ARIZONA DEPARTMENT OF TRANSPORTATION * MATERIALS GROUP

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CHANGE LETTER

James P. Delton
Assistant State Engineer

MATERIALS TESTING MANUAL	CHANGE LETTER NO. 23
SUBJECT: Table of Contents; Cover Sheet for Series 100; Arizona Test Method 103a; AASHTO T40; Arizona Test Method 105d; Cover Sheet for Series 200; Arizona Test Method 230a; Arizona Test Method 232b; Arizona Test Method 246a; Cover Sheet for Series 400; Arizona Test Method 412b; Cover Sheet for Series 800; Arizona Test Method 832.	EFFECTIVE DATE: November 14, 2008

SUMMARY:

NOTE: Changes issued under this Change Letter are effective for projects with a bid opening date on or after November 14, 2008. Retain items removed from the Materials Testing Manual under this change letter for use as necessary on projects with a bid opening date prior to November 14, 2008.

1. TABLE OF CONTENTS - The Table of Contents has been revised to reflect the changes made in this Change Letter.

2. The following items are revised by this Change Letter.

   Series 100 Cover Sheet, "Sampling".

   Arizona Test Method 105d, “Sampling Soils and Aggregates”.

   Series 200 Cover Sheet, "Soils and Aggregates".

   Arizona Test Method 230a, "Field Density by the Sand Cone Method".

   Arizona Test Method 232b, “Moisture-Density Relationship using typical Moisture – Density Curves (One Point Proctor) Method A”.

Arizona Test Method 246a, "Moisture-Density Relationship using typical Moisture – Density Curves (One Point Proctor) Alternate Method D".

Series 400 Cover Sheet, "Bituminous Mixtures".

Arizona Test Method 412b, "Density of Compacted Bituminous Mixtures – Nuclear Method".

Series 800 Cover Sheet, "Design".

3. The following items are added by this Change Letter.

   Arizona Test Method 103a, "Sampling Bituminous Materials".

   Arizona Test Method 832, "Marshall Mix Design Method for Asphaltic Concrete (Asphalt-Rubber) AR-AC".

4. The following item is deleted by this Change Letter.

   AASHTO T40, "Sampling Bituminous Materials".

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Attachments

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(5 Pages)

MATERIALS TESTING MANUAL

TABLE OF CONTENTS

****** The above Arizona Test Methods, and also commonly used AASHTO procedures in this category, are shown on Series 200 Cover Sheet (November 14, 2008).

SERIES 300 CONCRETE**

****** The above Arizona Test Methods, and also commonly used AASHTO and ASTM procedures in this category are show on Series 300 Cover Sheet (December 15, 2006).

SERIES 400 BITUMINOUS MIXTURES**

****** The above Arizona Test Methods, and also commonly used AASHTO procedures in this category, are show on Series 400 Cover Sheet (November 14, 2008).

SERIES 500 BITUMINOUS MATERIALS**

****** The above Arizona Test Methods, and also commonly used AASHTO and ASTM procedures and specifications are shown on Series 500 Cover Sheet (July 15, 2005).

SERIES 600 CEMENT AND RELATED MATERIALS**

****** Commonly used AASHTO and ASTM procedures in this category are show on Series 600 Cover Sheet (July 15, 2005).

SERIES 700 CHEMICAL AND SPECIALTY**

****** The above Arizona Test Methods, and also commonly used AASHTO and ASTM procedures in this category are show on Series 700 Cover Sheet (December 15, 2006).

SERIES 800 DESIGN**

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SERIES 100

SAMPLING

The following methods shall be performed in accordance with the respective designation:

ARIZONA TEST METHODS:

TITLE	DESIGNATION
Sampling Bituminous Materials…….	ARIZ 103a
Sampling Bituminous Mixtures…….	ARIZ 104c
Sampling Soils and Aggregates……..	ARIZ 105d
Sampling Hydrated Lime and Lime Products…….	ARIZ 108
Sampling Metallic Materials…….	ARIZ 109
Sampling Miscellaneous Materials…….	ARIZ 110

AASHTO TEST METHODS:

TITLE	DESIGNATION
Sampling and Testing Brick ……...	T 32
Sampling and Acceptance of Hydraulic Cement .....…….	T 127
Sampling Fresh Concrete .....…….	T 141
Reducing Samples of Aggregate to Testing Size…….	T 248

NOTE: It shall be assured that the appropriate methods as given in the project requirements are being adhered to.

NOTE: Refer to Series 900, “Materials Quality Assurance Program”, of the Materials Testing Manual for current guidelines on sampling of materials for acceptance, independent assurance, and correlation testing.

SAMPLING SOILS AND AGGREGATES

(An Arizona Method)

SCOPE

1. (a) This method describes the methods which are to be used when sampling soils and aggregates .

(b) Sampling is equally as important as the testing, and the individual doing the sampling shall use every precaution to obtain samples that will be representative of the materials being sampled.

(c) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(d) Table 1 shall be used to determine minimum sample weights based on the size of aggregate. The amount of material required may be greater depending on the tests that are to be performed on the material.

Table 1
Minimum sample sizes

Maximum Nominal Aggregate Size	Sample Mass, kg	lbs
Fine Aggregate		
#8	10	22
#4	10	22
Coarse Aggregate		
3/8”	10	22
1/2”	15	33
3/4”	25	55
1”	50	110
1-1/2”	75	165
2”	100	220
2-1/2”	125	331
3”	150	331

SAMPLING FROM STOCKPILES

2. In sampling materials from stockpiles it is difficult to ensure unbiased samples, due to the segregation which often occurs when the material is stockpiled with coarser particles rolling to the outside base of the pile. If power equipment is available then it would be advantageous to enlist the use of that equipment to develop a separate, small sampling pile composed of materials drawn from various levels and locations in the main stockpile. Once a small sampling pile has been established then a sample shall be taken from that pile by taking several increments and combining.

The stockpile may also be sampled by placing a wood or metal shield upslope from the point of sampling to prevent loose aggregate from sliding down into the sampling area. Remove approximately 3 to 6 inches of material from the sampling area. Utilizing a square point shovel, take a sample near the top, at the middle and near the bottom of the stockpile. The sample taken at each location shall be one shovelful of material. Repeat this operation at the sampling locations as shown in Figure 1, and combine all samples taken from the stockpile.

SAMPLING FROM BINS

3. A sample shall be taken by passing a sampling device through the entire cross-section of the flow of material as it is being discharged (see Figures 2 and 3). Sufficient material shall be allowed to pass at the beginning of discharge to ensure uniformity of material before the sample is taken. Repeat sampling procedure as necessary until the desired amount of material from each bin is obtained. Material from each bin shall be properly identified.

SAMPLING FROM A CONVEYOR BELT

4. Sampling from a conveyor belt may be performed either while the conveyor belt is running (by using a sampling device which diverts or intercepts the flow of material) or by taking a sample while the conveyor belt is stopped. The stopped belt method is also used when approving a sampling device used for sampling while the belt is running.

(a) If the sample is obtained while the conveyor belt is running, samples of the aggregate shall be taken utilizing a sampling device to divert or intercept the entire flow of material in such a manner that all portions of the flow are diverted or intercepted for an equal amount of time.

(b) Samples may be obtained by stopping the conveyor belt and sampling the full width of the belt utilizing a template which is shaped to the same contour of the belt. All material which is within the template area shall be removed, utilizing a brush to obtain all the fine aggregate material.

SAMPLING FROM A WINDROW

5. Figure 4 illustrates the method used to sample a windrow. At each point in the windrow where a sample is to be taken, remove sufficient material from the top of the windrow so that a representative sample can be obtained from the center of the freshly exposed top of the windrow using a square point shovel. The sample taken at each sampling location shall be one shovelful of material. Repeat the sampling as necessary, at the required number of locations in the windrow, to obtain the desired amount of material. The samples taken shall be combined.

SAMPLING FROM THE ROADWAY

6. In the case of sampling material in-place from the roadway, at least 3 samples shall be taken with a shovel at equally distributed locations across the width of the roadway. It may be necessary to use a hammer and chisel or similar tools to cut the hole in the compacted roadway. Care shall be taken to obtain all material from the hole which is dug. The samples taken shall be combined.

REDUCING FIELD SAMPLES TO TESTING SIZE

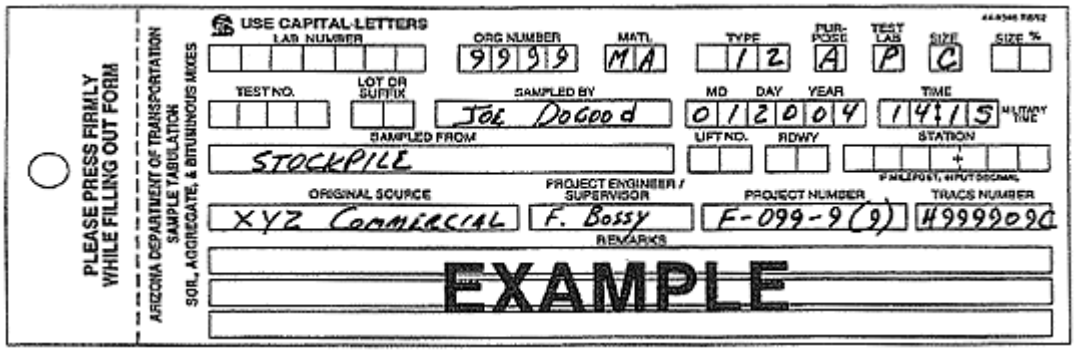
7. The reduction of samples to obtain the amount required for particular tests shall be performed in accordance with AASHTO T 248.

SAMPLE IDENTIFICATION

8. (a) Each sample shall be identified by an accompanying ticket. Sample tickets shall be filled out as required to provide necessary information. The remarks area of the sample ticket should be used as necessary to provide additional information.

(b) The source of the sample shall be the “original source” of the material, as indicated on the sample ticket.

(c) An example of a completed sample ticket used by ADOT for construction projects is given below.



(d) The sample ticket consists of three copies. The center copy in kept by the person submitting the sample, the original copy is included inside the sample container, and the third copy is attached to the sample container. When filling out sample tickets, make certain information as clear and easily read on all three copies.

