

WSDOT Errata to FOP for AASHTO T 166

Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens

WAQTC FOP for AASHTO T 166 has been adopted by WSDOT with the following changes:

Test Specimens

Include items below:

Transportation of warm laboratory molded specimens is not recommended before they have cooled to room temperature. If however, a specimen must be transported prior to reaching room temperature the following guidelines should be used to transport the specimen:

1. Place the specimen in a container that has a flat bottom surface to prevent deformation of the bottom of the specimen. **Note:** A flat piece of wood, rigid aluminum or reinforced cardboard may be used to create a flat surface in an HMA sample box.
2. Make sure the specimen is not deformed in handling.
3. Do not stack anything on top of the specimen container.
4. Transport the container in the cab of the vehicle or secure it in the vehicle bed to prevent movement during transit.

Procedure - Method A (Suspension)

Replace step 2 with below:

2. Cool the specimen in air for a minimum of 15 hours and a maximum of 24 hours to $25 \pm 5^\circ\text{C}$ ($77 \pm 9^\circ\text{F}$), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as "A."

ASPHALT

WAQTC

FOP AASHTO T 166 (18)

BULK SPECIFIC GRAVITY (G_{mb}) OF COMPACTED ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS FOP FOR AASHTO T 166

Scope

This procedure covers the determination of bulk specific gravity (G_{mb}) of compacted asphalt mixtures using three methods – A, B, and C – in accordance with AASHTO T 166-16. This FOP is for use on specimens not having open or interconnecting voids or absorbing more than 2.00 percent water by volume, or both. When specimens have open or interconnecting voids or absorbing more than 2.00 percent water by volume, or both, AASHTO T 275 or AASHTO T 331 should be performed.

Overview

- Method A: Suspension
- Method B: Volumeter
- Method C: Rapid test for A or B

Test Specimens

Test specimens may be either laboratory-molded or from asphalt mixture pavement. For specimens it is recommended that the diameter be equal to four times the maximum size of the aggregate and the thickness be at least one and one half times the maximum size.

Test specimens from asphalt mixture pavement will be sampled according to AASHTO R 67.

Terminology

Constant Mass: The state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus - Method A (Suspension)

- Balance or scale: 5 kg capacity, readable to 0.1 g, and fitted with a suitable suspension apparatus and holder to permit weighing the specimen while suspended in water, conforming to AASHTO M 231.
- Suspension apparatus: Wire of the smallest practical size and constructed to permit the container to be fully immersed.
- Water bath: For immersing the specimen in water while suspended under the balance or scale and equipped with an overflow outlet for maintaining a constant water level.

ASPHALT

WAQTC

FOP AASHTO T 166 (18)

- Towel: Damp cloth towel used for surface drying specimens.
- Oven: Capable of maintaining a temperature of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Thermometer: Having a range of 19 to 27°C (66 to 80°F), graduated in 0.1°C (0.2°F) subdivisions.
- Vacuum device: refer to AASHTO R 79 (optional)

Procedure - Method A (Suspension)

Recently molded laboratory samples that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
 - a. Oven method
 - i. Initially dry overnight at $52 \pm 3^{\circ}\text{C}$ ($125 \pm 5^{\circ}\text{F}$).
 - ii. Determine and record the mass of the specimen (M_p).
 - iii. Return the specimen to the oven for at least 2 hours.
 - iv. Determine and record the mass of the specimen (M_n).
 - v. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p) divide by the previous mass determination (M_p) multiply by 100.
 - vi. Continue drying until there is less than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
 - vii. Constant mass has been achieved, sample is defined as dry.
 - b. Vacuum dry method
 - i. Perform vacuum drying procedure according to AASHTO R 79.
 - ii. Determine and record the mass of the specimen (M_p).
 - iii. Perform a second vacuum drying procedure.

Note 1: To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.

