, as measured by a manometer, of  $3.7 \pm 0.3$  kPa ( $27.5 \pm 2.5$  mm Hg) absolute pressure for  $15 \pm 2$  minutes. Continuous agitation is recommended to help release the air bubbles. This agitation can best be completed with the use of a vibrating table. If continuous agitation is not possible, rock or shake the pycnometer at approximately 2 minute intervals for the duration of the air removal.

After the 15 minute vacuum period is complete, slowly release the vacuum.

Suspend pycnometer in a  $25^\circ\text{C} \pm 1$  ( $77^\circ\text{F} \pm 1.8$ ) water bath for the ten minutes or fill the pycnometer with water of the proper temperature. If a water bath is not used, the temperature of the water in the pycnometer needs to be adjusted to  $25^\circ \pm 1^\circ\text{C}$  ( $77^\circ \pm 1.8^\circ\text{F}$ ).

If it is not possible to maintain the proper temperature, correction factors for the change in density of the water and the asphalt cement must be used in conjunction with a calibration curve for the pycnometer.

After 10 +/- 1 minute, place the top or cover glass on the pycnometer, being sure that there are no air bubbles trapped inside. Dry the outside of the pycnometer. Weigh the pycnometer and record the mass to the nearest 0.1 gram. This is the mass of the pycnometer filled with the sample and water at the test temperature (E).



**Sample Being Tested**

## Calculations

$$\text{Maximum Specific Gravity (G}_{\text{mm}}) = \frac{A}{A+D-E}$$

where:      A = Mass of dry sample in air  
              D = Mass of pycnometer filled with water at test temperature  
              E = Mass of pycnometer filled with the sample and water at test temperature

Report Maximum Specific Gravity (G<sub>mm</sub>) to three decimal places.

## Example

Given: Mass of dry sample in air (A) = 2020.0 g  
       Mass of pycnometer filled with water at test temperature (D) = 7800.0 g  
       Mass of pycnometer filled with sample and water at test temperature (E) = 9000.0 g

$$\frac{2020.0}{2020.0 + 7800.0 - 9000.0} = 2.463$$

## **GLOSSARY**

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- Specific gravity** - the ratio of the mass in air of a volume of material to the mass in air of an equal volume of water.
- Pycnometer** - a vessel of known volume used to measure the volume of a material placed in it by determining how much water is displaced.
- Mercury Manometer** - a tube sealed at one end and filled with mercury, which, when subjected to a vacuum, will register a comparison between the applied vacuum and the nearly total vacuum that exists in the sealed end. The degree of vacuum is expressed as absolute pressure or residual pressure, in mm. Smaller numbers (less pressure) indicate more vacuum.

**RESISTANCE OF COMPACTED  
ASPHALT  
MIXTURES TO MOISTURE-INDUCED  
DAMAGE**

**AASHTO T 283**



Developed by  
Multi-Regional Asphalt Training & Certification Group  
Revised 2006



**NOTE**

Successful completion of the following training materials, including examination and performance evaluation is a prerequisite for this training package.

- AASHTO T168, Sampling Bituminous Paving Mixtures
- AASHTO T312, Standard Method for Preparing and Determining the Density of Hot Mix Asphalt (HMA) by Means of the Superpave Gyrotory Compactor
- AASHTO T209, Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures
- AASHTO T166, Bulk Specific Gravity of Compacted Hot Mix Asphalt Mixtures Using Saturated Surface Dry Specimens



# TABLE OF CONTENTS

---

Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage..... [Asph-T283-1](#)  
    Common Testing Errors..... [Asph-T283-1](#)

TEST METHODOLOGY ..... [Asph-T283-2](#)  
    Apparatus..... [Asph-T283-2](#)  
    Sample Preparation ..... [Asph-T283-2](#)  
    Moisture Conditioning ..... [Asph-T283-3](#)  
    Test Procedure ..... [Asph-T283-3](#)  
    Calculations..... [Asph-T283-4](#)

GLOSSARY ..... [Asph-T283-6](#)



# **Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage**

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Asphalt mixtures made from certain combinations of materials may be sensitive to the presence of water in the finished pavement. Water will cause the asphalt binder to stop sticking to the aggregate. Since the asphalt binder is the “glue” that holds the pavement together, rapid failure of the pavement can be expected if the asphalt cannot stick to the aggregate. This is often referred to as stripping. To help prevent stripping, additives such as hydrated lime or liquid anti-stripping chemicals may be required. AASHTO T 283 is a test method that can be used to determine if the materials used are subject to stripping and can also be used to evaluate the effectiveness of additives.

