OHD L-14
METHOD OF TEST FOR
DETERMINING THE SPECIFIC GRAVITY AND UNIT WEIGHT OF COMPACTED BITUMINOUS MIXTURES

I. **SCOPE.** This method of test covers the procedures for determining the bulk specific gravity and unit weight of specimens of compacted bituminous mixtures, as defined in the Standard Definitions of Terms Relating to Specific Gravity (AASHTO Designation M132).

A. This method should not be used with samples that contain open or interconnecting voids. This method may not be applicable to samples that absorb more than 2 percent water by volume, as determined herein.

B. The bulk specific gravity of the compacted bituminous mixtures may be used in calculating the unit weight of the mixture.

C. Method A is used for testing specimens which may contain a substantial amount of moisture. Specimens obtained by coring or sawing can be quickly tested by this method.

D. Method B is used for testing specimens which are thoroughly dry, such as lab-molded specimens.

E. Alternate Method A may be used for determining the unit weight and bulk specific gravity of compacted bituminous concrete pavement with a nuclear density gauge.

F. Alternate Method B may be used for determining the unit weight and bulk specific gravity of compacted bituminous concrete pavement with an electromagnetic density gauge.

II. **TEST SPECIMENS.** Test specimens may be either cut or cored from bituminous pavements or laboratory-molded from bituminous mixtures.

A. Pavement specimens shall be taken from pavements with core drill, diamond or carborundum saw, or other suitable means.

B. Care shall be taken to avoid distortion, bending, or cracking of specimens during and after the removal from pavement or mold. Specimens shall be stored in a safe, cool place.

C. Specimens shall be free from foreign materials such as seal coat, petromat, foundation material, soil, paper, or foil. When any of these materials are visually evident, they shall be removed by sawing or other suitable means.

D. Specimens may be separated from other pavement layers by sawing or other suitable means.

III. **APPARATUS.** The apparatus shall consist of the following:

A. **Weighing Device,** sufficient capacity and readability of 0.1 percent of the sample mass or better, conforming to the requirements of AASHTO M 231. The weighing device shall be equipped with suitable suspension apparatus and holder to permit weighing the specimen while suspended in water.

B. **Suspension Apparatus,** wire or string suspending the holder shall be the smallest practical size to minimize any possible effects of a variable immersed length. The suspension apparatus shall be constructed to enable the holder to be immersed to a depth sufficient to cover it and the test sample, during weighing.

C. **Water Bath,** at 77° ± 1.8°F (25° ± 1°C) for immersing the specimen in water while suspended under the balance, equipped with an overflow outlet for maintaining a constant water level.

D. **Oven,** at 125° ± 5°F (52° ± 3°C) or 230° ± 9°F (110° ± 5°C) to dry the specimen.

IV. **PROCEDURE.**

A. **Method A:** This procedure may be used for testing specimens which may contain a substantial amount of moisture. Specimens obtained by coring or sawing can be quickly tested by this method. The procedure shall be as follows:

1. Bring the specimen to room temperature at 77° ± 9°F (25° ± 5°C).

2. Immerse the specimen in the water bath at 77° ± 1.8°F (25° ± 1°C) for 4 ± 1 minutes, then record the immersed weight (C) to the nearest 0.1 gram.

3. Remove the specimen from the water bath, quickly damp dry the specimen by blotting with a damp towel and quickly determine the surface-dry weight (B) to the nearest 0.1 gram. Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen.

4. Place the specimen in a drying pan of known weight and dry to a constant weight of 230° ± 9°F (110° ± 5°C). If the specimen is to be used for further testing, dry to a constant weight at 125° ± 5°F (52° ± 3°C).

5. Cool the specimen in the drying pan to room temperature at 77° ± 9°F (25° ± 5°C) and record the dry weight (A) of the specimen to the nearest 0.1 gram.

6. Calculate the results as shown in Section V, paragraphs A, B, and C below.

   NOTE: Constant weight shall be defined as the mass at which further drying does not alter the mass by more than 0.05 percent over two-hour drying intervals.

B. **Method B.** This procedure may be used for testing specimens which are thoroughly dry, such as lab-molded specimens. The procedure shall be as follows:

1. Bring the specimen to room temperature at 77° ± 9°F (25° ± 5°C) and record the dry weight (A) to the nearest 0.1 gram. A fan may be used to blow air across the specimen to speed the cooling process.

2. Immerse the specimen in the water bath at 77° ± 1.8°F (25° ± 1°C) for 4

± 1 minutes, then record the immersed weight (C) to the nearest 0.1 gram.

3. Remove the specimen from the water bath, quickly damp dry the specimen by blotting with a damp towel and quickly determine the surface-dry weight (B) to the nearest 0.1 gram. Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen.

4. Calculate the results as shown in Section V, paragraphs A, B, and C below.

V. **CALCULATIONS.**

A. Calculate the bulk specific gravity of the specimen as follows (round and report the value to the nearest 0.001 gram):

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

Where:

G_{mb}	=	Bulk Specific Gravity
A	=	Dry weight of specimen in air
B	=	Weight of surface-dry specimen in air
C	=	Weight of specimen in water

NOTE: The Bulk Specific Gravity of a lab-molded specimen is commonly referred to as the Lab-molded Specific Gravity. The Bulk Specific Gravity of a roadway core is commonly referred to as the Core Specific Gravity.

B. Calculate the percent water absorbed by the specimen on a volume basis as follows:

$$\%\ Water\ Absorbed\ by\ Volume = \frac{B - A}{B - C} \ x\ 100$$

NOTE: If the percent water absorbed by the specimen exceeds 2 percent, retest using either OHD L-45 (Method of Test for Determining the Specific Gravity and Unit Weight of Compacted Bituminous Paving Mixtures Using the CoreLok™ Apparatus) or AASHTO T 275 (Bulk Specific Gravity of Compacted Bituminous Mixtures using Paraffin-Coated Specimens).

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ALTERNATE METHOD A

I. **SCOPE.** This test method covers the test procedure for determining the unit weight of bituminous concrete pavement by the attenuation of gamma radiation, where the source and detectors remain on the surface. The unit weight is determined by comparing the detected rate of gamma emissions with previously established calibration data. The bulk specific gravity of the compacted bituminous mixture can be calculated using the unit weight of the mixture.

II. **SIGNIFICANCE AND USE.** The test method described is useful as a rapid, nondestructive technique for determining the relative in-place unit weight of compacted bituminous mixtures. This test method may be used to establish the proper rolling effort and pattern to achieve the required density. With proper calibration and correlation testing, this test method is suitable for quality control and acceptance testing of compacted bituminous concrete.

