

## Method of Test for Theoretical Maximum Specific Gravity of Asphalt Concrete Paving Mixtures

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### 1. Scope:

This test is to determine the theoretical maximum specific gravity and/or density of uncompacted asphalt concrete paving mixtures. The theoretical maximum specific gravity or density is the standard used in the determination of in-place density of asphalt concrete pavements.

### 2. Apparatus:

- 2.1 Scale or balance having the capacity to weigh any sample which may be tested utilizing this procedure and readable to the nearest 0.1 gram. The scale or balance shall be equipped with a suitable suspension apparatus and holder to permit weighing the sample while suspended from the center of the scale pan of the weighing device.
- 2.2 Vacuum pycnometer capable of holding 3000 grams of loose asphalt mix.
- 2.3 Vacuum pump or water aspirator for evacuating air from the container. If a vacuum pump is used a suitable trap shall be installed between the pycnometer and the vacuum source.
- 2.4 Vibrating plate for continuously agitating the asphalt concrete mixture and container.
- 2.5 Water container that will provide a sufficient amount of potable water to maintain a uniform temperature throughout the testing procedure. An aquarium heater will work to control the temperature of water at  $77^{\circ} \pm 2^{\circ}$  F.
- 2.6 A thermometer with subdivisions and maximum scale error of  $1^{\circ}$  F to cover the range of testing.
- 2.7 A mercury or digital residual pressure manometer is required to measure the amount of vacuum.
- 2.8 A bleeder valve attached to the vacuum system to facilitate adjustment of the vacuum being applied to the vacuum container.
- 2.9 The water bath for immersing the sample if using the (Weighing in water method) shall be equipped with an overflow outlet for maintaining a constant water level. The water bath must be large enough to allow the suspension apparatus holder to be covered with water at all times. The sample and suspension apparatus must be completely covered with water during weighing. The wire suspending

the suspension apparatus shall be the smallest practical size to minimize any possible effects of a variable immersed length.

**3. Procedure:**

**3.1 Sampling of uncompacted mix.**

- A. A random sample, approximately 160 to 180 lbs., of hot mix shall be taken from the paver area, - plus an additional 80 to 90 lbs., when IA testing is required. Samples may be obtained from behind the paver screed or from the windrow in front of the pickup machine. Material from the same sample shall be used for both SD 312 and SD 313 test procedures. On projects not requiring QC/QA testing a minimum sample size of 40 to 45 lbs. is required.

| 17

Sampling from the windrow in front of the pickup machine.

The random sample for QC/QA projects shall be selected by using random numbers such as from the tables included in this test procedure. Use the random number selected to determine the tonnage location in the subplot where the sample will be obtained.

Do not sample the top surface of the windrow. Use a square bottom shovel to remove and discard the top foot of material from the windrow. Next, remove and discard the outside edge of the remaining windrow to create a vertical face parallel to the windrow. Obtain the sample from the exposed vertical face. Split samples can be obtained by alternating equal shovels of hot mix into the sample containers. The QC, QA and IA sample splits can be obtained by using this procedure. The sample in each sample container must be large enough for two complete sets of all required tests.

Sampling from behind the paver screed (Only when there is not a windrow available).

Example: Select a location in the random number table. Take that number (0.58) times the tonnage in the lot (1000). The sample will be taken at 580 tons into the lot on the road at the location the truck unloads where the weigh ticket is nearest to 580 tons. Record the weigh ticket number on the DOT 42Q. Use a 2<sup>nd</sup> random number (0.17) to select the distance from centerline where the sample will be taken. An example of this is  $0.17 \times 12' \text{ width} = 2.0'$  from centerline.

Sample the mix by placing a template through the entire lift of hot mix or by using a square bottom shovel to create a sample area with vertical faces. Remove all material within the template or between the vertical lifts and place in the sample container

or containers. On QC/QA projects obtain at least three approximately equal increments from this sample area for each sample container by placing the increments by alternating between sample container using a square bottom shovel or scoop. The QC/QA and IA sample splits can be obtained by using this procedure. The sample in each sample container must be large enough for two complete sets of all required tests.