The test is performed by compacting specimens to an air void level of 6.5 to 7.5 percent. Three specimens are selected as a control and tested without moisture conditioning, and three more are selected to be conditioned by saturating with water and freezing. The specimens are then tested for indirect tensile strength by loading the specimens at a constant rate and measuring the force required to break the specimen. The tensile strength of the conditioned specimens is compared to the control specimens to determine the tensile strength ratio (TSR). This test may also be performed on cores taken from finished pavement.

## **Common Testing Errors**

- Air voids in the conditioned specimens not the same as the unconditioned ones.
- Conditioned specimens not properly saturated with water.
- Conditioned specimens not soaked for 24 hours in a water bath at  $60 \pm 1^\circ\text{C}$  ( $140 \pm 1.8^\circ\text{F}$ ).

# TEST METHODOLOGY

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## Apparatus

- Vacuum container for saturating specimens
- Balance and water bath from T 166
- Water bath able to maintain  $60 \pm 1^{\circ}\text{C}$  ( $140 \pm 1.8^{\circ}\text{F}$ )
- Aluminum pans (cake pans)
- Loading jack and force measuring device
- Loading strips with a curved face to match the side of the specimen
- Forced air oven able to maintain any temperature from room temperature to  $176^{\circ}\text{C}$  ( $350^{\circ}\text{F}$ ) within  $\pm 3^{\circ}\text{C}$  ( $\pm 5^{\circ}\text{F}$ )
- Freezer able to maintain  $-18 \pm 3^{\circ}\text{C}$  ( $0 \pm 5^{\circ}\text{F}$ )
- Plastic wrap and heavy-duty leak proof plastic bags
- 10 mL graduated cylinder

## Sample Preparation

If pavement cores are to be tested, a minimum of six cores are required. Separate the cores into two sets of three so that each set has approximately the same average voids. If the layer thickness is less than 63.5mm (2.5 in) use 100mm (4 in) cores. For thicker layer, either 100mm (4 in) or 150mm (6 in) cores may be used.

For laboratory batched mixtures, 100mm (4 in.) diameter and  $63.5 \pm 2.5\text{mm}$  ( $2.5 \pm 0.1$  in.) thick specimens or 150mm (6 in.) diameter and  $95 \pm 5\text{mm}$  ( $3.75 \pm 0.20$  in.) thick specimens are used. The larger diameter specimens should be used if there is 25.0mm (1 in.) aggregate or larger in the mixture. Mix enough material to produce at least eight specimens at the asphalt content recommended for the mixture. Extra mixture will be needed for trials to establish the compaction required and for determining the maximum specific gravity of the mixture, if these values are not known.

After mixing, place the mixture in the aluminum pans and spread it to about 25mm (1 in.) thick. Allow the mix to cool to room temperature for  $2 \pm 0.5$  hours. Then put the mixture in the  $60^{\circ}\text{C}$  ( $140^{\circ}\text{F}$ ) oven for  $16 \pm 1$  hours to cure. After curing, put the mixture in an oven for 2 hours  $\pm 10$  minutes at the compaction temperature  $\pm 3^{\circ}\text{C}$  ( $5^{\circ}\text{F}$ ). For plant produced mixture, omit the curing and simply bring the mixture to compaction temperature. Compact the specimens to  $7 \pm 0.5$  percent air voids.

Some experimentation will be needed to find the correct compactive effort that will yield the desired voids. When using the Superpave gyratory compactor, the height needed can be calculated from one trial specimen. Other compactors may require several trials before the correct compactive effort can be established.