A. The results obtained by this test method are relative. This test method may be used for quality control and acceptance testing if correlation testing with roadway cores is performed. It is recommended that at least ten (10) roadway core results be compared with their corresponding nuclear gauge results to establish the correlation. A new correlation must be established for each paving mixture, each lift, each major change in job location, and each time a significant change is made in the paving mixture or in the construction process. This correlation is necessary to achieve accurate results (see Appendix A - Correlation of Nuclear Gauge with Roadway Cores).

III. **APPARATUS.** The apparatus shall consist of the following:

A. **Nuclear Device,** an electronic counting instrument, capable of being seated on the surface of the material under test, and which contains:

1. <u>Gamma Source</u>, a sealed high energy gamma source such as cesium or radium.

2. <u>Gamma Detector</u>, any type of gamma detector such as Geiger-Mueller tubes.

B. **Reference Standard,** a block of dense material used for checking instrument operation and to establish conditions for a reproducible reference-count rate.

C. **Site Preparation Device,** a metal plate, straightedge, or other suitable leveling tool which may be used to level the test site to the required smoothness using fine sand, fly ash, cement, or similar material.

NOTE: This equipment utilizes radioactive materials which may be hazardous to the health of the users unless proper precautions are taken. Users of this equipment must become familiar with applicable safety procedures and government regulations.

IV. **CALIBRATION.** Calibrate the instrument in accordance with the manufacturer's recommendations at least once each year or at intervals recommended by the manufacturer. ASTM D2950-91, Appendix A1 provides additional information on calibration.

V. **STANDARDIZATION AND REFERENCE CHECK.** Nuclear test devices are subject to long-term aging of the radioactive source, detectors, and electronic systems, which may change the relationship between count rate and material density. To offset this aging, the apparatus may be standardized as the ratio of the measured count rate to a count rate made on a reference standard. The reference count rate should be of the same order of magnitude as the measured count rate over the useful density range of the apparatus.

A. Standardization of equipment should be performed at the start of each day's work, and a permanent record of this data retained.

B. Perform the standardization with the apparatus located at least 25 ft (8 m) away, or other distance as recommended by the manufacturer from other sources of radioactivity and clear of large masses or other items which may affect the reference count rate.

C. Turn on the apparatus prior to standardization and allow it to stabilize. Follow the manufacturer's recommendations in order to provide the most stable and consistent results.

D. Using the reference standard, take the standard count in accordance with the manufacturer's recommendation.

E. If the value obtained is within the limits specified by the manufacturer, the apparatus is considered to be in satisfactory operating condition. If the value is outside these limits, allow additional time for the apparatus to stabilize, make sure the area is clear of sources of interference and then conduct another standardization check. If the second standardization check is within the limits, the apparatus may be used, but if it fails, the apparatus shall be adjusted or repaired as recommended by the manufacturer. ASTM D2950-91, Section 8 provides additional information on standardization.

NOTE: For some gauges, the adjustment may be to take a series of 5 to 6 standard counts, storing each count in memory, to establish a new standard count average in the gauge. If after the additional 6 standard counts, the value obtained is not within the limits specified by the manufacturer, the apparatus shall be repaired as recommended by the manufacturer.

VI. **PROCEDURE.** In order to provide stable and consistent results: 1) Turn the instrument on prior to use to allow it to stabilize, and 2) Leave the power on during the day's testing.

A. Standardize the apparatus.

B. Select a test location. Set instrument for minimum 2 minute count. Set depth to measure.

C. Maximum contact between the base of the instrument and the surface of the material under test is critical. The maximum void shall not exceed 6 mm. Use native fines, fine sand, cement, or fly ash to fill the voids and level with the guide/scraper plate.

D. Four (4) counts shall be taken at each location. Record the unit weight for each count.

NOTE: Do not leave the gauge on a hot surface for an extended period of time. Prolonged high temperatures may adversely affect the instrument's electronics. The gauge should be allowed to cool between measurements.

VII. **CALCULATION OF RESULTS.** Determine the bulk specific gravity as follows:

A. Determine the average unit weight for the test location.

B. Calculate the nuclear bulk specific gravity of the bituminous concrete as follows (round and report the value to the nearest 0.001):

$$NBSG = \frac{Unit\ Weight}{62.4}$$

Where:
NBSG = Nuclear Bulk Specific Gravity
Unit Weight is in lb/ft^3

or

$$NBSG = \frac{Unit\ Weight}{1000}$$

Where:
NBSG = Nuclear Bulk Specific Gravity
Unit Weight is in kg/m^3

C. Using the Correlation Graph or Correlation Equation developed for this mixture, convert the Nuclear Bulk Specific Gravity to Bulk Specific Gravity (see Appendix A - Correlation of Nuclear Gauge with Roadway Cores). Report the Bulk Specific Gravity to the nearest 0.001.

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ALTERNATE METHOD B

I. **SCOPE.** This test method covers the test procedure for determining the unit weight of bituminous concrete pavement by measuring the impedance or dielectric properties of the pavement using an electromagnetic sensing device. As the pavement is compacted, the air voids decrease and the dielectric properties change. The unit weight is determined by comparing the detected impedance or dielectric properties with previously established dielectric constants of the pavement components. The bulk specific gravity of the compacted bituminous mixture can be calculated using the unit weight of the mixture.

II. **SIGNIFICANCE AND USE.** The test method described is useful as a rapid, nondestructive technique for determining the relative in-place unit weight of compacted bituminous mixtures. This test method may be used to establish the proper rolling effort and pattern to achieve the required density. With proper calibration and correlation testing, this test method is suitable for quality control and acceptance testing of compacted bituminous concrete.

A. The results obtained by this test method are relative. This test method may be used for quality control and acceptance testing if correlation testing with roadway cores is performed. It is recommended that at least ten (10) roadway core results be compared with their corresponding electromagnetic gauge results to establish the correlation. A new correlation must be established for each paving mixture, each lift, each major change in job location, and each time a significant change is made in the paving mixture or in the construction process. This correlation is necessary to achieve accurate results (see Appendix B- Correlation of Electromagnetic Gauge with Roadway Cores).

III. **APPARATUS.** The apparatus shall consist of the following:

A. **Electromagnetic Device,** an electromagnetic instrument, capable of being seated on the surface of the material under test.

NOTE: Because this equipment has no nuclear source, it does not require a daily “standardization check”. However, some electromagnetic gauges come with a reference block. This allows the user to check the accuracy of gauge measurements whenever desired. If the reference check fails, contact the manufacturer’s technical support.

NOTE: This equipment does not utilize material which may be hazardous to the health of the users. Users of this equipment are not required to be certified or monitored by any regulatory agency.