- B. There will be a 200 ton buffer between the random locations of the hot mix samples.
- C. Transport the sample in a pail or box that is insulated or protected to help retain heat.

3.2 Calibration of the pycnometer for the weighing in air method.

- A. Determine the weight of the container completely full of water with the calibration lid on, over the range of temperatures that will likely be encountered in service. Be sure the outside of the container is dry when weighed. Measure and record the temperature of the water and the weight of the container to the nearest 0.1 gram for at least one calibration point per 4° F after allowing the water to be in the container for 15 minutes. Construct a calibration curve for the water and container that is being used so that the weight of the container filled with water can be determined for any temperature from the calibration curve. At least weekly check the weight of the container filled with water to verify the weight is very close to the same as obtained from the calibration curve. Record the checks in the field diary.

**Correction factor for different water temperatures °F**

°F		°F		°F	
60	1.0020	71	1.0008	81	0.9994
61	1.0019	72	1.0007	82	0.9992
62	1.0018	73	1.0005	83	0.9991
63	1.0017	74	1.0004	84	0.9989
64	1.0016	75	1.0003	85	0.9988
65	1.0015	76	1.0001	86	0.9986
66	1.0014	77	1.0000	87	0.9984
67	1.0013	78	0.9999	88	0.9983
68	1.0012	79	0.9998	89	0.9981
69	1.0011	80	0.9996	90	0.9979
70	1.0009				

NOTE: Whenever possible, use water that is close to 77°F.

3.3 Sample size and preparation.

A. The size of the sample shall conform to the following requirements.

Nominal maximum size of aggregate	Minimum size of sample
#4	500 grams
3/8"	1000 grams
1/2"	1500 grams
3/4"	2000 grams
1"	2500 grams
1 1/4"	3000 grams

B. Obtain 2 representative samples for testing from the sample taken in accordance with paragraph 3.1. Use the quartering method in SD 213, an asphalt quartering device, or by using the method as follows. Place the original sample in a large clean pan where there will be neither loss of material nor the addition of foreign matter. Mix the sample thoroughly and flatten the material in the pan. Obtain a representative cross section of the pan area by using a heated flat bottom scoop to obtain material for testing. Scoop material from several selected locations in the pan to achieve a sample size that will conform to the requirements in the sample size table 3.3 A.

C. Separate the particles of the sample on a clean surface, to prevent contamination. The fines portion of the hot mix shall be separated such that no lumps are larger than 1/4". If the mixture is not sufficiently soft to be separated manually, place it in a large flat pan and warm in an oven until it can be handled.

D. Cool the sample to room temperature before beginning the test.

3.4 Determine the theoretical maximum specific gravity by one of the following methods.

(Weighing in air method)

A. Weigh the cooled sample to the nearest 0.1 gram in a tared container and record the weight. Add sufficient water to cover the sample approximately 1". 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 20L of water. This solution is then diluted by about 20:1 to make a wetting agent of which 5 to 10 mL may be added to the container.

- B. Remove entrapped air by subjecting the contents to a partial vacuum of 25 to 30 mm Hg. absolute pressure for 15 minutes  $\pm$  30 seconds. Agitate the container and contents continuously by a mechanical device. A manometer shall be installed inline to measure the amount of vacuum applied. A bleeder valve shall be installed in the vacuum system to maintain the vacuum at the required level.
- C. Upon completion of the 15 minute vacuum period, slowly release the vacuum on the system. Fill the container with water. Place a thermometer in the container and record the water temperature 9 minutes after completing the vacuum period. Replace the calibration lid, dry the outside of the container, and record the weight of the container, sample and water to the nearest 0.1 gram.
- D. Repeat A., B., and C. for a duplicate sample. The values of the two samples will be averaged for final results.
- E. Duplicate specific gravity values not within 0.011 should be considered suspect and performed again.