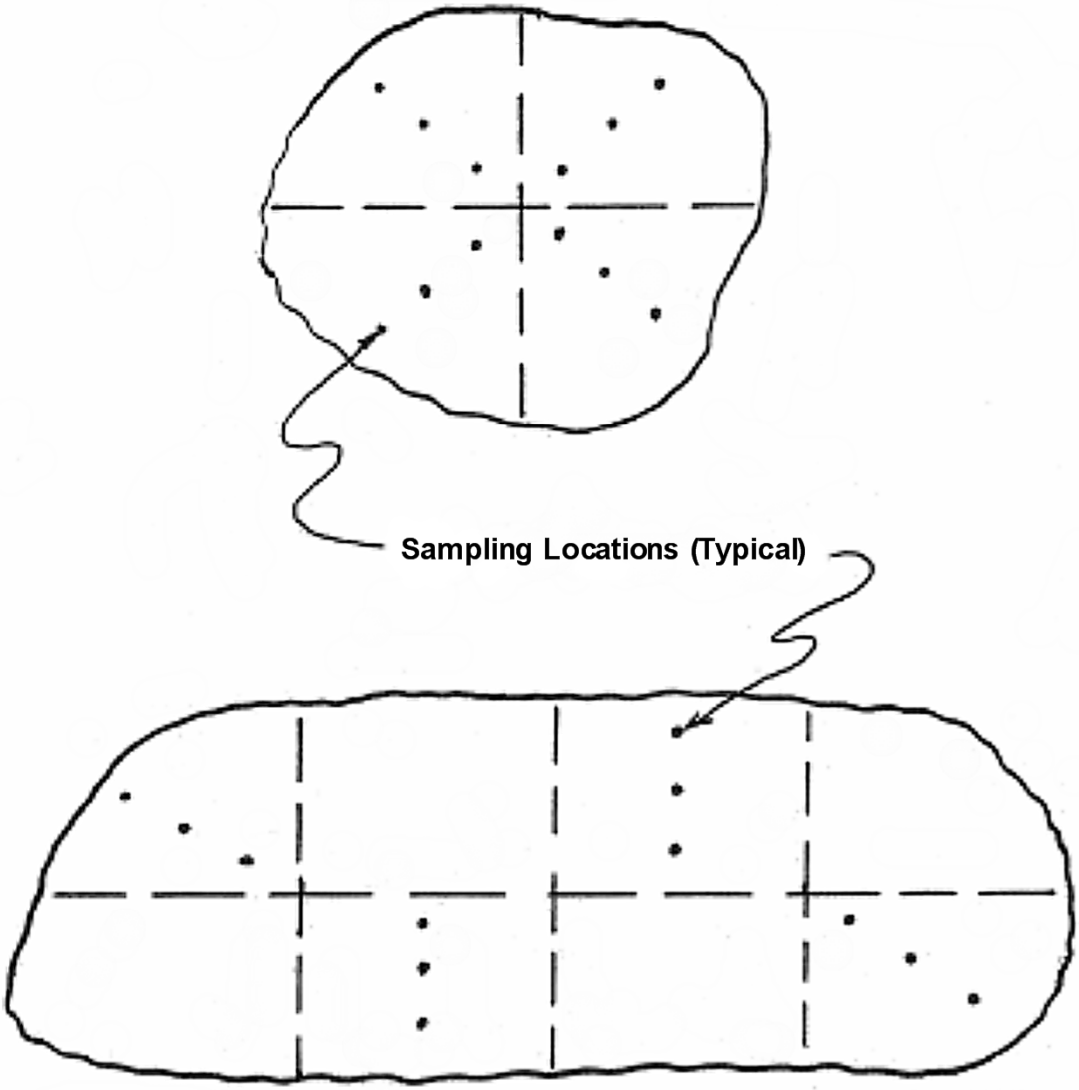
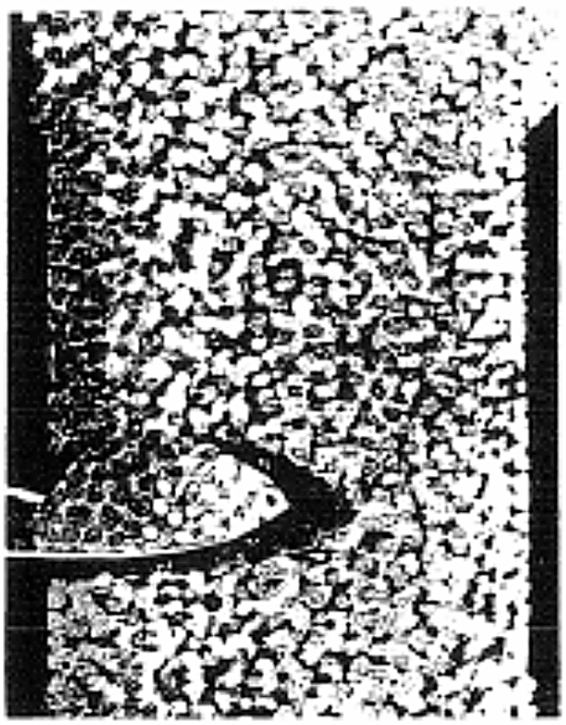


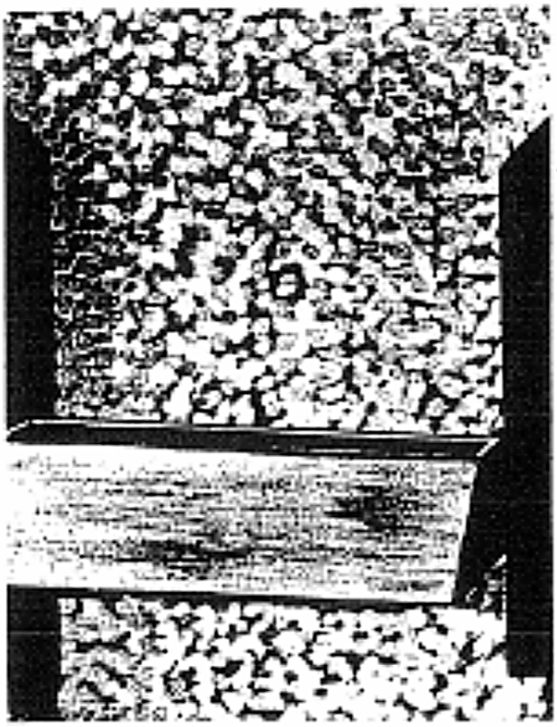
Illustration of Sampling Locations for Different Stockpile Types

FIGURE 1



WRONG

When aggregate is passed over a screen, the fines tend to drop through immediately and accumulate on one side of the hopper. A sample taken with a shovel or other small container will not be representative.

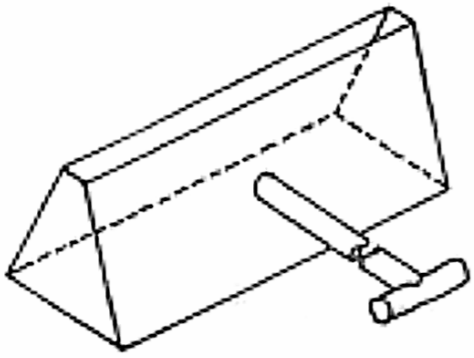


RIGHT

A sample taken by inserting the sampling device through the full flow of material will yield a representative sample. The restricted opening prevents the sampling device from filling all at once.

Illustration of Bin Sampling

FIGURE 2



Typical Bin Sampler

FIGURE 3

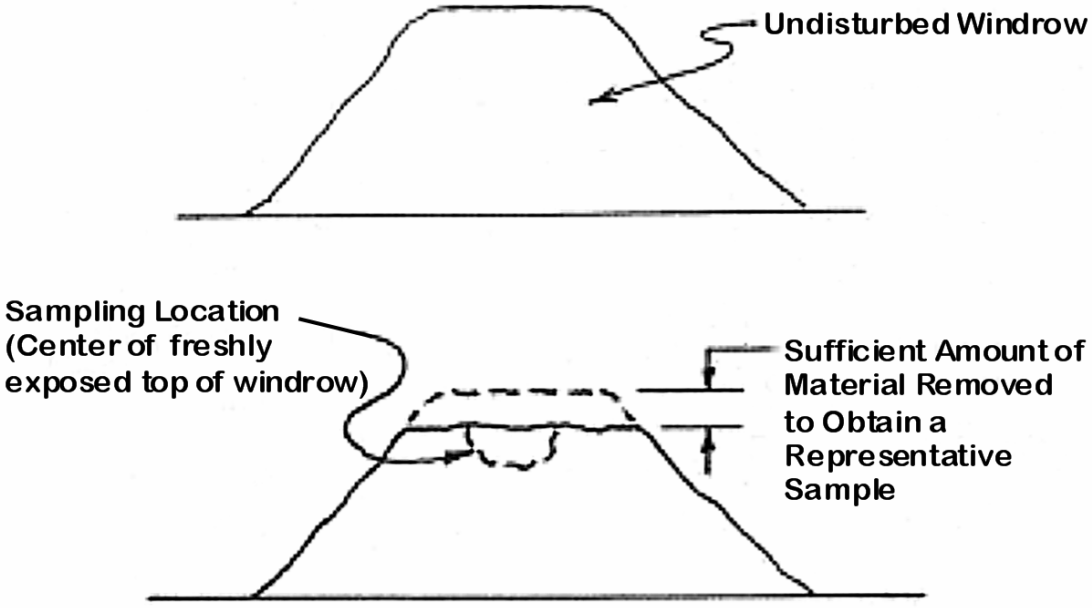


Illustration of Sampling From a Windrow

FIGURE 4

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SERIES 200

SOILS AND AGGREGATES

The following test methods shall be performed in accordance with the respective designation:

ARIZONA TEST METHODS:

TITLE	DESIGNATION
Sieving of Coarse and Fine Graded Soils and Aggregates……..	ARIZ 201c
Composite Grading…….	ARIZ 205c
Specific Gravity and Absorption of Coarse Aggregate…….	ARIZ 210b
Specific Gravity and Absorption of Fine Aggregate……..	ARIZ 211d
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Determination of Cement Content Required for Cement Treated Mixtures…….	ARIZ 220
Moisture-Density Relations of Cement Treated Mixtures…….	ARIZ 221
Rock Correction Procedure for Maximum Density Determination of Cement Treated Mixtures……	ARIZ 222b
Field Density of Cement Treated Mixtures by Sand Cone Method or by Rubber Balloon Method…..	ARIZ 223
Maximum Dry Density and Optimum Moisture of Soils by Proctor Method A…….	ARIZ 225a
Maximum Density and Optimum Moisture of Soils – Methods C and D…….	ARIZ 226
Rock Correction Procedure for Maximum Dry Density and Optimum Moisture Content Determination…….	ARIZ 227c

ARIZONA TEST METHODS: (continued)

TITLE	DESIGNATION
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Field Density by the Sand Cone Method……..	ARIZ 230a
Moisture-Density Relationship Using Typical Moisture-Density Curves (One Point Proctor) Method A……..	ARIZ 232b
Flakiness Index of Coarse Aggregate……...	ARIZ 233c
Density and Moisture Content of Soil and Soil-Aggregate Mixtures by the Nuclear Method……	ARIZ 235
Determining pH and Minimum Resistivity of Soils and Aggregates……...	ARIZ 236b
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Percent Carbonates in Aggregate…….....	ARIZ 238a
Sieve Analysis and Separation of Salvaged AC Pavement Particles for Recycled Asphaltic Concrete……	ARIZ 240a
Compressive Strength of Molded Cement Treated Base or Soil-Cement Specimens……..	ARIZ 241a
Sand Equivalent Test for Mineral Aggregate for Asphaltic Concrete Friction Course…….	ARIZ 242a
Artificial Grading of Mineral Aggregate……..	ARIZ 244
Maximum Dry Density and Optimum Moisture of Soils by Proctor Alternate Method D…….	ARIZ 245
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Particle Shape and Texture of Fine Aggregate Using Uncompacted Void Content……..……...	ARIZ 247

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AASHTO TEST METHODS:

TITLE	DESIGNATION
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Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test	T 87
Determining the Liquid Limit of Soils	T 89
Determining the Plastic Limit and Plasticity Index of Soils	T 90
Resistance to Abrasion of Small Size Coarse Aggregate by use of the Los Angeles Machine …….. .	T 96
Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate	T 104
Wetting-and-Drying Test of Compacted Soil-Cement Mixtures	T 135
Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures	T 136
Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test……..	T 176

AASHTO TEST METHODS: (continued)

TITLE	DESIGNATION
Resistance R-Value and Expansion Pressure of Compacted Soils	T 190
Determination of Moisture in Soils by Means of a Calcium Carbide Gas Pressure Moisture Tester	T 217
Determination of Strength of Soil-Lime Mixtures	T 220
Reducing Field Samples of Aggregates to Testing Size	T 248
Total Moisture Content of Aggregate by Drying	T 255
Laboratory Determination of Moisture Content of Soils	T 265

NOTE: It shall be assured that the appropriate test methods as given in the project requirements are being adhered to.

FIELD DENSITY BY THE SAND CONE METHOD

(A Modification of AASHTO Designation T 191)

SCOPE

1. (a) This method is used to determine the density of compacted soils or aggregates by determining the weight and moisture content material removed from a test hole and measuring the volume of the test hole.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

APPARATUS

2. Apparatus for this test procedure shall consist of the following:

(a) A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.01 lbs or at least the nearest gram.

(a) Miscellaneous digging tools.

(b) Sand cone apparatus consisting of base plate, cone and sand jar.

(c) Standard sand. (Sand shall be kept dry and free flowing).

(d) Containers with air tight covers (cylinder molds are satisfactory).

(e) Oven, hot plate, stove or Speedy Moisture Tester.

NOTE: Calibration of the sand and sand cone apparatus shall be done in accordance with AZ 229.

PREPARATION OF TEST SITE

3. The surface of the area where the test is to be conducted shall be prepared as follows:

(a) Clean away all loose soil and rock from an area of about 3 feet square at the spot where the test is to be made. In areas compacted by 'Sheep's foot' rollers, it is necessary to get below the depth of the 'foot' imprints.

(b) The top of the material at the chosen location shall be prepared to a plane and level surface for an area slightly larger than the size of the base plate. The base plate shall then be placed on this level surface.

PROCEDURE

4. (a) A hole shall be dug approximately the diameter of the hole in the base plate and to the desired depth. (Usually 6 inches to 8 inches). While digging, especially using a hammer and chisel, care must be taken to avoid prying as this may deform the hole, disturb the surrounding material and give a false reading. All of the material removed from the hole shall be carefully recovered and put into a suitable container and covered with a lid or damp cloth, also making sure to get the hole as clean as possible. This operation shall be done as quickly as possible to avoid any excessive drying of the sample.

Suggested test hole volumes and corresponding moisture sample weights are given in Table 1. There will be occasions where the values listed in Table 1 will be difficult to arrive at or follow, such as in the case where we are limited to a shallow depth of compacted material. This table is offered as a guide and should be followed in most cases, however, deviations from theses values are allowable when conditions warrant. The 'Speedy' Moisture Method (AASHTO T-217) may be used to determine the moisture content. The 'Speedy' Method will give the percent moisture on the passing the No. 4 material. If the sample contains material retained on the No. 4 sieve the 'Speedy' results must be adjusted in accordance with the following formula to obtain the percent moisture of the total sample.

$$W = \frac{w(100 - R) + R}{100}$$

Where:

W = % moisture in total sample
w = % moisture in Pass No. 4 material
R = % rock (Plus No. 4 sieve)

An example of this formula is shown under Calculations in this procedure.

Table 1

Maximum Particle Size Retained	Minimum Test Hole Volume cu ft	Minimum Moisture Content Sample grams
No. 4 sieve	0.060	100
½ in.	0.060	250
1 in.	0.075	500
2 in.	0.100	1000
2-1/2 in.	0.135	1500

(b) Weigh the filled sand cone apparatus and place over the base plate with the cone down. A match mark on the cone of the apparatus and the base plate is required to ensure that the apparatus is placed on the base plate the same way every time.

(c) Make sure there is no construction equipment operating in the immediate vicinity as any vibrations will cause a false volume determination.

(d) Open the valve all the way and let the sand flow freely, being careful not to jar the apparatus while the sand is flowing. When the sand ceases to move in the bottle, close the valve and remove the apparatus.

(e) Weigh the sand cone apparatus with the remaining sand to determine the volume of the hole.

REFERENCE TO METHOD 'A' PROCTOR

5. If referencing to Method 'A' Proctor continue as follows:

(a) Weigh the material removed from the test hole.

(b) Screen over a 3" and No. 4 sieve.

(c) With a small brush clean as many fines from the rock as possible.

(d) If any rock is retained on the 3" sieve, verify this with a sieve analysis and call this the end point. This sieve analysis shall be reported with a note stating the density is not determinable due to the rock retained on a 3" sieve.

(e) Weigh and record the weight of the material retained on the No. 4 sieve.

(f) Immediately weigh a moisture sample from the passing No. 4 material to be run either by 'Speedy' or Hot Plate Method.

(g) Determine the percent of rock by the following equation.

$$\% \text{ Rock} = \frac{\text{wt. of +\#4 material}}{\text{total wt. of material removed from hole}} \times 100$$

(h) If the rock content is greater than 50% (or 60% in the case of Aggregate Base) report the sieve analysis with a note stating that the density is not determinable due to excess rock.

Note: When conditions prevent density determination in areas due to the presence of excessive rock or rock retained on the 3" sieve, an attempt shall be made to compact these areas comparable to those surrounding locations where the required compaction was found through testing to be satisfactory.

(i) If less than 50% (or 60% in the case of Aggregate Base) is retained on the No. 4 sieve, proceed with the following calculations.

CALCULATIONS

6. (a) Weight of sand, in lbs., to fill hole and funnel (W_s):

$$W_s = \frac{W_o - W_f}{453.6 \text{ g/lb}}$$

Where:

W_o = original wt. of sand and apparatus, g.
W_f = final wt. of sand and apparatus, g.

Example:

$$W_s = \frac{(8560 \text{ g}) - (4314 \text{ g})}{453.6 \text{ g/lb}}$$

$$= \frac{4246 \text{ g}}{453.6 \text{ g/lb}}$$

$$= 9.36 \text{ lbs}$$

(b) Volume, in cubic feet, of hole (V):

$$V = \frac{W_s}{D_s} - V_c$$

Where:
W_s = wt. of sand to fill hole and funnel, lb.
D_s = density of sand, lb/cu. ft.
V_c = volume of cone and base plate

Example:

$$V = \frac{(9.36 \text{ lbs})}{(96.4 \text{ lb/cu ft})} - (.0407 \text{ cu ft})$$

$$= .0564 \text{ cu ft}$$

(c) Percent moisture of pass No. 4 material may be determined by utilizing the Speedy Test Method, (AASHTO T 217), or by oven-dry Method, (AASHTO T 265).

$$w = \frac{W_w - W_d}{W_d} \times 100$$

Where:

W_w = weight of wet soil, g.
W_d = weight of dry soil, g.
w = % moisture in pass No. 4 material

Example:

$$W = \frac{(322\text{ g}) - (289\text{ g})}{(289\text{ g})} \times 100 = \frac{33\text{ g}}{289\text{ g}}$$

$$= 11.4\ \%$$

(d) Moisture content of the total sample expressed in percentage shall be calculated as follows:

$$W = \frac{w(100 - R) + R}{100}$$

Where:
W = % moisture in total sample
w = % moisture in Pass No. 4 material
R = % rock (Plus No. 4 material)

Example:

w = 11.4 %
R = 29 %

$$W = \frac{11.4\ (100 - 29) + 29}{100} = \frac{838.4}{100} = 8.4\ \%$$

The formula assumes that the rock has a moisture content of 1% and is sufficiently accurate to use in most cases. If the moisture content of the rock is appreciably above 2% as on absorbent materials, the central laboratory should be contacted for instructions.

(e) Wet density, D_w in lb/cu. ft. of material:

$$D_w = \frac{W_t}{V}$$

Where:

W_t = weight of total sample, lb.