IV. **CALIBRATION.** Calibrate the instrument at intervals recommended by the manufacturer.

V. **PROCEDURE.**

A. The gauge will have some general settings to input, such as maximum theoretical density. There will also be inputs that are manufacturer-specific. Input these values as indicated in the manufacturer’s instruction manual. There are also calibration techniques for the gauge outlined by the manufacturers, the purpose of which is to make the gauge show the proper density at the time of testing. These may be followed before the correlation is established, but it is not a requirement. The official correlation routine will be outlined in Appendix B. Once the correlation is established, do not change any of the settings on the gauge unless a new correlation is established.

B. Select a test location. Set instrument for single reading mode. If the gauge does not have a single reading mode, use averaging mode set to 1 test average.

C. Maximum contact between the base of the instrument and the surface of the material under test is critical. If the gauge can be rocked, select another location which will provide a stable base for the gauge. **DO NOT** use any type of fines to fill the voids and level the gauge.

D. Five (5) counts shall be taken at each location. Record the unit weight for each count. Clean the gauge foot after each use. Any material buildup will adversely affect the gauge readings.

NOTE: Do not leave the gauge on a hot surface for an extended period of time. Prolonged high temperatures may adversely affect the instrument's electronics.

NOTE: Do not use the gauge when a high level of moisture is present, for example any degree of ponding. Roadway moisture has a very high dielectric constant and will make the density readings read falsely high. Similarly, do not operate the gauge immediately after removing from an air-conditioned vehicle on a hot day because some internal condensation may occur.

NOTE: Be sure to remove your hand from the gauge during the reading. Your body will be grounded and affect the gauge reading to show falsely low readings.

VI. **CALCULATION OF RESULTS.** Determine the bulk specific gravity as follows:

A. Determine the average unit weight for the test location.

B. Calculate the electromagnetic bulk specific gravity of the bituminous concrete as follows (round and report the value to the nearest 0.001):

$$EBSG = \frac{Unit\ Weight}{62.4}$$

Where:
EBSG = Electromagnetic Bulk Specific Gravity
Unit Weight is in lb/ft^3

or

$$EBSG = \frac{Unit\ Weight}{1000}$$

Where:
EBSG = Electromagnetic Bulk Specific Gravity
Unit Weight is in kg/m^3

C. Using the Correlation Graph or Correlation Equation developed for this mixture, convert the Electromagnetic Bulk Specific Gravity to Bulk Specific Gravity (see

Appendix B - Correlation with Roadway Cores). Report the Bulk Specific Gravity to the nearest 0.001.

APPENDIX A
CORRELATION OF NUCLEAR GAUGE WITH ROADWAY CORES

1. On the compaction test strip or on a "Lot" of asphalt concrete, identify at least ten (10) test locations using random methods.

2. At each location, determine the unit weight and nuclear bulk specific gravity in accordance with the alternate method of this procedure. The gauge positions shall be as shown in Figure 1.

3. After nuclear testing, cut a roadway core at each location as shown in Figure 1 and determine the core bulk specific gravity in accordance with this method.

4. Tabulate the data as shown in Table 1.

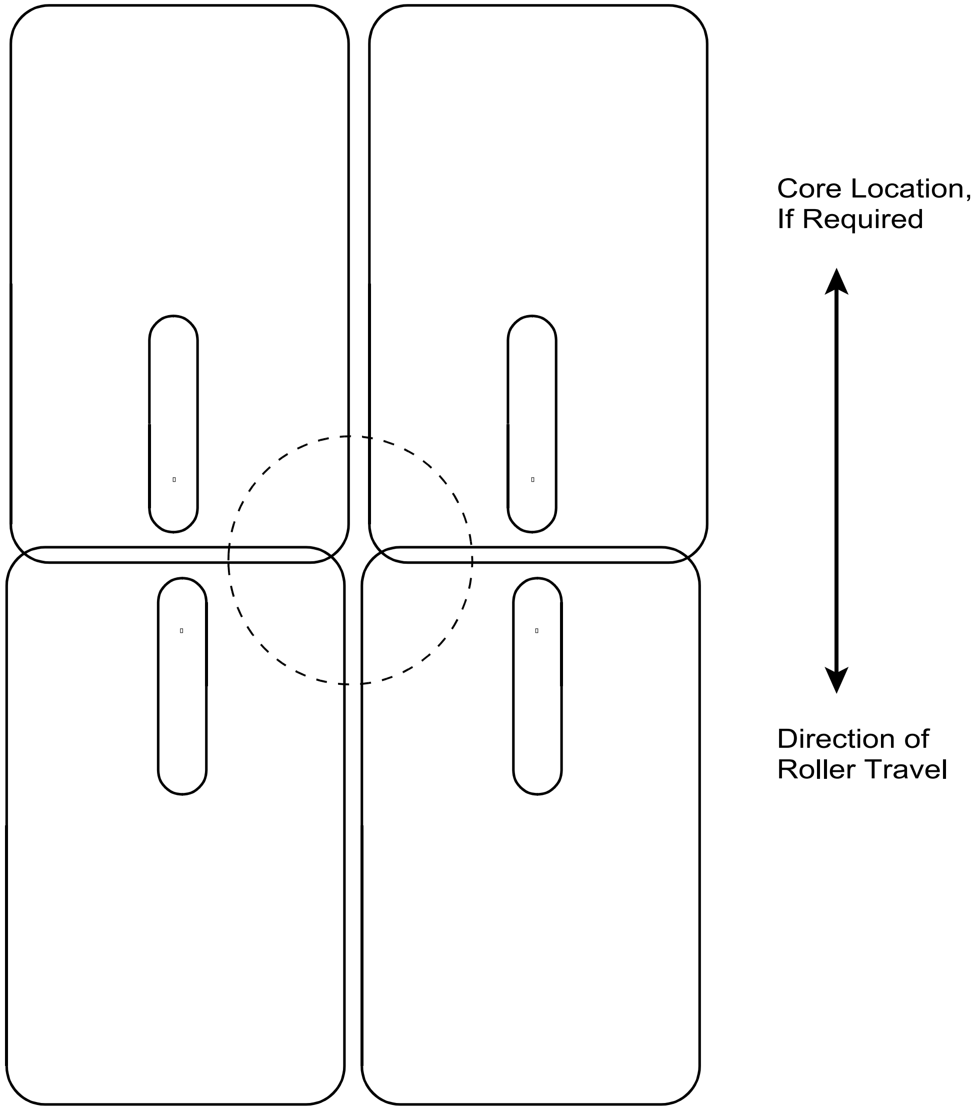
5. Graph the data as shown in Figure 2, plotting the nuclear bulk specific gravity on the horizontal axis and the core bulk specific gravity on the vertical axis.