(Weighing in water method)

- F. Weigh the cooled sample to the nearest 0.1 gram in a tared container and record the weight. Add sufficient water to cover the sample approximately 1". 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 20L of water. This solution is then diluted by about 20:1 to make a wetting agent of which 5 to 10 mL may be added to the container.
- G. Remove entrapped air by subjecting the contents to a partial vacuum of 25 to 30 mm Hg. absolute pressure for 15 minutes  $\pm$  30 seconds. Agitate the container and contents continuously by a mechanical device. A manometer shall be installed inline to measure the amount of vacuum applied. A bleeder valve shall be installed in the vacuum system to maintain the vacuum at the required level.
- H. Upon completion of the 15 minute vacuum period, slowly release the vacuum on the system. Suspend the container and material in the water bath for 9 minutes. Record the water temperature. Record the weight of the container and sample suspended under water to the nearest 0.1 gram. Maintain a constant level of water in the water bath with the use of an overflow outlet.

- I. Weigh the empty container suspended under water and record the weight to the nearest 0.1 gram.
- J. Repeat F., G., H., and I. for a duplicate sample. The values of the two samples will be averaged for final results.
- K. Duplicate specific gravity values not within 0.011 should be considered suspect and performed again.

**4. Report:**

4.1 Calculate the theoretical maximum specific gravity of the asphalt concrete mix in one of the following manners:

4.2 (Weighing in air method) (Figure 1 or figure 2)

$$\text{Theoretical maximum specific gravity} = (A / (A + B - C)) \times D$$

A = Dry weight of the sample.

B = Calibration weight of the canister and water at the test temperature.

C = Final weight of the canister, water & sample.

D = Correction factor for water temperature.

(Weighing in water method) (Figure 1 or figure 3)

$$\text{Theoretical maximum specific gravity} = ((A / (A + B - C)) \times D$$

A = Dry weight of the sample.

B = Weight of the canister suspended under water.

C = Weight of the canister and sample suspended under water.

D = Correction factor for water temperature.

Report the theoretical maximum specific gravity to the third decimal place.

4.3 Calculate the standard unit weight in the following manner if required by the specifications:

$$\text{Standard Unit Weight (lb./ft}^3\text{)} = \text{Theo. maximum specific gravity} \times 62.245$$

4.4 Report the standard unit weight to one decimal place if required by the specifications.

**5. References:**

SD 213  
SD 313  
DOT-42  
DOT-86

Sample ID 2224267  
File No.

Gyratory Specific Gravity

DOT - 86  
9-14

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015  
 Field # QC01QA01 Date Sampled 08/05/2015 Date Tested 08/05/2015  
 Sampled By Tester, One Tested By Tester, One Checked By Tester, Two  
 Material Type Class Q2 Hot Mixed Asphalt Concrete Ticket # 15729  
 Source \_\_\_\_\_ Lift 1 of 1  
 Lot No. 1 Sublot No. 1

Mix Temp 270 Offset 6 ESAL's Q2  
 Daily Ton 483.83 Total Ton 2632.46 Oil Type PG 64-28

% binder Pb Gsb binder Gb dust (-#200) lime dust (-#200) + lime	5.1	N initial	6	Gse	2.681
	2.636	N design	50	Pba	0.66
	1.032	N max	75	Pbe	4.5
	4.9				
	0.49				
	5.4				

	Spec. A (Ndes)		Spec. B (Ndes)		Spec. M (Nmax)		
	@ N ini	@ N des	@ N ini	@ N des	@ N ini	@ N des	@ N max
a) Height, mm	123.60	113.40	123.90	113.90			
b) Weight in air		4705.1		4708.3			
c) Weight in water		2729.6		2729.0			
d) SSD weight		4707.9		4710.9			
e) Bulk SpGr meas b / (d - c)		2.378		2.376			
f) Bulk SpGr calc (Gmb)	2.182		2.184				

	Gmm #1	Gmm #2
Weight of sample in air	1,522.0	1,524.9
Weight of canister + water	1376.4	1376.4
Weight of canister + water + sample	2284.1	2286.2
Temperature of the water	77F (25.0C)	77F (25.0C)
Water correction factor	1.0000	1.0000
Rice SpGr (Gmm)	2.478	2.479

Average Maximum SpGr (Gmm) 2.479

	N initial	N design	N maximum
Average Gmb	2.183	2.377	
% of Rice SpGr (Gmm)	88.1	95.9	

% Air Voids(Va) 4.1 % VMA 14.4 % VFA 72 Dust to binder ratio 1.2

Figure 1

Sample ID 2223955  
File No.