After removing the specimens from the molds, store them at room temperature for  $24 \pm 3$  hours.

Determine the maximum specific gravity of the loose mixture according to T166. Measure the thickness and diameter and determine the bulk specific gravity of each specimen. Calculate the air voids of each specimen. Sort the specimens into two groups of three so that each group has about the same average voids. One set will be stored at room temperature until tested, the other set will be conditioned before testing. The unconditioned control set should be sealed in plastic wrap or a plastic bag.

## **Moisture Conditioning**

Put the specimens to be conditioned into the vacuum container and fill with distilled water so that at least 25mm (1 in.) of water is covering them. Apply a partial vacuum (13 - 67kPa 10-26 in Hg) to the container for about 5 to 10 minutes. Release the vacuum and allow the specimens to sit submerged in the water for another 5 to 10 minutes. Determine the bulk specific gravity of the saturated specimens. Compare the saturated surface dry (SSD) mass of the saturated specimens to the original SSD mass of the specimens before saturation. The difference will be the volume of absorbed water. Compare the volume of absorbed water to the original volume of air voids to determine the amount of saturation. The volume of absorbed water needs to be between 70 to 80 percent of the original volume of air voids. If the volume of absorbed water is less than 70 percent, repeat the vacuum saturation procedure. If the volume of absorbed water is greater than 80 percent, the specimens have been damaged and must be discarded and replaced.

Once properly saturated, wrap the saturated specimens tightly with plastic wrap and place in a plastic bag with 10mL of water and seal the bag. Place the bag in the freezer at  $-18 \pm 3^{\circ}\text{C}$  ( $0 \pm 5^{\circ}\text{F}$ ) for at least 16 hours. Remove the bags from the freezer and place in the water bath at  $60 \pm 1^{\circ}\text{C}$  ( $140 \pm 1.8^{\circ}\text{F}$ ) for  $24 \pm 1$  hours. As soon as possible after putting in the bath, remove the plastic bag and plastic wrap from the specimens.

## **Test Procedure**

After the 24 hour soak, remove the specimens and place in a water bath at  $25 \pm 0.5^{\circ}\text{C}$  ( $77 \pm 1^{\circ}\text{F}$ ) for  $2 \text{ hours} \pm 10 \text{ minutes}$ . The bath should return to  $25^{\circ}\text{C}$  within 15 minutes after the warm specimens are placed in the bath. The unconditioned specimens, still sealed in plastic, also need to be placed in the  $25^{\circ}\text{C}$  bath for at least 2 hours.

Remove a specimen from the bath, measure and record the thickness and place it on its side between the steel loading strips.

Apply the load to the specimen by forcing the bearing plates together at a constant rate of 50 mm (2 in.) per minute. Record the maximum load, then continue to load the specimen until it cracks. Stop the machine, remove the specimen and break it apart at the crack. Look at the

inside of the specimen and estimate the percent of stripped aggregate. Record the observations.

## Calculations

Calculate the tensile strength using the following equation:

$$S_t = \frac{2P}{\pi t D}$$

where:

- S<sub>t</sub> = tensile strength, Pa (psi)
- P = maximum load, Newtons (pounds)
- t = specimen thickness, mm (inches)
- D = specimen diameter, mm (inches)

The tensile strength ratio (TSR) is calculated by dividing the average tensile strength of the conditioned specimens by the average tensile strength of the unconditioned control specimens. TSR is reported to two decimal points.

A TSR value of at least 80 percent is normally required as evidence that the mixture will not be subject to stripping.



## TESTING SPECIMENS



Asph-T283-5

## **GLOSSARY**

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- Tensile strength** - a measure of the force required to pull apart a material.
- Steel loading strips** - square or rectangular steel bars long enough to cover the full thickness of the specimen with one side curved to match the side of the specimen. For 101.6 mm (4 in.) specimens, the strips shall be 12.7 mm (0.5 in.) wide, and for 152.4 mm (6 in.) specimens, the strips shall be 19.05 mm (0.75 in.) wide.
- Loading jack** - a mechanical device or machine that can apply a constant rate of loading.