6. Calculate the equation of the line of best fit as shown in the Example. Compute three (3) points on the line as shown and plot the points on the graph, drawing a line through the points as shown in Figure 3. Various computer applications are available that are suitable for analyzing and graphing this data.

7. For daily acceptance tests, use the Correlation Equation or Correlation Graph to determine the Bulk Specific Gravity from the Nuclear Bulk Specific Gravity.

8. A new correlation is required for each paving mixture, each lift, each major change in job location, and each time a change is made in the paving mixture or in the construction process.

FIGURE 1
GAUGE POSITIONS



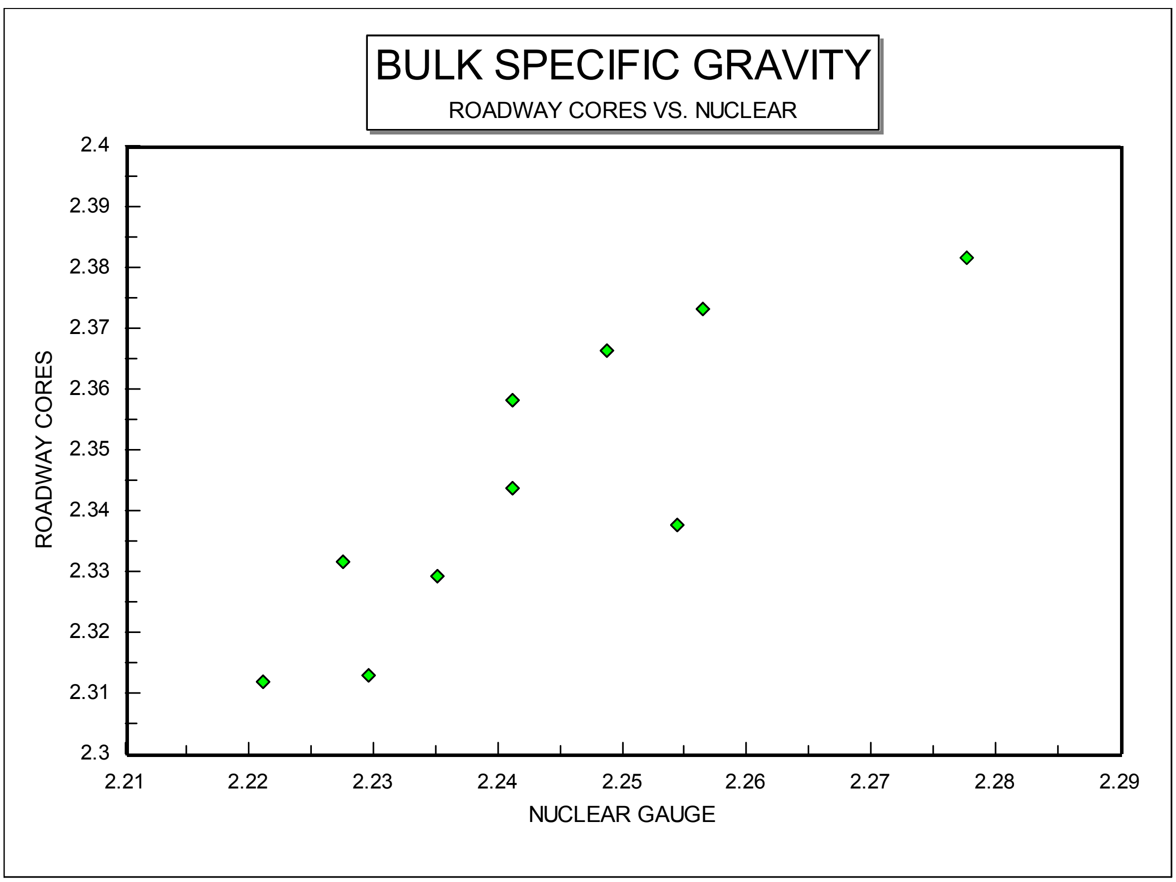
Shown are the required gauge positions for density testing. Note the direction of roller travel. Core required for correlation purposes only, not required for routine acceptance testing.

NOTE: This Document has been Replaced

TABLE 1: NUCLEAR DENSITY GAUGE SAMPLE DATA

Location Test Number	Nuclear Gauge Readings Unit Weight				Unit Weight Average	Nuclear Bulk Specific Gravity	Core Bulk Specific Gravity
	TEST 1	TEST 2	TEST 3	TEST 4			
1	141.8	142.6	142.3	142.1	142.2	2.279	2.382
2	141.8	136.3	140.0	141.6	139.9	2.242	2.344
3	139.2	139.0	141.6	141.8	140.4	2.250	2.366
4	138.5	141.8	139.6	139.8	139.9	2.242	2.358
5	138.8	139.8	140.8	138.8	139.6	2.236	2.329
6	141.5	139.6	140.3	141.6	140.8	2.256	2.338
7	142.1	141.8	141.1	138.3	140.8	2.256	2.373
8	136.3	140.8	140.1	139.6	139.2	2.231	2.313
9	140.3	136.5	138.5	139.5	138.7	2.223	2.312
10	138.8	136.6	139.8	141.1	139.1	2.229	2.332

FIGURE 2: BULK SPECIFIC GRAVITY - CORES VS. NUCLEAR



EXAMPLE

1. The equation of the line of best fit uses the following formula:

$$y = (m * x) + b$$

Where:

y = Core Bulk Specific Gravity = CBSG
x = Nuclear Bulk Specific Gravity = NBSG
m = Slope of Line
b = Constant

Substituting terms, CBSG = (m * NBSG) + b

2. Tabulate the data as shown below:

a) Column 1 contains the test number.
b) Column 2 contains the Nuclear Bulk Specific Gravity (NBSG).
c) Column 3 contains the corresponding Core Bulk Specific Gravity (CBSG).
d) Multiply column 2 by column 3 and place the result in column 4.
e) Square column 2 and place the result in column 5.
f) Add the entries in column 2 and call the sum A.
g) Add the entries in column 3 and call the sum B.
h) Add the entries in column 4 and call the sum C.
i) Add the entries in column 5 and call the sum D.