ASPHALT

WAQTC

FOP AASHTO T 166 (18)

- iv. Determine and record the mass of the specimen (M_n).
 - v. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p) divide by the previous mass determination (M_p) multiply by 100.
 - vi. Continue drying until there is less than 0.05 percent change in specimen mass (constant mass).
 - vii. Constant mass has been achieved, sample is defined as dry.
2. Cool the specimen in air to $25 \pm 5^\circ\text{C}$ ($77 \pm 9^\circ\text{F}$), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as "A."
 3. Fill the water bath to overflow level with water at $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$) and allow the water to stabilize.
 4. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath.
 5. Immerse the specimen shaking to remove the air bubbles. Place the specimen on its side in the suspension apparatus. Leave it immersed for 4 ± 1 minutes.
 6. Determine and record the submerged weight to the nearest 0.1 g. Designate this submerged weight as "C."
 7. Remove the sample from the water and quickly surface dry with a damp cloth towel within 5 seconds.
 8. Zero or tare the balance.
 9. Immediately determine and record the mass of the SSD specimen to nearest 0.1 g. Designate this mass as "B." Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen. Do not to exceed 15 seconds performing Steps 7 through 9.

ASPHALT

WAQTC

FOP AASHTO T 166 (18)

Calculations - Method A (Suspension)**Constant Mass:**

Calculate constant mass using the following formula:

$$\%Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

 M_p = previous mass measurement, g M_n = new mass measurement, g**Bulk specific gravity (G_{mb}) and percent water absorbed:**

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

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

where:

 G_{mb} = Bulk specific gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

C = Weight of specimen in water at $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$), g**Example:**

$$G_{mb} = \frac{4833.6 \text{ g}}{4842.4 \text{ g} - 2881.3 \text{ g}} = 2.465$$

$$\% \text{ Water Absorbed (by volume)} = \frac{4842.4 \text{ g} - 4833.6 \text{ g}}{4842.4 \text{ g} - 2881.3 \text{ g}} \times 100 = 0.45\%$$

ASPHALT

WAQTC

FOP AASHTO T 166 (18)

Apparatus - Method B (Volumeter)

- Balance or scale: 5 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- Water bath: Thermostatically controlled to $25 \pm 0.5^{\circ}\text{C}$ ($77 \pm 0.9^{\circ}\text{F}$).
- Thermometer: Range of 19 to 27°C (66 to 80°F), and graduated in 0.1°C (0.2°F) subdivisions.
- Volumeter: Calibrated to 1200 mL or appropriate capacity for test sample and having a tapered lid with a capillary bore.
- Oven: Capable of maintaining a temperature of $110 \pm 5^{\circ}\text{C}$ ($230 \pm 9^{\circ}\text{F}$) for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Towel: Damp cloth towel used for surface drying specimens.
- Vacuum device: AASHTO R 79 (optional)

Procedure - Method B (Volumeter)

Recently molded laboratory samples that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
 - a. Oven method:
 - i. Initially dry overnight at $52 \pm 3^{\circ}\text{C}$ ($125 \pm 5^{\circ}\text{F}$).
 - ii. Determine and record the mass of the specimen (M_p).
 - iii. Return the specimen to the oven for at least 2 hours.
 - iv. Determine and record the mass of the specimen (M_n).
 - v. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p) divide by the previous mass determination (M_p) multiply by 100.
 - vi. Continue drying until there is less than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
 - vii. Constant mass has been achieved, sample is defined as dry.

ASPHALT

WAQTC

FOP AASHTO T 166 (18)

Note 1: To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.

b. Vacuum dry method

- i. Perform vacuum drying procedure according to AASHTO R 79.
 - ii. Determine and record the mass of the specimen (M_p).
 - iii. Perform a second vacuum drying procedure.
 - iv. Determine and record the mass of the specimen (M_n).
 - v. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p) divide by the previous mass determination (M_p) multiply by 100.
 - vi. Continue drying until there is less than 0.05 percent change in specimen mass (constant mass).
 - vii. Constant mass has been achieved, sample is defined as dry.
2. Cool the specimen in air to $25 \pm 5^\circ\text{C}$ ($77 \pm 9^\circ\text{F}$), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as "A."
 3. Immerse the specimen in the temperature-controlled water bath for at least 10 minutes.
 4. Fill the volumeter with distilled water at $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$) making sure some water escapes through the capillary bore of the tapered lid.
 5. Wipe the volumeter dry. Determine the mass of the volumeter to the nearest 0.1 g. Designate this mass as "D."
 6. At the end of the ten minute period, remove the specimen from the water bath and quickly surface dry with a damp cloth towel within 5 seconds.
 7. Immediately determine and record the mass of the SSD specimen to the nearest 0.1 g. Designate this mass as "B." Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen.
 8. Place the specimen in the volumeter and let stand 60 seconds.
 9. Bring the temperature of the water to $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$) and cover the volumeter, making sure some water escapes through the capillary bore of the tapered lid.
 10. Wipe the volumeter dry.
 11. Determine and record the mass of the volumeter and specimen to the nearest 0.1 g. Designate this mass as "E."