Example:

$$D_w = \frac{7.41 \text{ lbs}}{.0564 \text{ cu ft}} = 131.4 \text{ lb/ cu ft}$$

(f) Field dry density, D_d in lb/ cu. ft, of material:

$$D_d = \frac{D_w}{100 + W} \times 100$$

Example:

$$D_d = \frac{131.4 \text{ lb/ cu ft}}{100 + 8.4} \times 100 = 121.2 \text{ lb/ cu ft}$$

(g) $$\% \text{ compaction} = \frac{D_d \times 100}{\text{Maximum Density (Corrected)}}$$

Example:

Maximum Dry Density (pass No. 4 material) = 114.0 lb/ cu ft

Percent rock = 29 %

Corrected Maximum Dry Density = 122.0 lb/ cu ft

Note: Compaction shall be reported to the nearest whole percent

$$\% \text{ compaction} = \frac{121.2 \text{ lb/ cu ft} \times 100}{122.0 \text{ lb/ cu ft}}$$

$$= 99 \%$$

REFERENCE TO ALTERNATE METHOD 'D' PROCTOR

7. If referencing to Alternate Method 'D' Proctor continue as follows:

(a) Weigh the material removed from the test hole.

(b) Screen over a 3" and No. 3/4 sieve.

(c) With a small brush clean as many fines from the rock as possible.

(d) If any rock is retained on the 3" sieve, verify this with a sieve analysis and call this the end point. This sieve analysis shall be reported with a note stating the density is not determinable due to the rock retained on a 3" sieve.

(e) Weigh and record the weight of the material retained on the 3/4" sieve.

(f) Screen the material that passes the 3/4" sieve over the No. 4 sieve. Weigh the material that is retained on the No. 4 sieve and add this weight to the weight of the material retained on the 3/4" sieve.

(g) Immediately weigh a moisture sample from the passing No. 4 material to be run either by 'Speedy' or Hot Plate Method.

(h) Determine the percent of rock by the following equation.

$$\% \text{ Rock} = \frac{\text{wt. of +3/4" material}}{\text{total wt. of material removed from hole}} \times 100$$

(h) If the rock content is greater than 40% report the sieve analysis with a note stating that the density is not determinable due to excess rock.

Note: When conditions prevent density determination in areas due to the presence of excessive rock or rock retained on the 3" sieve, an attempt shall be made to compact these areas comparable to those surrounding locations where the required compaction was found through testing to be satisfactory.

(i) If less than 40% is retained on the 3/4" sieve, proceed with the following calculations.

CALCULATIONS

8. (a) The calculations are the same as those for referencing to a Method 'A' Proctor. Section 6.

ARIZ 232b
November 14, 2008
(10 Pages)

MOISTURE - DENSITY RELATIONSHIP USING TYPICAL MOISTURE - DENSITY CURVES (ONE POINT PROCTOR) METHOD A

(An Arizona Method)

SCOPE

1. (a) This method of test is for the determination of the optimum moisture content and maximum dry density of a soil or soil-aggregate mixture utilizing one moisture-density determination on the portion of the sample passing the No. 4 sieve. Some materials may be more appropriately tested by Arizona Test Method 246, "Moisture-Density Relationship using Typical Moisture-Density Curves (One Point Proctor) Alternate Method D".

(b) The one-point proctor is used with the typical moisture-density curves, shown on the back of the One Point Proctor Density Test Card (Figures 1 and 2); or by utilizing a family of moisture-density curves developed for the immediate local conditions.

(c) This method is not to be used for volcanic cinders or light porous material on which the specific gravity cannot be determined with consistency or when the absorption of the coarse aggregate is greater than 4.0%.

(d) This method may be used to determine if an existing proctor maximum density determination is valid for the soil being tested. If the existing proctor maximum density determination is not valid, a full proctor according to Arizona 225 should normally be run to determine the maximum density required for that soil type.

(e) An example is provided in Section 7, and Figures 3 and 4, for the calculations and determinations referenced herein.

(f) This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

APPARATUS

2. The apparatus shall consist of the following:

(a) The general apparatus utilized for this test method shall conform to the apparatus requirements of Arizona Test Method 225.

(b) In place of the oven listed in the general apparatus, a hot plate or stove capable of maintaining a temperature of approximately 230° F. may be used. A Speedy Moisture Tester with a conversion table or calibration curve may also be used for moisture determinations made in the field. Finally, a microwave oven may be used in accordance with Arizona Test Method 719.

(c) Instead of the scale or balance capable of measuring the weight to be determined to at least one gram, a scale capable of measuring the weight to at least 0.01 pound may be utilized.

CALIBRATION OF MOLD

3. Molds shall be calibrated in accordance with APPENDIX A of ARIZ 225.

SAMPLE

4. A representative sample of passing No. 4 material weighing approximately 2500 grams shall be obtained for each one-point proctor.

PROCEDURE

5. (a) The approximate 2500 gram sample of passing No. 4 material shall be thoroughly mixed with sufficient water to bring the sample to slightly less than its optimum moisture content.

(b) Form a specimen by compacting the prepared soil in the four inch mold (with extension collar attached) in three equal layers to give a total compacted depth of about 5 inches. Compact each layer with 25 uniformly distributed blows from the rammer, dropping free from a height of 12 inches. While each layer is being compacted, the remainder of material shall be in a pan covered by a damp cloth. During compaction, the mold shall rest firmly on a dense, uniform, rigid and stable foundation.

NOTE: Each of the following has been found to be a satisfactory base on which to rest the mold during compaction of the soil: A block of concrete, weighing not less than 200 lbs., supported by a stable foundation; a sound concrete floor; and for field application, such surfaces as found in concrete box culverts, bridges, and pavements.

(c) When compacting granular, free-draining materials, at moisture contents which are at or above optimum, the mold shall be prepared by first sealing the bottom of the mold with waterproofing grease. All excess grease shall be wiped from the mold and base plate.

(d) Following compaction, carefully remove the extension collar. It may be necessary to use a follower to retain the soil in the mold while removing the collar to prevent damage or disturbance of the soil below the top of the mold. Carefully trim the compacted soil even with the top of the mold by means of the straightedge. If any voids are created during trimming, these shall be filled with fine material and smoothed off. Determine the weight of compacted specimen and mold. Determine the wet density, "WD", of the compacted soil by the following:

$$WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb)}^*}$$

Where:
- WD = Wet density of compacted soil, lb./cu. ft.
- Ml = Weight of compacted specimen and mold, grams or lbs.
- M2 = Weight of the mold, grams or lbs.
- VM = Volume of the mold, cu. ft. (See Section 3 of this procedure).

* If the weights of the compacted specimen and mold, Ml, and the empty mold, M2, are measured in pounds, eliminate 453.6 (grams/lb.) from the denominator of the above equation.

(e) Remove the material from the mold and slice vertically through the center. Take a representative minimum 300 gram sample from the full length and width of one of the cut faces. Record the weight of wet soil to the nearest 0.1 gram as "WW". Dry the sample to constant weight at approximately 230° F. and record weight of dry soil to the nearest 0.1 gram as "DW". The percent moisture shall be recorded to the nearest 0.1 percent. The equation below is used when the percent moisture is determined by drying the sample. For testing performed in the field, the Speedy Moisture Tester (AASHTO T 217), may be used. For the Speedy Moisture Tester, a representative

sample of the pass No. 4 material shall be utilized and tested in accordance with the instructional manual for that apparatus.

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100$$

MAXIMUM DENSITY DETERMINATION

6. (a) The point representing the wet density and moisture content (dry basis) is then plotted on the Typical Moisture-Density Curves (Figure 2) and the maximum wet density and optimum moisture content determined. When this plotted point falls between two moisture-density curves, a minor interpolation is necessary. The maximum dry density in lb/cu. ft. and the corresponding percent optimum moisture is then read directly or interpolated from the chart. The family of typical moisture-density curves provided should be periodically verified for the local conditions. If it is ascertained that the family of curves provided by Figure 2 is of questionable reliability for given local conditions, then an independent family of curves should be established and used.

(b) The plotted point for wet density and moisture content should be on the dry side of the curve at or near optimum, as it is difficult to interpolate between curves for friable soils when on the wet side of the peak.

(c) If the plotted point representing the wet density and moisture content of the compacted material is on the right of the peak, the test should be repeated using a lower moisture content. An exception to this rule must be made for those soils having high clay contents and relatively flat curves. These soils cannot readily be dried to optimum in the field due to the creation of a cloddy condition which will cause voids in the proctor. Proctors for these materials should be made as near to optimum as possible.

EXAMPLE

7. An illustration of determining the maximum dry density and optimum moisture content is described below, and shown in Figures 3 and 4:

For:

Wet Density	= 120.0 lb./cu. ft.
Moisture Content	= 20.0%

By plotting this point on the Typical Moisture-Density Curves and interpolating, it shows a point which is approximately 60 percent of the distance from Curve Q to Curve R. From the chart, the dry density for Curve Q is 102.4 @ 20.3% moisture and Curve R is 99.9 @ 21.5% moisture.

By interpolation:

Density: 102.4 - 99.9 = 2.5
.60 X 2.5 = 1 .5 lb./cu. ft. difference

Moisture: 21 .5 - 20.3 = 1 .2
.60 X 1.2 = 0.7% difference

Therefore:

Maximum dry density = 102.4 - 1.5
= 100.9 lb./cu. ft.

Optimum Moisture = 20.3 + 0.7 = 21.0%

* As an alternate to performing the interpolation procedure, Table 1 below can be used to determine the maximum dry density and optimum moisture content when the plotted point falls between two moisture-density curves.

NOTE: The optimum moisture and maximum dry density determinations above are for the material passing the No. 4 sieve. When testing field samples for comparison to proctor optimum moisture and maximum dry density, a correction to the proctor optimum moisture and maximum dry density must be made, in accordance with ARIZ 227, for the percent rock which the field sample contains.

REPORT

8. Record the moisture and density data on the laboratory test form along with the laboratory number, material source and type, and other information required.