COLUMN 1	COLUMN 2	COLUMN 3	COLUMN 4	COLUMN 5
1	2.279	2.382	5.428578	5.193841
2	2.242	2.344	5.255248	5.026564
3	2.250	2.366	5.323500	5.062500
4	2.242	2.358	5.286636	5.026564
5	2.236	2.329	5.207644	4.999696
6	2.256	2.338	5.274528	5.089536
7	2.256	2.373	5.353488	5.089536
8	2.231	2.313	5.160303	4.977361
9	2.223	2.312	5.139576	4.941729
10	2.229	2.332	5.198028	4.968441
	A=22.444	B=23.447	C=52.627529	D=50.375768

3. Compute the average values for column 2 and column 3 as follows:

$$X = \frac{A}{n} \qquad Y = \frac{B}{n}$$

Where:

X = Average value for column 2.
Y = Average value for column 3.
n = Number of test locations.
A and B as previously defined.

$$X = \frac{22.444}{10} = 2.2444$$

$$Y = \frac{23.447}{10} = 2.3447$$

4. Compute the slope of the line as follows:

$$m = \frac{(n * C) - (A * B)}{(n * D) - (A * A)}$$

Where:

m = Slope of line
A, B, C, D, and n as previously defined.

$$m = \frac{(10 * 52.627529) - (22.444 * 23.447)}{(10 * 50.375768) - (22.444 * 22.444)}$$

$$m = \frac{526.27529 - 526.24447}{503.75768 - 503.73314}$$

$$m = \frac{0.03082}{0.02454}$$

$$m = 1.256$$

NOTE: m should always be a positive number.

5. Compute the constant as follows:

$$b = Y - (m * X)$$

Where:

b = constant
m, X, and Y as previously defined.

$$b = 2.3447 = (1.256 * 2.2444)$$

$$b = 2.3447 - 2.8190$$

$$b = -0.474$$

6. Using the equation in Step 1 and substituting the calculated values gives the following:

CBSG = (m * NBSG) + b

CBSG = (1.256 * NBSG) - 0.474

7. Calculate 3 points on the line of best fit by selecting 3 values of Nuclear Bulk Specific Gravity that fall within the range of values in Figure 2. Select one value on the low end of the range, one in the middle of the range, and one from the upper end of the range.

First Point:
Select NBSG = 2.220
CBSG = (1.256 * NBSG) - 0.474
CBSG = (1.256 * 2.220) - 0.474
CBSG = 2.788 - 0.474
CBSG = 2.314

Second Point:
Select NBSG = 2.250
CBSG = (1.256 * 2.250) - 0.474
CBSG = 2.826 - 0.474
CBSG = 2.352

Third Point:
Select NBSG = 2.280
CBSG = (1.256 * 2.280) - 0.474
CBSG = 2.864 - 0.474
CBSG = 2.390

8. Plot these three points on the graph, drawing a straight line through the points as shown in Figure 3. Review the graph to determine if the computed line appears to represent a linear interpolation of the data. If the line does not appear to represent the data, recheck your calculations in Steps 2 through 7. If the line still does not appear to represent the data, discard this data and perform a new correlation starting over at Step 1 of the Appendix or do not use the nuclear gauge for quality control or acceptance testing for this mixture.

9. If the line does appear to represent the data, then the equation determined in Step 6 is the Correlation Equation and may be used to convert Nuclear Bulk Specific Gravity results to Bulk Specific Gravity for daily acceptance tests. The graph shown in Figure 3 is the Correlation Graph and may also be used to convert Nuclear Bulk Specific Gravity results to Bulk Specific Gravity for daily acceptance tests.

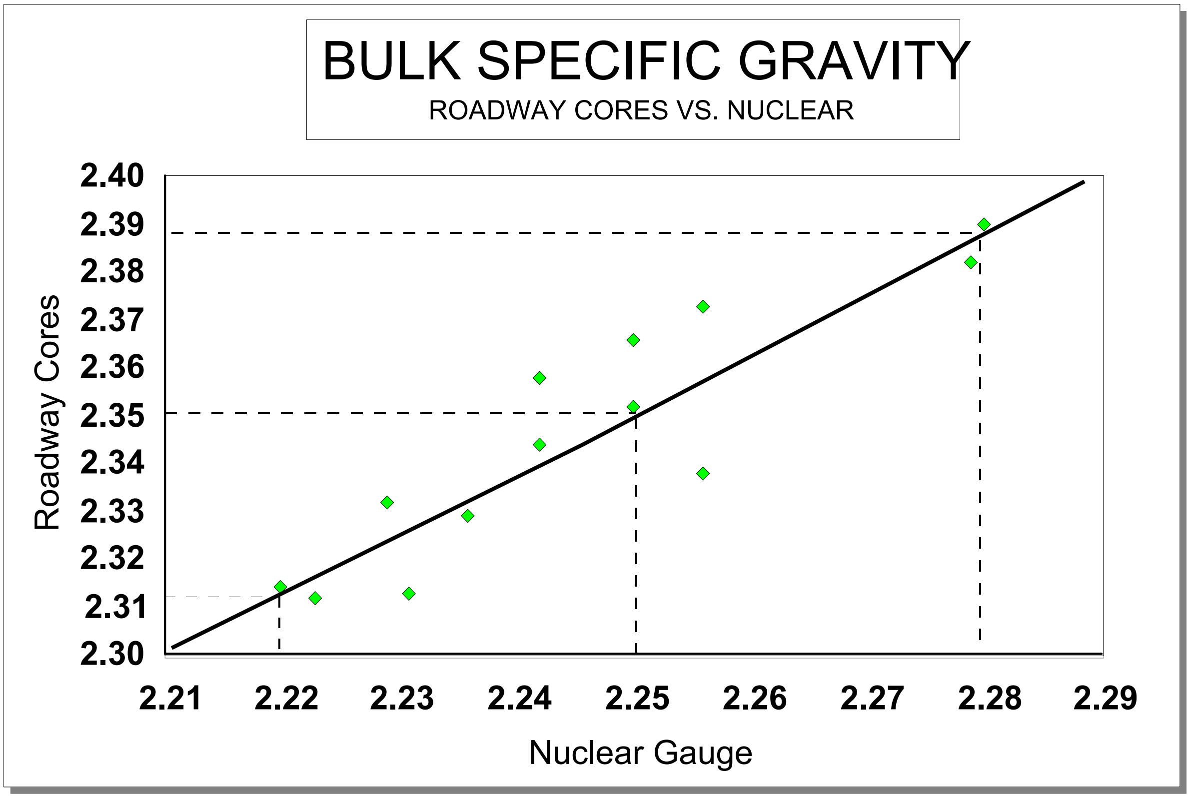


FIGURE 3: BULK SPECIFIC GRAVITY - CORES VS. NUCLEAR

APPENDIX B
CORRELATION OF ELECTROMAGNETIC GAUGE WITH ROADWAY CORES

1. On the compaction test strip or on a "Lot" of asphalt concrete, identify at least ten (10) test locations using random methods.