ASPHALT

WAQTC

FOP AASHTO T 166 (18)

Note 2: Method B is not acceptable for use with specimens that have more than 6 percent air voids.

Calculations - Method B (Volumeter)

Constant Mass:

Calculate constant mass using the following formula:

$$\%Change = \frac{M_p - M_n}{M_p} \times 100$$

Where:

M_p = previous mass measurement, g

M_n = new mass measurement, g

Bulk specific gravity (G_{mb}) and percent water absorbed:

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

$$\text{Percent Water Absorbed (by volume)} = \frac{B - A}{B + D - E} \times 100$$

where:

G_{mb} = Bulk specific gravity

A = Mass of dry specimen in air, g

B = Mass of SSD specimen in air, g

D = Mass of volumeter filled with water at $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$), g

E = Mass of volumeter filled with specimen and water, g

Example:

$$G_{mb} = \frac{4833.6 \text{ g}}{4842.4 \text{ g} + 2924.4 \text{ g} - 5806.0 \text{ g}} = 2.465$$

$$\% \text{ Water Absorbed (by volume)} = \frac{4842.4 \text{ g} - 4833.6 \text{ g}}{4842.4 \text{ g} + 2924.4 \text{ g} - 5806.0 \text{ g}} \times 100 = 0.45\%$$

ASPHALT

WAQTC

FOP AASHTO T 166 (18)

Method C (Rapid Test for Method A or B)

See Methods A or B.

Note 3: This procedure can be used for specimens that are not required to be saved and contain substantial amounts of moisture. Cores can be tested the same day as obtained by this method.

Procedure - Method C (Rapid Test for Method A or B)

1. Start on Step 3 of Method A or B, and complete that procedure, then determine dry mass, "A," as follows.
2. Determine and record mass of a large, flat-bottom container.
3. Place the specimen in the container.
4. Place in an oven at a minimum of 105°C (221°F). Do not exceed the Job Mix Formula mixing temperature.
5. Dry until the specimen can be easily separated into fine aggregate particles that are not larger than 6.3 mm (¼ in.).
6. Determine and record the mass of the specimen (M_p).
7. Return the specimen to the oven for at least 2 hours.
8. Determine and record the mass of the specimen (M_n).
9. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p) divide by the previous mass determination (M_p) multiply by 100.
10. Continue drying until there is less than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
11. Constant mass has been achieved, sample is defined as dry.
12. Cool in air to 25 ±5°C (77 ±9°F).
13. Determine and record the mass of the container and dry specimen to the nearest 0.1 g.
14. Determine and record the mass of the dry specimen to the nearest 0.1 g by subtracting the mass of the container from the mass determined in Step 13. Designate this mass as "A."

ASPHALT

WAQTC

FOP AASHTO T 166 (18)

Calculations - Method C (Rapid Test for Method A or B)

Complete the calculations as outlined in Methods A or B, as appropriate.

Report

- Results on forms approved by the agency
- Sample ID
- G_{mb} to 0.001
- Absorption to 0.01 percent
- Method performed.

ASPHALT

WAQTC

FOP AASHTO T 166 (18)

ASPHALT

WAQTC

FOP AASHTO T 166 (13)

PERFORMANCE EXAM CHECKLIST**BULK SPECIFIC GRAVITY OF COMPACTED ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS
FOP FOR AASHTO T 166**