DENSITY REPORT - BITUMINOUS SURFACING

DOT - 42  
1-16

PROJECT PH 0066(00)15 COUNTY Aurora, Ziebach PCN B015  
Test No. IA01/04 Class and Type Class E Asphalt Concrete Lift 1 of 1 Thickness 1.5  
% Asphalt Binder Actual Finished Width 12.00  
Date 08/31/2015 Tested By Tester, One Checked By Tester, Two

Standard Density

Standard Density Test No: Station: 369+00 RT Sample obtained from:

	Theoretical Maximum Density (Rice)		Gyratory Density	
	1	2	1	2
A. Wt. of sample in Air	1602.2	1609.8	1246.5	1243.6
B. Wt. of Canister + Water	1250.6	1250.6	726.5	724.1
C. Wt. of Canister + Water + Sample	2202.0	2207.2	1247.0	1244.4
Temperature of the Water	77F (25.0C)	77F (25.0C)	D. Volume Displaced (C - B)	520.50
D. Water Correction Factor	1.0000	1.0000	E. Bulk Specific Gravity (A / D)	2.395
E. Max. Specific Gravity [ A / (A + B - C) ] x D	2.462	2.464	F. Unit Weight (E x 62.245)	149.1
F. Max. Unit Weight ( E x 62.245 )	153.2	153.4	G. Compaction Sample Temp.	270.0
			H. Avg. Unit Weight	148.9
G. Average Unit Weight	153.3			
H. Moving Avg. (Last 5 Tests)	153.3			

% Air Void Calculations

[ (Maximum Specific Gravity - Bulk Specific Gravity) / Maximum Specific Gravity ] x 100 = 2.9

In-Place Density Measurement

Nuclear Gauge No: n/a  
Lot Loc. Sta: To Sta: Dist. From Center:  
Length: Width: 12.0 Quantity Represented: 0

Site No.	Random No.	Distance Lot. Beg.	Station	Random No.	Dist. From Out. Edge	Distance From C/L	Wet Density PCF	Corrected W.D. PCF	% of Standard
1									
2									
3									
4									
5									

No more than 2 test below spec. Only 1 test may be 2% below spec. 1 Test @ 3% Below fails the Entire Lot Lot Average

Specification Requirements - % of Standard Required 92 Min.

Cutout / Core Correction

Cutout No.	Station	Distance From C/L	Actual Dry Wt.	Submersed Wt. in Water	SSD Wt. in Air	Density PCF	Nuclear Gauge Readings Wet Density, PCF	Avg. PCF
1						1		
2						2		
3						3		