2. At each location, determine the unit weight and electromagnetic bulk specific gravity in accordance with the alternate method of this procedure. The gauge positions shall be as shown in Figure 4.

3. After electromagnetic testing, cut a roadway core at each location as shown in Figure 4 and determine the core bulk specific gravity in accordance with this method.

4. Tabulate the data as shown in Table 2.

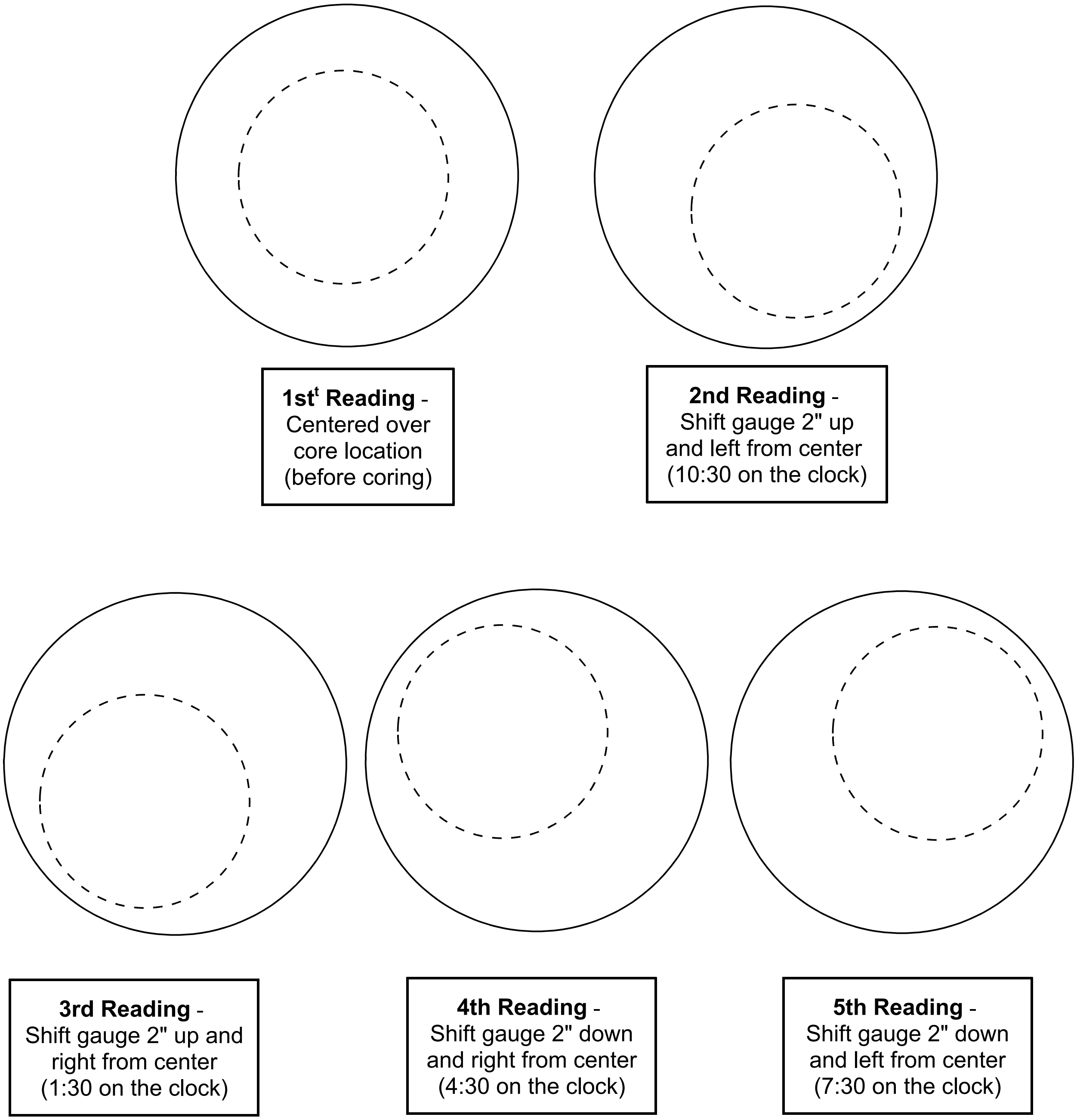
5. Graph the data as shown in Figure 5, plotting the electromagnetic bulk specific gravity on the horizontal axis and the core bulk specific gravity on the vertical axis.

6. Calculate the equation of the line of best fit as shown in the Example. Compute three (3) points on the line as shown and plot the points on the graph, drawing a line through the points as shown in Figure 6. Various computer applications are available that are suitable for analyzing and graphing this data.

7. For daily acceptance tests, use the Correlation Equation or Correlation Graph to determine the Bulk Specific Gravity from the Electromagnetic Bulk Specific Gravity.

8. A new correlation is required for each paving mixture, each lift, each major change in job location, and each time a change is made in the paving mixture or in the construction process.