A	**141.8**	**6.6**	**F**	**129.3**	**9.7**	**K**	**117.0**	**13.5**	**P**	**104.7**	**19.2**	**U**	**92.1**	**25.8**
10%	141.5	6.7	**10%**	129.0	9.8	**10%**	116.8	13.6	**10%**	104.5	19.3	**10%**	91.9	26.0
20%	141.3	6.7	**20%**	128.8	9.9	**20%**	116.5	13.7	**20%**	104.2	19.4	**20%**	91.7	26.1
30%	141.0	6.8	**30%**	128.5	9.9	**30%**	116.3	13.8	**30%**	104.0	19.5	**30%**	91.4	26.3
40%	140.7	6.8	**40%**	128.2	10.0	**40%**	116.0	13.9	**40%**	103.8	19.6	**40%**	91.2	26.4
50%	140.5	6.9	**50%**	128.0	10.1	**50%**	115.8	14.1	**50%**	103.6	19.8	**50%**	91.0	26.6
60%	140.2	7.0	**60%**	127.7	10.2	**60%**	115.6	14.2	**60%**	103.3	19.9	**60%**	90.8	26.8
70%	139.9	7.0	**70%**	127.4	10.3	**70%**	115.3	14.3	**70%**	103.1	20.0	**70%**	90.6	26.9
80%	139.6	7.1	**80%**	127.1	10.3	**80%**	115.1	14.4	**80%**	102.9	20.1	**80%**	90.3	27.1
90%	139.4	7.1	**90%**	126.9	10.4	**90%**	114.8	14.5	**90%**	102.6	20.2	**90%**	90.1	27.2
B	**139.1**	**7.2**	**G**	**126.6**	**10.5**	**L**	**114.6**	**14.6**	**Q**	**102.4**	**20.3**	**V**	**89.9**	**27.4**
10%	138.8	7.3	**10%**	126.4	10.6	**10%**	114.3	14.7	**10%**	102.2	20.4	**10%**	89.7	27.6
20%	138.5	7.3	**20%**	126.1	10.6	**20%**	114.1	14.8	**20%**	101.9	20.5	**20%**	89.4	27.8
30%	138.3	7.4	**30%**	125.9	10.7	**30%**	113.8	15.0	**30%**	101.7	20.7	**30%**	89.2	28.0
40%	138.0	7.5	**40%**	125.6	10.8	**40%**	113.6	15.1	**40%**	101.4	20.8	**40%**	88.9	28.2
50%	137.7	7.6	**50%**	125.4	10.9	**50%**	113.3	15.2	**50%**	101.2	20.9	**50%**	88.7	28.5
60%	137.4	7.6	**60%**	125.2	10.9	**60%**	113.0	15.3	**60%**	100.9	21.0	**60%**	88.5	28.7
70%	137.1	7.7	**70%**	124.9	11.0	**70%**	112.8	15.4	**70%**	100.7	21.1	**70%**	88.2	28.9
80%	136.9	7.8	**80%**	124.7	11.1	**80%**	112.5	15.6	**80%**	100.4	21.3	**80%**	88.0	29.1
90%	136.6	7.8	**90%**	124.4	11.1	**90%**	112.3	15.7	**90%**	100.2	21.4	**90%**	87.7	29.3
C	**136.3**	**7.9**	**H**	**124.2**	**11.2**	**M**	**112.0**	**15.8**	**R**	**99.9**	**21.5**	**W**	**87.5**	**29.5**
10%	136.1	8.0	**10%**	124.0	11.3	**10%**	111.8	15.9	**10%**	99.7	21.6	**10%**	87.3	29.6
20%	135.9	8.0	**20%**	123.7	11.3	**20%**	111.5	16.0	**20%**	99.4	21.7	**20%**	87.0	29.7
30%	135.6	8.1	**30%**	123.5	11.4	**30%**	111.3	16.1	**30%**	99.2	21.9	**30%**	86.8	29.8
40%	135.4	8.1	**40%**	123.2	11.5	**40%**	111.0	16.2	**40%**	98.9	22.0	**40%**	86.5	29.9
50%	135.2	8.2	**50%**	123.0	11.6	**50%**	110.8	16.4	**50%**	98.7	22.1	**50%**	86.3	30.0
60%	135.0	8.3	**60%**	122.7	11.6	**60%**	110.6	16.5	**60%**	98.4	22.2	**60%**	86.0	30.1
70%	134.8	8.3	**70%**	122.5	11.7	**70%**	110.3	16.6	**70%**	98.2	22.3	**70%**	85.8	30.2
80%	134.5	8.4	**80%**	122.2	11.8	**80%**	110.1	16.7	**80%**	97.9	22.5	**80%**	85.5	30.3
90%	134.3	8.4	**90%**	122.0	11.8	**90%**	109.8	16.8	**90%**	97.7	22.6	**90%**	85.3	30.4
D	**134.1**	**8.5**	**I**	**121.7**	**11.9**	**N**	**109.6**	**16.9**	**S**	**97.4**	**22.7**	**X**	**85.0**	**30.5**
10%	133.9	8.6	**10%**	121.5	12.0	**10%**	109.4	17.0	**10%**	97.1	22.9	**10%**	84.8	30.6
20%	133.7	8.6	**20%**	121.2	12.1	**20%**	109.1	17.1	**20%**	96.8	23.0	**20%**	84.6	30.7
30%	133.5	8.7	**30%**	121.0	12.1	**30%**	108.9	17.3	**30%**	96.6	23.2	**30%**	84.4	30.8
40%	133.3	8.7	**40%**	120.7	12.2	**40%**	108.6	17.4	**40%**	96.3	23.4	**40%**	84.2	30.9
50%	133.1	8.8	**50%**	120.5	12.3	**50%**	108.4	17.5	**50%**	96.0	23.6	**50%**	84.0	31.0
60%	132.8	8.8	**60%**	120.3	12.4	**60%**	108.1	17.6	**60%**	95.7	23.7	**60%**	83.8	31.1
70%	132.6	8.9	**70%**	120.0	12.5	**70%**	107.9	17.7	**70%**	95.4	23.9	**70%**	83.6	31.2
80%	132.4	8.9	**80%**	119.8	12.5	**80%**	107.6	17.9	**80%**	95.2	24.1	**80%**	83.4	31.3
90%	132.2	9.0	**90%**	119.5	12.6	**90%**	107.4	18.0	**90%**	94.9	24.2	**90%**	83.2	31.4
E	**132.0**	**9.0**	**J**	**119.3**	**12.7**	**O**	**107.1**	**18.1**	**T**	**94.6**	**24.4**	**Y**	**83.0**	**31.5**
10%	131.7	9.1	**10%**	119.1	12.8	**10%**	106.9	18.2	**10%**	94.4	24.5	**10%**	82.8	31.6
20%	131.5	9.1	**20%**	118.8	12.9	**20%**	106.6	18.3	**20%**	94.1	24.7	**20%**	82.6	31.7
30%	131.2	9.2	**30%**	118.6	12.9	**30%**	106.4	18.4	**30%**	93.9	24.8	**30%**	82.4	31.8
40%	130.9	9.3	**40%**	118.4	13.0	**40%**	106.1	18.5	**40%**	93.6	25.0	**40%**	82.2	31.9
50%	130.7	9.4	**50%**	118.2	13.1	**50%**	105.9	18.7	**50%**	93.4	25.1	**50%**	82.1	32.0
60%	130.4	9.4	**60%**	117.9	13.2	**60%**	105.7	18.8	**60%**	93.1	25.2	**60%**	81.9	32.1
70%	130.1	9.5	**70%**	117.7	13.3	**70%**	105.4	18.9	**70%**	92.9	25.4	**70%**	81.7	32.2
80%	129.8	9.6	**80%**	117.5	13.3	**80%**	105.2	19.0	**80%**	92.6	25.5	**80%**	81.5	32.3
90%	129.6	9.6	**90%**	117.2	13.4	**90%**	104.9	19.1	**90%**	92.4	25.7	**90%**	81.3	32.4
F	**129.3**	**9.7**	**K**	**117.0**	**13.5**	**P**	**104.7**	**19.2**	**U**	**92.1**	**25.8**	**Z**	**81.1**	**32.5**

TABLE 1

ONE POINT PROCTOR DENSITY

Lab. No: _____ Org No.: _____ Date: _____
Project No. _____ Tracs No. _____
Original Source: _____ Type of Material: _____
Coarse Agg. % Absorp.: _____ Coarse Agg. Bulk O.D. Sp. Gr.: _____
Proctor Method Used: Method A _____ Alternate Method D _____
Test Operator: _____ Date: _____
Supervisor: _____ Date: _____

Wet Density Determination

Volume of Mold = VM = _____ Cu. ft.
Weight of Mold = M2 = _____ grams _____ pounds
Weight of Sample and Mold = M1 = _____ grams _____ pounds

$$\text{Wet Density} = WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb.)}^*} = \_\_\_\_\_ \text{ lb./cu.ft.}$$

*If M1 and M2 are in pounds, eliminate "453.6 (grams/lb.)" from denominator in above equation.