# **DETERMINING THE ASPHALT BINDER CONTENT OF HOT-MIX ASPHALT (HMA) BY THE IGNITION METHOD**

## **AASHTO T 308**



Developed by  
Multi-Regional Asphalt Training & Certification Group  
Revised 2006



**Note**

Successful completion of the following training materials, including examination and performance evaluation are prerequisites for this training package.

- AASHTO T168, Sampling Bituminous Paving Mixtures



# TABLE OF CONTENTS

---

METHOD FOR DETERMINING THE ASPHALT CONTENT OF HOT MIX ASPHALT (HMA) BY THE IGNITION METHOD .....	<a href="#">Asph-T308-1</a>
Common Testing Errors.....	<a href="#">Asph-T308-1</a>
TEST METHODOLOGY .....	<a href="#">Asph-T308-2</a>
Apparatus.....	<a href="#">Asph-T308-2</a>
Correction Factor Determination.....	<a href="#">Asph-T308-2</a>
Sample Preparation .....	<a href="#">Asph-T308-4</a>
Test Procedure .....	<a href="#">Asph-T308-4</a>
Example .....	<a href="#">Asph-T308-5</a>
GLOSSARY .....	<a href="#">Asph-T308-6</a>



# **METHOD FOR DETERMINING THE ASPHALT CONTENT OF HOT MIX ASPHALT (HMA) BY THE IGNITION METHOD**

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Consistently maintaining the proper asphalt content in HMA paving mixtures is a key factor in producing quality pavements. One method of determining the asphalt content uses a very high temperature oven, commonly called a muffle furnace, to burn off the asphalt. By comparing the mass of the sample before and after the burn off, the asphalt content can be determined.

Some aggregates break down at the high temperatures employed in the test, and, therefore, a correction factor for each mix may be needed to produce accurate results. After the asphalt content is determined, the aggregate that is left can be tested for gradation and other properties.

Although the technician may encounter very hot materials and must use proper precautions, this is the easiest and safest method available for determining asphalt content and providing clean aggregate for further testing. This test method is appropriate for both field labs conducting quality control tests and Agency labs performing independent assurance, verification and acceptance testing.

## **Common Testing Errors**

- Moisture in the sample.
- Aggregate correction factor not used.
- Materials used for calibration were not the same as project materials.
- Inaccurate asphalt contents used for calibration.
- Improper loading of sample baskets.

# TEST METHODOLOGY

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There are two methods listed in AASHTO T 308 which may be used for this test. They are basically the same; the difference is related to the type of equipment used. Some ignition ovens have built in scales and processors that can detect when the test is complete and report the results (Method A). Other ovens require the operator to determine the end point and calculate the results (Method B). The calibration and sample preparation are the same for both methods.

## Apparatus

- Balance (accurate to 0.1 g)
- Ignition furnace: forced air oven able to accommodate 3500g sample and maintain a temperature of 578C (1072F)
- Sample baskets and catch pan
- Safety equipment: insulated gloves, face shield, long sleeves, etc.
- Timer (Method B)
- Oven: able to maintain 125 +/- 5°C (257 +/- 9°F)

## Correction Factor Determination

Determine the correct sample size for the mixture to be tested from the following chart:

Nominal Max. Aggr. Size, mm	Sieve Size	Min. Sample Mass, g
4.75	No. 4	1200
9.5	3/8 in.	1200
12.5	2 in.	1500
19.0	3/4 in.	2000
25.0	1 in.	3000
37.5	1 1/2 in.	4000

Using the aggregates and binder produced for the project, mix two samples in the lab at the Job Mix Formula (JMF) intended asphalt content.

Weigh a sample basket on a scale and record the mass. If the sample has cooled, preheat the sample in a 125°C (257°F) oven for 25 min. Place the sample in the basket. Spread the sample in a thin layer, but avoid placing material near the edge of the basket. Record the mass of the sample with basket(s), catch pan and basket guards. For automatic ovens (method A) enter the mass of the sample into the oven processor.