FIGURE 4
GAUGE POSITIONS

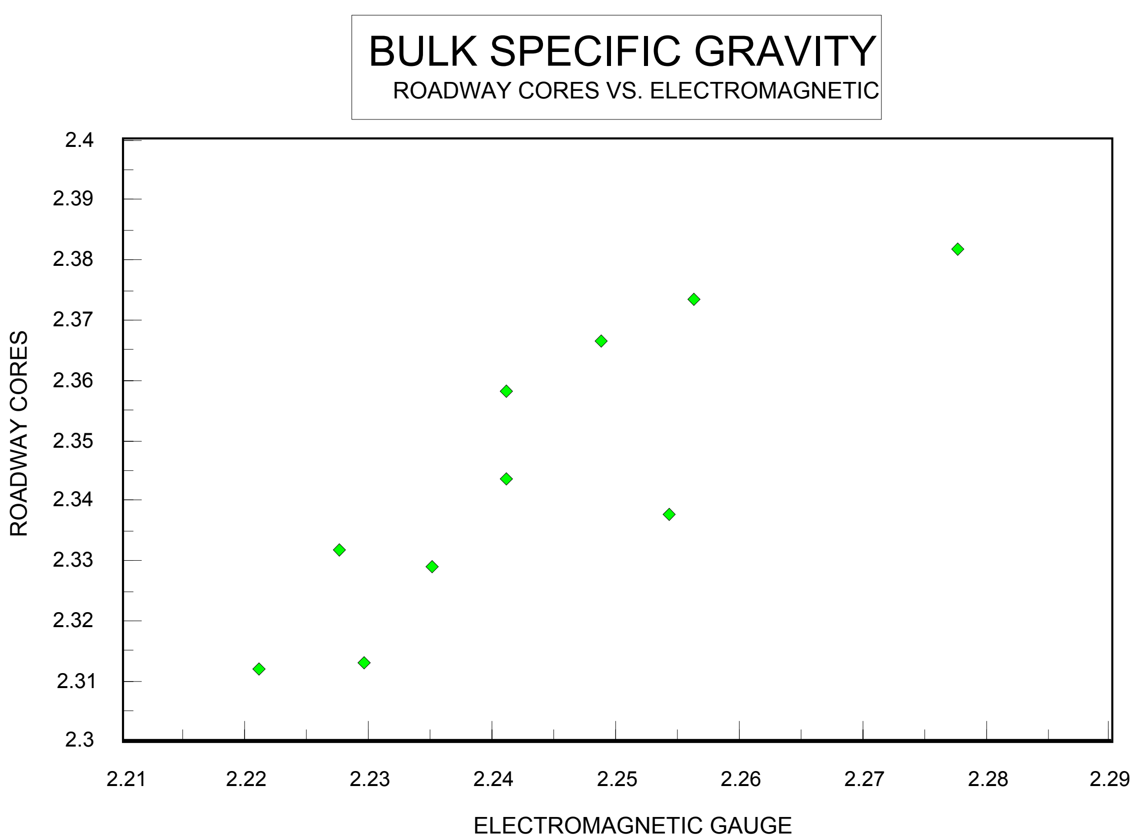


Shown are the required gauge positions for density testing. Core required for correlation purposes only, not required for routine acceptance testing.

TABLE 2: ELECTROMAGNETIC DENSITY GAUGE SAMPLE DATA

Location Test Number	Electromagnetic Gauge Readings Unit Weight					Unit Weight Average	Electro-magnetic Bulk Specific Gravity	Core Bulk Specific Gravity
	TEST 1	TEST 2	TEST 3	TEST 4	TEST 5			
1	141.8	142.6	142.2	142.1	142.3	142.2	2.279	2.382
2	141.8	136.3	139.8	141.6	140.0	139.9	2.242	2.344
3	139.2	139.0	140.4	141.8	141.6	140.4	2.250	2.366
4	138.5	141.8	139.8	139.8	139.6	139.9	2.242	2.358
5	138.8	139.9	139.7	138.8	140.8	139.6	2.236	2.329
6	141.5	139.6	141.0	141.6	140.3	140.8	2.256	2.338
7	142.1	141.8	140.7	138.3	141.1	140.8	2.256	2.373
8	136.3	140.8	139.2	139.6	140.1	139.2	2.231	2.313
9	140.3	136.5	138.7	139.5	138.5	138.7	2.223	2.312
10	138.8	136.6	139.2	141.1	139.8	139.1	2.229	2.332

FIGURE 5: BULK SPECIFIC GRAVITY - CORES VS. ELECTROMAGNETIC



EXAMPLE

1. The equation of the line of best fit uses the following formula:

$$y = (m * x) + b$$

Where:

y	=	Core Bulk Specific Gravity = CBSG
x	=	Electromagnetic Bulk Specific Gravity = EBSG
m	=	Slope of Line
b	=	Constant

Substituting terms, CBSG = (m * EBSG) + b

2. Tabulate the data as shown below:

a) Column 1 contains the test number.
b) Column 2 contains the Electromagnetic Bulk Specific Gravity (EBSG).
c) Column 3 contains the corresponding Core Bulk Specific Gravity (CBSG).
d) Multiply column 2 by column 3 and place the result in column 4.
e) Square column 2 and place the result in column 5.
f) Add the entries in column 2 and call the sum A.
g) Add the entries in column 3 and call the sum B.
h) Add the entries in column 4 and call the sum C.
i) Add the entries in column 5 and call the sum D.

COLUMN 1	**COLUMN 2**	**COLUMN 3**	**COLUMN 4**	**COLUMN 5**
1	2.279	2.382	5.428578	5.193841
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4	2.242	2.358	5.286636	5.026564
5	2.236	2.329	5.207644	4.999696
6	2.256	2.338	5.274528	5.089536
7	2.256	2.373	5.353488	5.089536
8	2.231	2.313	5.160303	4.977361
9	2.223	2.312	5.139576	4.941729
10	2.229	2.332	5.198028	4.968441
	A=22.444	B=23.447	C=52.627529	D=50.375768

3. Compute the average values for column 2 and column 3 as follows:

$$X = \frac{A}{n} \qquad Y = \frac{B}{n}$$

Where:

X = Average value for column 2.
Y = Average value for column 3.
n = Number of test locations.
A and B as previously defined.

$$X = \frac{22.444}{10} = 2.2444$$

$$Y = \frac{23.447}{10} = 2.3447$$

4. Compute the slope of the line as follows:

$$m = \frac{(n * C) - (A * B)}{(n * D) - (A * A)}$$

Where:

m = Slope of line
A, B, C, D, and n as previously defined.

$$m = \frac{(10 * 52.627529) - (22.444 * 23.447)}{(10 * 50.375768) - (22.444 * 22.444)}$$

$$m = \frac{526.27529 - 526.24447}{503.75768 - 503.73314}$$

$$m = \frac{0.03082}{0.02454}$$

$$m = 1.256$$

NOTE: m should always be a positive number.

5. Compute the constant as follows:

$$b = Y - (m * X)$$

Where:

b = constant
m, X, and Y as previously defined.

$$b = 2.3447 = (1.256 * 2.2444)$$

$$b = 2.3447 - 2.8190$$

$$b = -0.474$$

6. Using the equation in Step 1 and substituting the calculated values gives the following:

CBSG = (m * EBSG) + b

CBSG = (1.256 * EBSG) - 0.474

7. Calculate 3 points on the line of best fit by selecting 3 values of Electromagnetic Bulk Specific Gravity that fall within the range of values in Figure 2. Select one value on the low end of the range, one in the middle of the range, and one from the upper end of the range.

   First Point:
   Select EBSG = 2.220
   CBSG = (1.256 * EBSG) - 0.474
   CBSG = (1.256 * 2.220) - 0.474
   CBSG = 2.788 - 0.474
   CBSG = 2.314

   Second Point:
   Select EBSG = 2.250
   CBSG = (1.256 * 2.250) - 0.474
   CBSG = 2.826 - 0.474
   CBSG = 2.352

   Third Point:
   Select EBSG = 2.280
   CBSG = (1.256 * 2.280) - 0.474
   CBSG = 2.864 - 0.474
   CBSG = 2.390

8. Plot these three points on the graph, drawing a straight line through the points as shown in Figure 3. Review the graph to determine if the computed line appears to represent a linear interpolation of the data. If the line does not appear to represent the data, recheck your calculations in Steps 2 through 7. If the line still does not appear to represent the data, discard this data and perform a new correlation starting over at Step 1 of the Appendix or do not use the electromagnetic gauge for quality control or acceptance testing for this mixture.