Percent Moisture Determination

For either Method A or Alternate Method D, when sample is oven dried:

Wet Weight of Moisture Sample = WW = _____ grams
Dry Weight of Moisture Sample = DW = _____ grams

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100 = \_\_\_\_\_ \%$$

For Method A, when Speedie Moisture Tester is used:

% Moisture = _____ %

For Alternate Method D, when Speedie Moisture Tester is used:

WT = _____ WR4 = _____ PR4 = $\frac{WR4}{WT} \times 100$ = _____ %

% Moisture in Pass No. 4 material from Speedie = W = _____ %

$$\text{Total \% Moisture} = TW = \frac{W(100 - PR4) + PR4}{100} = \_\_\_\_\_ \%$$

From Typical Moisture-Density Curves:
Maximum Dry Density = MD = _____ lb./cu. ft.
Percent Optimum Moisture = OM = _____ %

REMARKS: _____

FIGURE 1

Curve	Max Dry Wt. lbs/cu.ft.	Optimum Moisure
A	141.8	6.6
B	139.1	7.2
C	136.3	7.9
D	134.1	8.5
E	132.	9.0
F	129.3	9.7
G	126.6	10.5
H	124.2	11.2
I	121.7	11.9
J	119.3	12.7
K	117.0	13.5
L	114.6	14.6
M	112.0	15.8
N	109.6	16.9
O	107.1	18.1
P	104.7	19.2
Q	102.4	20.3
R	99.9	21.5
S	97.4	22.7
T	94.6	24.4
U	92.1	25.8
V	89.9	27.4
W	87.5	29.5
X	85.0	30.5
Y	83.0	31.5
Z	81.1	32.5

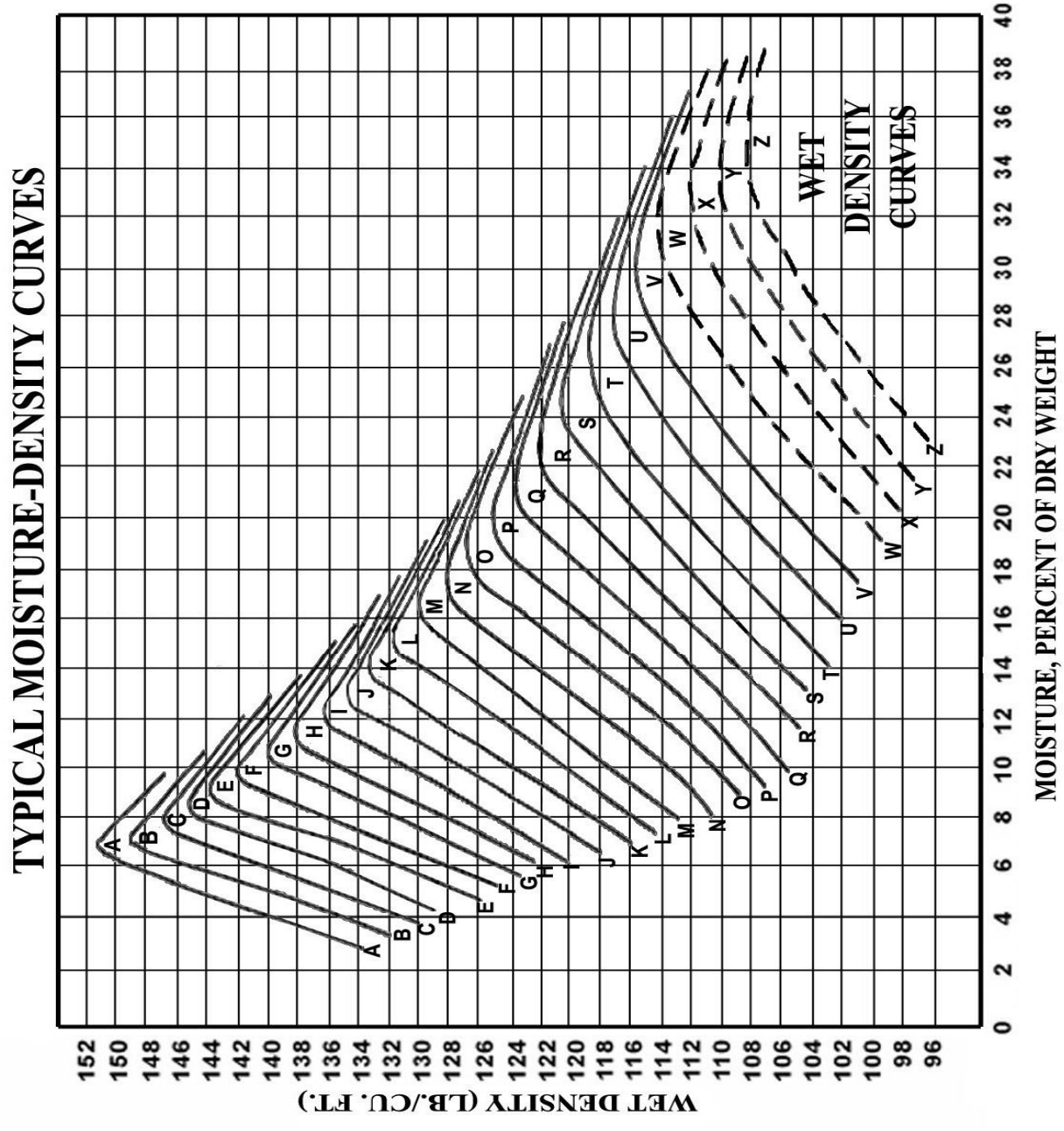


FIGURE 2

ONE POINT PROCTOR DENSITY

Lab. No: _____ Org No.: _____ Date: _____
Project No. _____ Tracs No. _____
Original Source: _____ Type of Material: _____
Coarse Agg. % Absorp.: _____ Coarse Agg. Bulk O.D. Sp. Gr.: _____
Proctor Method Used: Method A **X** Alternate Method D _____
Test Operator: _____ Date: _____
Supervisor: _____ Date: _____

Wet Density Determination

Volume of Mold = VM = **0.0335** Cu. ft.
Weight of Mold = M2 = _____ grams **10.23** pounds
Weight of Sample and Mold = M1 = _____ grams **14.25** pounds

$$\text{Wet Density} = WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb.)}^*} = \textbf{120.0} \text{ lb./cu.ft.}$$

*If M1 and M2 are in pounds, eliminate "453.6 (grams/lb.)" from denominator in above equation.

Percent Moisture Determination

For either Method A or Alternate Method D, when sample is oven dried:

Wet Weight of Moisture Sample = WW = **340.4** grams
Dry Weight of Moisture Sample = DW = **283.7** grams

$$\text{\% Moisture} = \frac{WW - DW}{DW} \times 100 = \textbf{20.0} \%$$

For Method A, when Speedie Moisture Tester is used:

% Moisture = _____ %

For Alternate Method D, when Speedie Moisture Tester is used:

WT = _____ WR4 = _____ PR4 = $\frac{WR4}{WT} \times 100$ = _____ %

% Moisture in Pass No. 4 material from Speedie = W = _____ %

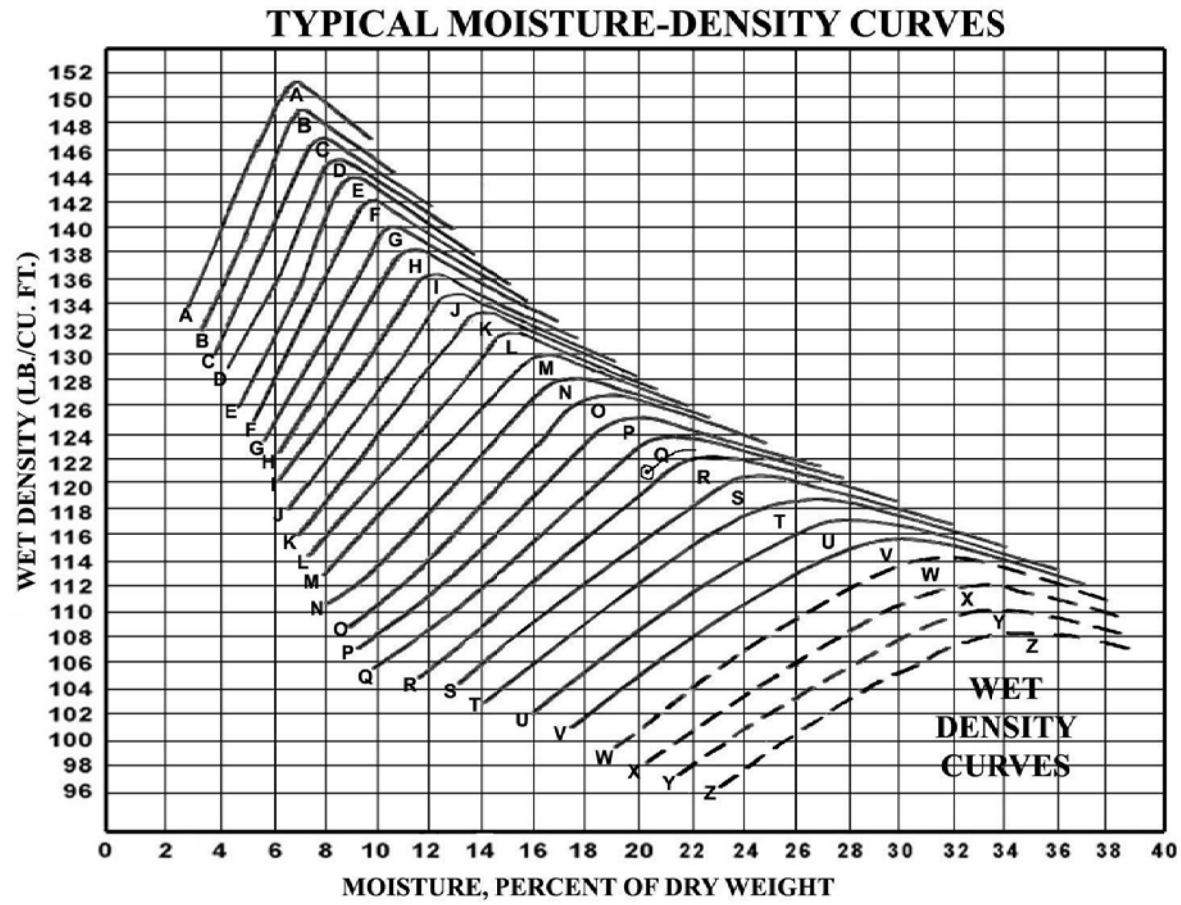
$$\text{Total \% Moisture} = TW = \frac{W(l00 — PR4) + PR4}{100} = \_\_\_\_\_ \%$$

From Typical Moisture-Density Curves:

Maximum Dry Density = MD = **100.9** lb./cu. ft.
Percent Optimum Moisture = OM = **21.0** %

REMARKS: _____

FIGURE 3



Curve	Max Dry Wt. lbs/cu.ft.	Optimum Moisure
A	141.8	6.6
B	139.1	7.2
C	136.3	7.9
D	134.1	8.5
E	132.	9.0
F	129.3	9.7
G	126.6	10.5
H	124.2	11.2
I	121.7	11.9
J	119.3	12.7
K	117.0	13.5
L	114.6	14.6
M	112.0	15.8
N	109.6	16.9
O	107.1	18.1
P	104.7	19.2
Q	102.4	20.3
R	99.9	21.5
S	97.4	22.7
T	94.6	24.4
U	92.1	25.8
V	89.9	27.4
W	87.5	29.5
X	85.0	30.5
Y	83.0	31.5
Z	81.1	32.5

FIGURE 4

Approx. 60% Below Curve Q

Interpolated Max. Dry Density: 102.4 (Curve Q)
- 99.9 (Curve R)
2.5 X 0.60 = 1.5 lb./cu. ft.