Place the sample in the ignition oven and burn off the asphalt according to the manufacturers recommendation.

**NOTE**

Temperatures in excess of 538°C (1000°F) may be encountered when using an ignition oven. Use caution when handling hot samples or opening the oven.

**SAFETY FIRST**

The automatic ovens (method A) will stop the test when all the asphalt is burned off and will calculate the apparent percent asphalt. For manual ovens (method B), allow the sample to burn for at least 45 min., remove from the oven and allow to cool. Weigh and record the mass of the sample. Return the sample to the oven. After the oven has returned to its set temperature, allow the sample to burn off for an additional 15 min. Repeat the burn off - cool - weigh routine until two consecutive weighings of the sample do not change more than 0.01 percent of the original mass of the sample. Record the final mass of the sample. Calculate the apparent percent asphalt by subtracting the final mass from the original mass to get the loss from ignition then dividing by the original sample mass.

If the difference between the two samples exceeds 0.15%, repeat the calibration process with two more samples and discard the high and low result. Compare the apparent percent asphalt from ignition to the actual asphalt content of the calibration samples. Subtract the apparent percent asphalt from the actual percent for each sample and average the two results. This will be the correction factor which must be applied to all tests on the same mixture. Record the correction factor.

If the correction factor exceeds 0.5% it may be necessary to repeat the calibration procedure at a lower (482 +/- 5°C (900 +/- 8°F)) temperature. If a lower temperature is required to produce a consistent correction, this temperature should be recorded and all HMA samples of that material should be tested at the same temperature as the calibration samples.

If the State Highway Agency requires the gradation of the aggregate to be checked on test samples, a third sample of aggregate should be prepared but not mixed with asphalt. The gradation of this "blank" sample can then be compared to the gradation of one of the burned off calibration samples to evaluate the amount of aggregate breakdown.

## Sample Preparation

If moisture is present in the sample, dry the sample in an oven at  $105 \pm 5^\circ \text{C}$  ( $221 \pm 9^\circ \text{F}$ ), or determine the moisture content and record it. If necessary, reduce the sample to the proper size by quartering or other suitable means that will produce a representative sample. Preheat the sample, if needed, as described above for calibration.

## Test Procedure

Place the sample in the sample basket and record the mass. For automatic ovens (Method A), enter the mass and the correction factor into the oven controls. Test the sample as described above for calibration.

The automatic ovens (Method A) will display and/or printout the corrected asphalt content. For the manual ovens (Method B), the apparent asphalt content is determined the same way as for calibration, then the correction factor is added to the result to produce the final reported asphalt content. The correction factor is normally a negative number. If moisture is present in the sample, subtract the percent moisture from the corrected asphalt content to get the final reported asphalt content. Report the asphalt content by ignition to two decimal places.



Sample in Basket



Sample Basket in Oven

## Example

Correction factor determination:

where: Percent asphalt in the calibration sample ( $P_b$ ) = 5.00%

Original dry mass of the calibration sample = 2507.5 g

Final mass of burned off calibration sample = 2370.7 g

$$\text{Apparent percent asphalt} = \frac{(2507.5 - 2370.7)}{2507.5} 100 = 5.46 \%$$

$$\text{Correction factor: } 5.00 - 5.46 = -0.46$$

Corrected asphalt content determination:

where: Original dry mass of the test sample = 2512.4 g

Final mass of burned off test sample = 2379.5 g

$$\frac{(2512.4 - 2379.5)}{2512.4} 100 - 0.46 = 4.83 \%$$

Note
Follow the rounding rules specified by your state.

## **GLOSSARY**

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- Ignition oven** - A muffle furnace specifically designed for the purpose of burning off organic components from a material at high temperatures.
- Correction factor** - The difference between the actual and the measured asphalt content.
- Sample basket** - A sample container designed for use in the ignition oven which allows the heated air to move through the sample. Each oven manufacturer provides baskets designed for use in their oven.