9. If the line does appear to represent the data, then the equation determined in Step 6 is the Correlation Equation and may be used to convert Electromagnetic Bulk Specific Gravity results to Bulk Specific Gravity for daily acceptance tests. The graph shown in Figure 3 is the Correlation Graph and may also be used to convert Electromagnetic Bulk Specific Gravity results to Bulk Specific Gravity for daily acceptance tests.

NOTE: This Document has been Replaced

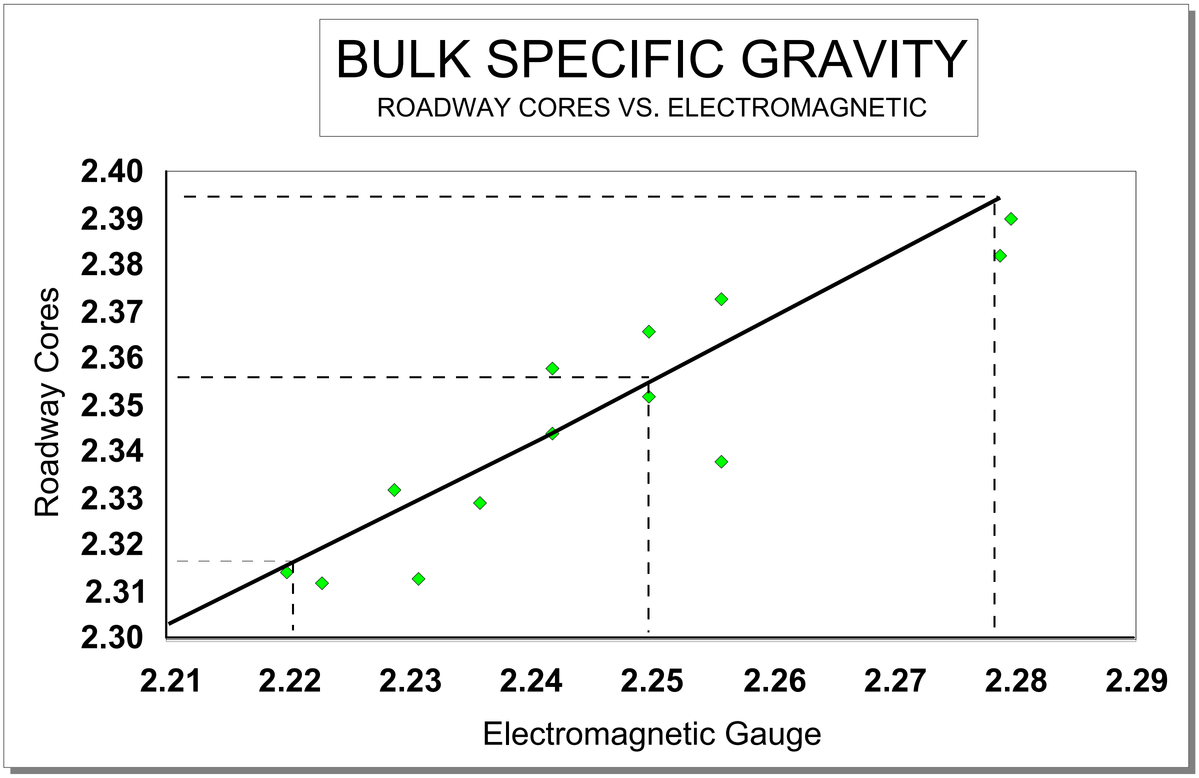

FIGURE 6: BULK SPECIFIC GRAVITY - CORES VS. ELECTROMAGNETIC

Revision Date	Revision Description
4/1/04	Formatted measurements, where applicable, as English unit (metric unit)
	Changed water bath temperature tolerance from 77˚ ± 2˚F (25˚ ± 1˚C) to match AASHTO T 166 tolerance of 77˚ ± 1.8˚F (25˚ ± 1˚C)
	Changed oven low allowable temperature range from 140˚ ± 9˚F (60˚ ± 5˚C) to match AASHTO T 166 temperature of 125˚ ± 5˚F (52˚ ± 3˚C)
	Changed immersion time in Sections IV A. and B. from "until the weight stabilizes and no air bubbles are escaping from the specimen" to "4 ± 1 minutes"
	Added after Section IV., A. "**NOTE:** Constant weight shall be defined as the mass at which further drying does not alter the mass by more than 0.05 percent over two-hour drying intervals."
	Deleted after Section IV., B., 2. "**NOTE:** The immersion tim e for the specimen shall not exceed 5 minutes"
	Changed in Section V. "B.S.G" to "G_{mb}"
	Deleted section V., B., the requirement to calculate the unit weight Renamed Section V., C., to V., B.
	Added to **NOTE** after section V., B., allowing OHD L-45, CoreLok[TM], as an alternative to AASHTO T 275 if the specimen absorption exceeds 2%
	Deleted from **NOTE** after section V., B., "If the test results from T 275 compare favorably with the results from L-14, then L-14 may be used to test specimens of that particular asphalt mixture."
	Deleted from Alternate Method, Section I, "(Backscatter Method)"
	Added to Alternate Method, Section V II, B., the calculation for NBSG in English units Deleted from Alternate Method, Section VII, D., the requirement to calculate the unit weight
	Added to Appendix, Step 1, the qualifier "at least" to the 10 test location requirement
	Changed in Appendix, the example from metric units to English units
5/10/05	Changed in Scope, section E. " Alternate Method" to "Alternate Method A"
	Added Section F to Scope for Alternate Method B, electromagnetic gauge.
	Changed section III, Balance to "Weighing Device" and reworded section more closely to the similar section in AASHTO T 166.
	Changed in Section IV., A., 4., "125° ± 5°C" to "125° ± 5°F"
	Changed section titled "ALTERNATE METHOD" to "ALTERNATE METHOD A"
	Changed section titled "APPENDIX" to "APPENDIX A"
	Added section "OHD L-14 ALTERNATE METHOD B" outlining the acceptable usage of the electromagnetic density gauge.
	Added section "APPENDIX B CORRELATION OF ELECTROMAGNETIC GAUGE WITH ROADWAY CORES" outlining the method to correlate electromagnetic gauge readings to roadway cores.