102.4 - 1.5 = 100.9 lb. / cu. ft.

Interpolated % Optimum Moisture: 21.5 (Curve R)
- 20.3 (Curve Q)
1.2 X 0.60 = 0.7%

20.3 + 0.7 = 21.0%

ARIZ 246a
November 14, 2008
(11 Pages)

MOISTURE - DENSITY RELATIONSHIP USING TYPICAL MOISTURE - DENSITY CURVES (ONE POINT PROCTOR) ALTERNATE METHOD D

(An Arizona Method)

SCOPE

1. (a) This method of test is for the determination of the optimum moisture content and maximum dry density of a soil or soil-aggregate mixture utilizing one moisture-density determination on the portion of the sample passing the 3/4 inch sieve.

(b) The one-point proctor is used with the typical moisture-density curves, shown on the back of the One Point Proctor Density Test Card (Figures 1 and 2); or by utilizing a family of moisture-density curves developed for the immediate local conditions.

(c) This method is not to be used for volcanic cinders or light porous material on which the specific gravity cannot be determined with consistency or when the absorption of the coarse aggregate is greater than 4.0%.

(d) This method may be used to determine if an existing proctor maximum density determination is valid for the soil being tested. If the existing proctor maximum density determination is not valid, a full proctor according to Arizona 245 should normally be run to determine the maximum density required for that soil type.

(e) An example is provided in Section 7, and Figures 3 and 4, for the calculations and determinations referenced herein.

(f) This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of who ever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

APPARATUS

2. The apparatus shall consist of the following:

(a) The general apparatus utilized for this test method shall conform to the apparatus requirements of Arizona Test Method 245.

(b) In place of the oven listed in the general apparatus, a hot plate or stove capable of maintaining a temperature of approximately 230° F. may be used. A Speedy Moisture Tester with a conversion table or calibration curve may also be used for moisture determinations made in the field. Finally, a microwave oven may be used in accordance with Arizona Test Method 719.

(c) Instead of the scale or balance capable of measuring the weight to be determined to at least one gram, a scale capable of measuring the weight to at least 0.01 pound may be utilized.

CALIBRATION OF MOLD

3. Molds shall be calibrated in accordance with APPENDIX A of ARIZ 225.

SAMPLE

4. A representative sample of passing 3/4 inch material weighing approximately 5000 grams shall be obtained for each one-point proctor.

PROCEDURE

5. (a) If the Speedy Moisture Tester is <u>not</u> to be used in making the moisture content determination, proceed to paragraph 5(d).

(b) For testing performed in the field, the Speedy Moisture Tester (AASHTO T 217) may be used to make the moisture content determination. The approximate 5000 gram sample of pass 3/4 inch material is sieved over a No. 4 sieve. Calculate the percent of coarse aggregate or rock particles retained on the No. 4 sieve by the following:

$$PR4 = \frac{WR4}{WT} \times 100$$

Where: PR4 = Percentage of coarse aggregate or rock particles retained on the No. 4 sieve.
WR4 = Weight of coarse aggregate or rock particles retained on the No. 4 sieve.
WT = Total Weight of material sieved.

(c) Recombine and thoroughly blend the plus No. 4 material with the passing No. 4 material.

(d) The approximate 5000 gram sample of passing 3/4 inch material shall be thoroughly mixed with sufficient water to bring the sample to slightly less than its optimum moisture content.

(e) Form a specimen by compacting the prepared soil in the six inch mold (with extension collar attached) in three equal layers to give a total compacted depth of about 5 inches. Compact each layer with 56 uniformly distributed blows from the rammer, dropping free from a height of 12 inches. While each layer is being compacted, the remainder of material shall be in a pan covered by a damp cloth. During compaction, the mold shall rest firmly on a dense, uniform, rigid and stable foundation.

NOTE: Each of the following has been found to be a satisfactory base on which to rest the mold during compaction of the soil: A block of concrete, weighing not less than 200 lbs., supported by a stable foundation; a sound concrete floor; and for field application, such surfaces as found in concrete box culverts, bridges, and pavements.

(f) When compacting granular, free-draining materials, at moisture contents which are at or above optimum, the mold shall be prepared by first sealing the bottom of the mold with waterproofing grease. All excess grease shall be wiped from the mold and base plate.

(g) Following compaction, carefully remove the extension collar. It may be necessary to use a follower to retain the soil in the mold while removing the collar to prevent damage or disturbance of the soil below the top of the mold. Carefully trim the compacted soil even with the top of the mold by means of the straightedge. If any voids are created during trimming, these shall be filled with fine material and smoothed off. Determine the weight of compacted specimen and mold. Determine the wet density, “WD”, of the compacted soil by the following:

$$WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb.)}^*}$$

Where: WD = Wet density of compacted soil, lb./cu. ft.
M1 = Weight of compacted specimen and mold, grams or lbs.
M2 = Weight of the mold, grams or lbs.
VM = Volume of the mold, cu. ft. (See Section 3 of this procedure).

* If the weights of the compacted specimen and mold, M1, and the empty mold, M2, are measured in pounds, eliminate 453.6 (grams/lb.) from the denominator of the above equation.

(h) The moisture content of the sample is determined either by drying (See paragraph (I) below); or, when testing is performed in the field, the Speedy Moisture Tester may be used (See in paragraph (j) below).

(i) When the percent moisture is determined by drying, remove the material from the mold and slice vertically through the center. Take a representative minimum 600 gram sample from the full length and width of one of the cut faces. Record the weight of wet soil to the nearest 0.1 gram as “WW”. Dry the sample to constant weight at approximately 230° F. and record weight of dry soil to the nearest 0.1 gram as “DW”. The percent moisture shall be recorded to the nearest 0.1 percent. The equation below is used when the percent moisture is determined by drying the sample.

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100$$

(j) For testing in the field, the percent moisture may be determined using the Speedy Moisture Tester. Remove the material from the mold and slice vertically through the center. Obtain a minimum of 600 grams of material from the full length and width of one of the cut faces. This material is screened over a No. 4 sieve as rapidly as possible to avoid drying of the sample. A representative sample of the pass No. 4 material shall be utilized and tested in accordance with the instructional manual for that apparatus. The percent moisture of the pass No. 4 material determined by the Speedy Moisture Tester is recorded to the nearest 0.1 percent as “W”. The moisture content of the pass 3/4 inch material is determined and recorded as “TW” to the nearest 0.1 percent by the following:

$$TW = \frac{W\,(100 - PR4) + PR4}{100}$$

Where: TW = % moisture in pass 3/4 material.
W = % moisture in pass 3/4 material. (determined by Speedy)
PR4 = % rock retained on the No. 4 sieve (determined in paragraph 5(b))

MAXIMUM DENSITY DETERMINATION

6. (a) The point representing the wet density and moisture content (dry basis) is then plotted on the Typical Moisture-Density Curves (Figure 2) and the maximum wet density and optimum moisture content determined. When this plotted point falls between two moisture-density curves, a minor interpolation is necessary. The maximum dry density in lb/cu. ft. and the corresponding percent optimum moisture is then read directly or interpolated from the chart. The family of typical moisture-density curves provided should be periodically verified for the local conditions. If it is ascertained that the family of curves provided by Figure 2 is of questionable reliability for given local conditions, then an independent family of curves should be established and used.

(b) The plotted point for wet density and moisture content should be on the dry side of the curve at or near optimum, as it is difficult to interpolate between curves for friable soils when on the wet side of the peak.

(c) If the plotted point representing the wet density and moisture content of the compacted material is on the right of the peak, the test should be repeated using a lower moisture content. An exception to this rule must be made for those soils having high clay contents and relatively flat curves. These soils cannot readily be dried to optimum in the field due to the creation of a cloddy condition which will cause voids in the proctor. Proctors for these materials should be made as near to optimum as possible.

EXAMPLE

7. An illustration of determining the maximum dry density and optimum moisture content is described below, and shown in Figures 3 and 4:

For:

Wet Density = 122.5 lb./cu. ft.
Moisture Content = 18.7%

By plotting this point on the Typical Moisture-Density Curves and interpolating to the peak, it shows a point which is approximately 20 percent of the distance from Curve P to Curve Q. From the chart, the dry density for Curve P is 104.7 @ 19.2% moisture and Curve Q is 102.4 @ 20.3% moisture.

By interpolation:

Density: 104.7 - 102.4 = 2.3
.20 X 2.3 = 0.5 lb./cu. ft. difference

Moisture: 20.3- 19.2 = 1.1
.20 X 1.1 = 0.2% difference

Therefore:

Maximum dry density = 104.7 - 0.5
= 104.2 lb./cu. ft.

Optimum Moisture = 19.2 + 0.2 = 19.4%

* As an alternate to performing the interpolation procedure, Table 1 below can be used to determine the maximum dry density and optimum moisture content when the plotted point falls between two moisture-density curves.

NOTE: The optimum moisture and maximum dry density determinations above are for the material passing the 3/4 inch sieve. When testing field samples for comparison to proctor optimum moisture and maximum dry density, a correction to the proctor optimum moisture and maximum dry density must be made, in accordance with ARIZ 227, for the percent rock which the field sample contains.

REPORT

8. Record the moisture and density data on the laboratory test form along with the laboratory number, material source and type, and other information required.