Cutout/Core Average in PCF

Nuclear Gauge Average in PCF

Nuclear Gauge Correction 0 PCF

Figure 2



SDDOT  
TABLE OF RANDOM NUMBERS

.53 .74 .23 .99 .67	.61 .32 .28 .69 .84	.94 .62 .67 .86 .24	.98 .33 .74 .19 .95	.47 .53 .53 .38 .09
.63 .38 .06 .86 .54	.99 .00 .65 .26 .94	.02 .82 .90 .23 .07	.79 .62 .67 .80 .60	.75 .91 .12 .81 .19
.35 .30 .58 .21 .46	.06 .72 .17 .10 .94	.25 .21 .31 .75 .96	.49 .28 .24 .00 .49	.55 .65 .79 .78 .07
.63 .43 .36 .82 .69	.65 .51 .18 .37 .88	.61 .38 .44 .12 .45	.32 .92 .85 .88 .65	.54 .34 .81 .85 .35
.98 .25 .37 .55 .26	.01 .91 .82 .81 .46	.74 .71 .12 .94 .97	.24 .02 .71 .37 .07	.03 .92 .18 .66 .75
.02 .63 .21 .17 .69	.71 .50 .80 .89 .56	.38 .15 .70 .11 .48	.43 .40 .45 .86 .98	.00 .83 .26 .91 .03
.64 .55 .22 .21 .82	.48 .22 .28 .06 .00	.61 .54 .13 .43 .91	.82 .78 .12 .23 .29	.06 .66 .24 .12 .27
.85 .07 .26 .13 .89	.01 .10 .07 .82 .04	.59 .63 .69 .36 .03	.69 .11 .15 .83 .80	.13 .29 .54 .19 .28
.58 .54 .16 .24 .15	.51 .54 .44 .82 .00	.62 .61 .65 .04 .69	.38 .18 .65 .18 .97	.85 .72 .13 .49 .21
.34 .85 .27 .84 .87	.61 .48 .64 .56 .26	.90 .18 .48 .13 .26	.37 .70 .15 .42 .57	.65 .65 .80 .39 .07
.03 .92 .18 .27 .46	.57 .99 .16 .96 .56	.30 .33 .72 .85 .22	.84 .64 .38 .56 .98	.99 .01 .30 .98 .64
.62 .95 .30 .27 .59	.37 .75 .41 .66 .48	.86 .97 .80 .61 .45	.23 .53 .04 .01 .63	.45 .76 .08 .64 .27
.08 .45 .93 .15 .22	.60 .21 .75 .46 .91	.98 .77 .27 .85 .42	.28 .88 .61 .08 .84	.69 .62 .03 .42 .73
.07 .08 .55 .18 .40	.45 .44 .75 .13 .90	.24 .94 .96 .61 .02	.57 .55 .66 .83 .15	.73 .42 .37 .11 .16
.01 .85 .89 .95 .66	.51 .10 .19 .34 .88	.15 .84 .97 .19 .75	.12 .76 .39 .43 .78	.64 .63 .91 .08 .25
.72 .84 .71 .14 .35	.19 .11 .58 .49 .26	.50 .11 .17 .17 .76	.86 .31 .57 .20 .18	.95 .60 .78 .46 .75
.88 .78 .28 .16 .84	.13 .52 .53 .94 .53	.75 .45 .69 .30 .96	.73 .89 .65 .70 .31	.99 .17 .43 .48 .76
.45 .17 .75 .65 .57	.28 .40 .19 .72 .12	.25 .12 .74 .75 .67	.60 .40 .60 .81 .19	.24 .62 .01 .61 .16
.96 .76 .28 .12 .54	.22 .01 .11 .94 .25	.71 .96 .16 .16 .88	.68 .64 .36 .74 .45	.19 .59 .50 .88 .92
.43 .31 .67 .72 .30	.24 .02 .94 .08 .63	.38 .32 .36 .66 .02	.69 .36 .38 .25 .39	.48 .03 .45 .15 .22
.50 .44 .66 .44 .21	.66 .06 .58 .05 .62	.68 .15 .54 .35 .02	.42 .35 .48 .96 .32	.14 .52 .41 .52 .48
.22 .55 .22 .15 .86	.26 .63 .75 .41 .99	.58 .42 .36 .72 .24	.58 .37 .52 .18 .51	.03 .37 .18 .39 .11
.96 .24 .40 .14 .51	.23 .22 .30 .88 .57	.95 .67 .47 .29 .83	.94 .69 .40 .06 .07	.18 .16 .36 .78 .86
.31 .73 .91 .61 .19	.60 .20 .72 .93 .48	.98 .57 .07 .23 .69	.65 .95 .39 .69 .58	.56 .80 .30 .19 .44