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	Trial 1	Trial 2
Method A:		
1. Mass of dry sample in air determined.		
a. Oven dried overnight at $52 \pm 3^\circ\text{C}$ ($125 \pm 5^\circ\text{F}$) and at successive 2-hour intervals to constant mass?	_____	_____
b. Cooled in air to $25 \pm 5^\circ\text{C}$ ($77 \pm 9^\circ\text{F}$)?	_____	_____
c. Dry mass determined to 0.1g?	_____	_____
2. Water at the overflow?	_____	_____
3. Balance zeroed?	_____	_____
4. Immersed weight determined.		
a. Water at $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$)?	_____	_____
b. Immersed, shaken, on side, for 4 ± 1 minutes?	_____	_____
c. Immersed weight determined to 0.1g?	_____	_____
5. Sample rapidly surface dried with damp towel and saturated surface dry (SSD) mass determined to 0.1 g (entire operation performed within 15 seconds)?	_____	_____
6. G_{mb} calculated to 0.001?	_____	_____
7. Absorption calculated to 0.01 percent	_____	_____
Method B:		
1. Specimen dried, cooled, and mass determined as in Method A?	_____	_____
2. Saturated surface dry (SSD) mass determined to 0.1g.		
a. Immersed at least 10 minutes at $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$)?	_____	_____
b. Sample rapidly dried with damp towel?	_____	_____
c. Specimen mass determined to 0.1 g?	_____	_____
d. Any water that seeps from specimen included in mass?	_____	_____
3. Mass of volumeter filled with distilled water at $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$) determined?	_____	_____
4. SSD specimen placed into volumeter and let stand for 1 minute?	_____	_____

OVER

ASPHALT

WAQTC

FOP AASHTO T 166 (13)

Procedure Element	Trial 1	Trial 2
5. Temperature of water brought to $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$) and volumeter covered, allowing some water to escape through the capillary bore of the tapered lid?	_____	_____
6. Volumeter wiped dry, and mass of volumeter and contents determined?	_____	_____
7. G_{mb} calculated to 0.001?	_____	_____
8. Absorption calculated to 0.01 percent?	_____	_____
Method C/A:		
1. Immersed weight determined.		
a. Water at $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$)?	_____	_____
b. Immersed, shaken, on side, for 4 ± 1 minutes?	_____	_____
c. Immersed weight determined to 0.1 g?	_____	_____
2. Sample rapidly surface dried with damp cloth (within 5 seconds)?	_____	_____
3. Saturated surface dry mass determined to 0.1 g?	_____	_____
4. Dry mass determined by:		
a. Heating in oven at a minimum of 105°C (221°F)?	_____	_____
b. Breaking down to 6.3 mm ($\frac{1}{4}$ in.) particles?	_____	_____
c. Drying in oven to constant mass (change less than 0.05 percent in 2 hours of additional drying)?	_____	_____
d. Cooled in air to $25 \pm 5^\circ\text{C}$ ($77 \pm 9^\circ\text{F}$) and mass determined to 0.1 g?	_____	_____
5. G_{mb} calculated to 0.001?	_____	_____
6. Absorption calculated to 0.01?	_____	_____
Method C/B:		
1. Saturated surface dry (SSD) mass determined to 0.1 g.		
a. Immersed at least 10 minutes at $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$)?	_____	_____
b. Sample rapidly dried with damp towel (within 5 seconds)?	_____	_____
c. Specimen mass determined to 0.1 g?	_____	_____
d. Any water that seeps from specimen included in mass?	_____	_____
2. Mass of volumeter filled with distilled water at $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$) determined to 0.1 g?	_____	_____
3. SSD specimen placed into volumeter and let stand for 1 minute?	_____	_____
4. Temperature of water brought to $25 \pm 1^\circ\text{C}$ ($77 \pm 1.8^\circ\text{F}$) and volumeter covered, allowing some water to escape through the capillary pore of the tapered lid?	_____	_____
5. Volumeter wiped dry, and mass of volumeter and contents determined to 0.1 g?	_____	_____

OVER

ASPHALT

WAQTC

FOP AASHTO T 166 (13)

Procedure Element	Trial 1	Trial 2
6. Dry mass determined by:		
a. Warming in oven at a minimum of 105°C (221°F)?	_____	_____
b. Breaking down to 6.3 mm (¼ in.) particles?	_____	_____
c. Drying in oven to constant mass (change less than 0.05 percent in 2 hours of additional drying)?	_____	_____
d. Cooled in air to 25 ±5°C (77 ±9°F) and mass determined to 0.1 g?	_____	_____
7. G_{mb} calculated to 0.001?	_____	_____
8. Absorption calculated to 0.01 percent?	_____	_____

Comments: First attempt: Pass _____ Fail _____ Second attempt: Pass _____ Fail _____

Examiner Signature _____ WAQTC #: _____

ASPHALT

WAQTC

FOP AASHTO T 166 (13)