.78 .60 .73 .99 .34	.43 .89 .94 .36 .45	.56 .69 .47 .07 .41	.90 .22 .91 .07 .12	.78 .35 .34 .08 .72
.84 .37 .90 .61 .56	.70 .10 .23 .98 .05	.85 .11 .34 .76 .60	.76 .48 .45 .34 .60	.01 .64 .18 .39 .96
.36 .67 .10 .08 .23	.98 .93 .35 .08 .86	.99 .29 .76 .29 .81	.33 .34 .91 .58 .93	.63 .14 .52 .32 .52
.07 .28 .59 .07 .48	.89 .64 .58 .89 .75	.83 .85 .62 .27 .89	.30 .14 .78 .56 .27	.86 .63 .59 .80 .02
.10 .15 .83 .87 .60	.79 .24 .31 .66 .56	.21 .48 .24 .06 .93	.91 .98 .94 .05 .49	.01 .47 .59 .38 .00
.55 .19 .68 .97 .65	.03 .73 .52 .16 .56	.00 .53 .55 .90 .27	.33 .42 .29 .38 .87	.22 .13 .88 .83 .34
.53 .81 .29 .13 .39	.35 .01 .20 .71 .34	.62 .33 .74 .82 .14	.53 .73 .19 .09 .03	.56 .54 .29 .56 .93
.51 .86 .32 .68 .92	.33 .98 .74 .66 .99	.40 .14 .71 .94 .58	.45 .94 .19 .38 .81	.14 .44 .99 .81 .07
.35 .91 .70 .29 .13	.80 .03 .54 .07 .27	.96 .94 .78 .32 .66	.50 .95 .52 .74 .33	.13 .80 .55 .62 .54
.37 .71 .67 .95 .13	.20 .02 .44 .95 .94	.64 .85 .04 .05 .72	.01 .32 .90 .76 .14	.53 .89 .74 .60 .41
.93 .66 .13 .83 .27	.92 .79 .64 .64 .72	.28 .54 .96 .53 .84	.48 .14 .52 .98 .94	.56 .07 .93 .89 .30
.02 .96 .08 .45 .65	.13 .05 .00 .41 .84	.93 .07 .54 .72 .59	.21 .45 .57 .09 .77	.19 .48 .56 .27 .44
.49 .83 .43 .48 .35	.82 .88 .33 .69 .96	.72 .36 .04 .19 .76	.47 .45 .15 .18 .60	.82 .11 .08 .95 .97
.84 .60 .71 .62 .46	.40 .80 .81 .30 .37	.34 .39 .23 .05 .38	.25 .15 .35 .71 .30	.88 .12 .57 .21 .77
.18 .17 .30 .88 .71	.44 .91 .14 .88 .47	.89 .23 .30 .63 .15	.56 .34 .20 .47 .89	.99 .82 .93 .24 .98
.79 .69 .10 .61 .78	.71 .32 .76 .95 .62	.87 .00 .22 .58 .40	.92 .54 .01 .75 .25	.43 .11 .71 .99 .31
.75 .93 .36 .57 .83	.56 .20 .14 .82 .11	.74 .21 .97 .90 .65	.96 .42 .68 .63 .86	.74 .54 .13 .26 .94
.38 .30 .92 .29 .03	.06 .28 .81 .39 .38	.62 .25 .06 .84 .63	.61 .29 .08 .93 .67	.04 .32 .92 .08 .09
.51 .28 .50 .10 .34	.31 .57 .75 .95 .80	.51 .97 .02 .74 .77	.76 .15 .48 .49 .44	.18 .55 .63 .77 .09
.21 .31 .38 .86 .24	.37 .79 .81 .53 .74	.73 .24 .16 .10 .33	.52 .83 .90 .94 .76	.70 .47 .14 .54 .36
.29 .01 .23 .87 .88	.58 .02 .39 .37 .67	.42 .10 .14 .20 .92	.16 .55 .23 .42 .45	.54 .96 .09 .11 .06
.95 .33 .95 .22 .00	.18 .74 .72 .00 .18	.38 .79 .58 .69 .32	.81 .76 .80 .26 .92	.82 .80 .84 .25 .39
.90 .84 .60 .79 .80	.24 .36 .59 .87 .38	.82 .07 .53 .89 .35	.96 .35 .23 .79 .18	.05 .98 .90 .07 .35
.46 .40 .62 .98 .82	.54 .97 .20 .56 .95	.15 .74 .80 .08 .32	.16 .46 .70 .50 .80	.67 .72 .16 .42 .79
.20 .31 .89 .03 .43	.38 .46 .82 .68 .72	.32 .14 .82 .99 .70	.80 .60 .47 .18 .97	.63 .49 .30 .21 .30
.71 .59 .73 .05 .50	.08 .22 .23 .71 .77	.91 .01 .93 .20 .49	.82 .96 .59 .26 .94	.66 .39 .67 .98 .60

Figure 3