A	**141.8**	**6.6**	**F**	**129.3**	**9.7**	**K**	**117.0**	**13.5**	**P**	**104.7**	**19.2**	**U**	**92.1**	**25.8**
10%	141.5	6.7	**10%**	129.0	9.8	**10%**	116.8	13.6	**10%**	104.5	19.3	**10%**	91.9	26.0
20%	141.3	6.7	**20%**	128.8	9.9	**20%**	116.5	13.7	**20%**	104.2	19.4	**20%**	91.7	26.1
30%	141.0	6.8	**30%**	128.5	9.9	**30%**	116.3	13.8	**30%**	104.0	19.5	**30%**	91.4	26.3
40%	140.7	6.8	**40%**	128.2	10.0	**40%**	116.0	13.9	**40%**	103.8	19.6	**40%**	91.2	26.4
50%	140.5	6.9	**50%**	128.0	10.1	**50%**	115.8	14.1	**50%**	103.6	19.8	**50%**	91.0	26.6
60%	140.2	7.0	**60%**	127.7	10.2	**60%**	115.6	14.2	**60%**	103.3	19.9	**60%**	90.8	26.8
70%	139.9	7.0	**70%**	127.4	10.3	**70%**	115.3	14.3	**70%**	103.1	20.0	**70%**	90.6	26.9
80%	139.6	7.1	**80%**	127.1	10.3	**80%**	115.1	14.4	**80%**	102.9	20.1	**80%**	90.3	27.1
90%	139.4	7.1	**90%**	126.9	10.4	**90%**	114.8	14.5	**90%**	102.6	20.2	**90%**	90.1	27.2
B	**139.1**	**7.2**	**G**	**126.6**	**10.5**	**L**	**114.6**	**14.6**	**Q**	**102.4**	**20.3**	**V**	**89.9**	**27.4**
10%	138.8	7.3	**10%**	126.4	10.6	**10%**	114.3	14.7	**10%**	102.2	20.4	**10%**	89.7	27.6
20%	138.5	7.3	**20%**	126.1	10.6	**20%**	114.1	14.8	**20%**	101.9	20.5	**20%**	89.4	27.8
30%	138.3	7.4	**30%**	125.9	10.7	**30%**	113.8	15.0	**30%**	101.7	20.7	**30%**	89.2	28.0
40%	138.0	7.5	**40%**	125.6	10.8	**40%**	113.6	15.1	**40%**	101.4	20.8	**40%**	88.9	28.2
50%	137.7	7.6	**50%**	125.4	10.9	**50%**	113.3	15.2	**50%**	101.2	20.9	**50%**	88.7	28.5
60%	137.4	7.6	**60%**	125.2	10.9	**60%**	113.0	15.3	**60%**	100.9	21.0	**60%**	88.5	28.7
70%	137.1	7.7	**70%**	124.9	11.0	**70%**	112.8	15.4	**70%**	100.7	21.1	**70%**	88.2	28.9
80%	136.9	7.8	**80%**	124.7	11.1	**80%**	112.5	15.6	**80%**	100.4	21.3	**80%**	88.0	29.1
90%	136.6	7.8	**90%**	124.4	11.1	**90%**	112.3	15.7	**90%**	100.2	21.4	**90%**	87.7	29.3
C	**136.3**	**7.9**	**H**	**124.2**	**11.2**	**M**	**112.0**	**15.8**	**R**	**99.9**	**21.5**	**W**	**87.5**	**29.5**
10%	136.1	8.0	**10%**	124.0	11.3	**10%**	111.8	15.9	**10%**	99.7	21.6	**10%**	87.3	29.6
20%	135.9	8.0	**20%**	123.7	11.3	**20%**	111.5	16.0	**20%**	99.4	21.7	**20%**	87.0	29.7
30%	135.6	8.1	**30%**	123.5	11.4	**30%**	111.3	16.1	**30%**	99.2	21.9	**30%**	86.8	29.8
40%	135.4	8.1	**40%**	123.2	11.5	**40%**	111.0	16.2	**40%**	98.9	22.0	**40%**	86.5	29.9
50%	135.2	8.2	**50%**	123.0	11.6	**50%**	110.8	16.4	**50%**	98.7	22.1	**50%**	86.3	30.0
60%	135.0	8.3	**60%**	122.7	11.6	**60%**	110.6	16.5	**60%**	98.4	22.2	**60%**	86.0	30.1
70%	134.8	8.3	**70%**	122.5	11.7	**70%**	110.3	16.6	**70%**	98.2	22.3	**70%**	85.8	30.2
80%	134.5	8.4	**80%**	122.2	11.8	**80%**	110.1	16.7	**80%**	97.9	22.5	**80%**	85.5	30.3
90%	134.3	8.4	**90%**	122.0	11.8	**90%**	109.8	16.8	**90%**	97.7	22.6	**90%**	85.3	30.4
D	**134.1**	**8.5**	**I**	**121.7**	**11.9**	**N**	**109.6**	**16.9**	**S**	**97.4**	**22.7**	**X**	**85.0**	**30.5**
10%	133.9	8.6	**10%**	121.5	12.0	**10%**	109.4	17.0	**10%**	97.1	22.9	**10%**	84.8	30.6
20%	133.7	8.6	**20%**	121.2	12.1	**20%**	109.1	17.1	**20%**	96.8	23.0	**20%**	84.6	30.7
30%	133.5	8.7	**30%**	121.0	12.1	**30%**	108.9	17.3	**30%**	96.6	23.2	**30%**	84.4	30.8
40%	133.3	8.7	**40%**	120.7	12.2	**40%**	108.6	17.4	**40%**	96.3	23.4	**40%**	84.2	30.9
50%	133.1	8.8	**50%**	120.5	12.3	**50%**	108.4	17.5	**50%**	96.0	23.6	**50%**	84.0	31.0
60%	132.8	8.8	**60%**	120.3	12.4	**60%**	108.1	17.6	**60%**	95.7	23.7	**60%**	83.8	31.1
70%	132.6	8.9	**70%**	120.0	12.5	**70%**	107.9	17.7	**70%**	95.4	23.9	**70%**	83.6	31.2
80%	132.4	8.9	**80%**	119.8	12.5	**80%**	107.6	17.9	**80%**	95.2	24.1	**80%**	83.4	31.3
90%	132.2	9.0	**90%**	119.5	12.6	**90%**	107.4	18.0	**90%**	94.9	24.2	**90%**	83.2	31.4
E	**132.0**	**9.0**	**J**	**119.3**	**12.7**	**O**	**107.1**	**18.1**	**T**	**94.6**	**24.4**	**Y**	**83.0**	**31.5**
10%	131.7	9.1	**10%**	119.1	12.8	**10%**	106.9	18.2	**10%**	94.4	24.5	**10%**	82.8	31.6
20%	131.5	9.1	**20%**	118.8	12.9	**20%**	106.6	18.3	**20%**	94.1	24.7	**20%**	82.6	31.7
30%	131.2	9.2	**30%**	118.6	12.9	**30%**	106.4	18.4	**30%**	93.9	24.8	**30%**	82.4	31.8
40%	130.9	9.3	**40%**	118.4	13.0	**40%**	106.1	18.5	**40%**	93.6	25.0	**40%**	82.2	31.9
50%	130.7	9.4	**50%**	118.2	13.1	**50%**	105.9	18.7	**50%**	93.4	25.1	**50%**	82.1	32.0
60%	130.4	9.4	**60%**	117.9	13.2	**60%**	105.7	18.8	**60%**	93.1	25.2	**60%**	81.9	32.1
70%	130.1	9.5	**70%**	117.7	13.3	**70%**	105.4	18.9	**70%**	92.9	25.4	**70%**	81.7	32.2
80%	129.8	9.6	**80%**	117.5	13.3	**80%**	105.2	19.0	**80%**	92.6	25.5	**80%**	81.5	32.3
90%	129.6	9.6	**90%**	117.2	13.4	**90%**	104.9	19.1	**90%**	92.4	25.7	**90%**	81.3	32.4
F	**129.3**	**9.7**	**K**	**117.0**	**13.5**	**P**	**104.7**	**19.2**	**U**	**92.1**	**25.8**	**Z**	**81.1**	**32.5**

TABLE 1

ONE POINT PROCTOR DENSITY

Lab. No: _____ Org No.: _____ Date: _____
Project No. _____ Tracs No. _____
Original Source: _____ Type of Material: _____
Coarse Agg. % Absorp.: _____ Coarse Agg. Bulk O.D. Sp. Gr.: _____
Proctor Method Used: Method A _____ Alternate Method D _____
Test Operator: _____ Date: _____
Supervisor: _____ Date: _____

Wet Density Determination

Volume of Mold = VM = _____ Cu. ft.
Weight of Mold = M2 = _____ grams _____ pounds
Weight of Sample and Mold = Ml = _____ grams _____ pounds

$$\text{Wet Density} = WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb.)}^*} = \_\_\_\_\_ \text{ lb./cu.ft.}$$

*If Ml and M2 are in pounds, eliminate "453.6 (grams/lb.)" from denominator in above equation.

Percent Moisture Determination

For either Method A or Alternate Method D, when sample is oven dried:

Wet Weight of Moisture Sample = WW = _____ grams
Dry Weight of Moisture Sample = DW = _____ grams

$$\text{\% Moisture} = \frac{WW - DW}{DW} \times 100 = \_\_\_\_\_ \%$$

For Method A, when Speedie Moisture Tester is used:

% Moisture = _____ %

For Alternate Method D, when Speedie Moisture Tester is used:

WT = _____ WR4 = _____ PR4 = $\frac{WR4}{WT} \times 100 =$ _____ %

% Moisture in Pass No. 4 material from Speedie = W = _____ %

$$\text{Total \% Moisture} = TW = \frac{W(100 - PR4) + PR4}{100} = \_\_\_\_\_ \%$$

From Typical Moisture-Density Curves:

Maximum Dry Density = MD = _____ lb./cu. ft.
Percent Optimum Moisture = OM = _____ %

REMARKS: _____

FIGURE 1

Curve	Max Dry Wt. lbs/cu.ft.	Optimum Moisure
A	141.8	6.6
B	139.1	7.2
C	136.3	7.9
D	134.1	8.5
E	132.	9.0
F	129.3	9.7
G	126.6	10.5
H	124.2	11.2
I	121.7	11.9
J	119.3	12.7
K	117.0	13.5
L	114.6	14.6
M	112.0	15.8
N	109.6	16.9
O	107.1	18.1
P	104.7	19.2
Q	102.4	20.3
R	99.9	21.5
S	97.4	22.7
T	94.6	24.4
U	92.1	25.8
V	89.9	27.4
W	87.5	29.5
X	85.0	30.5
Y	83.0	31.5
Z	81.1	32.5

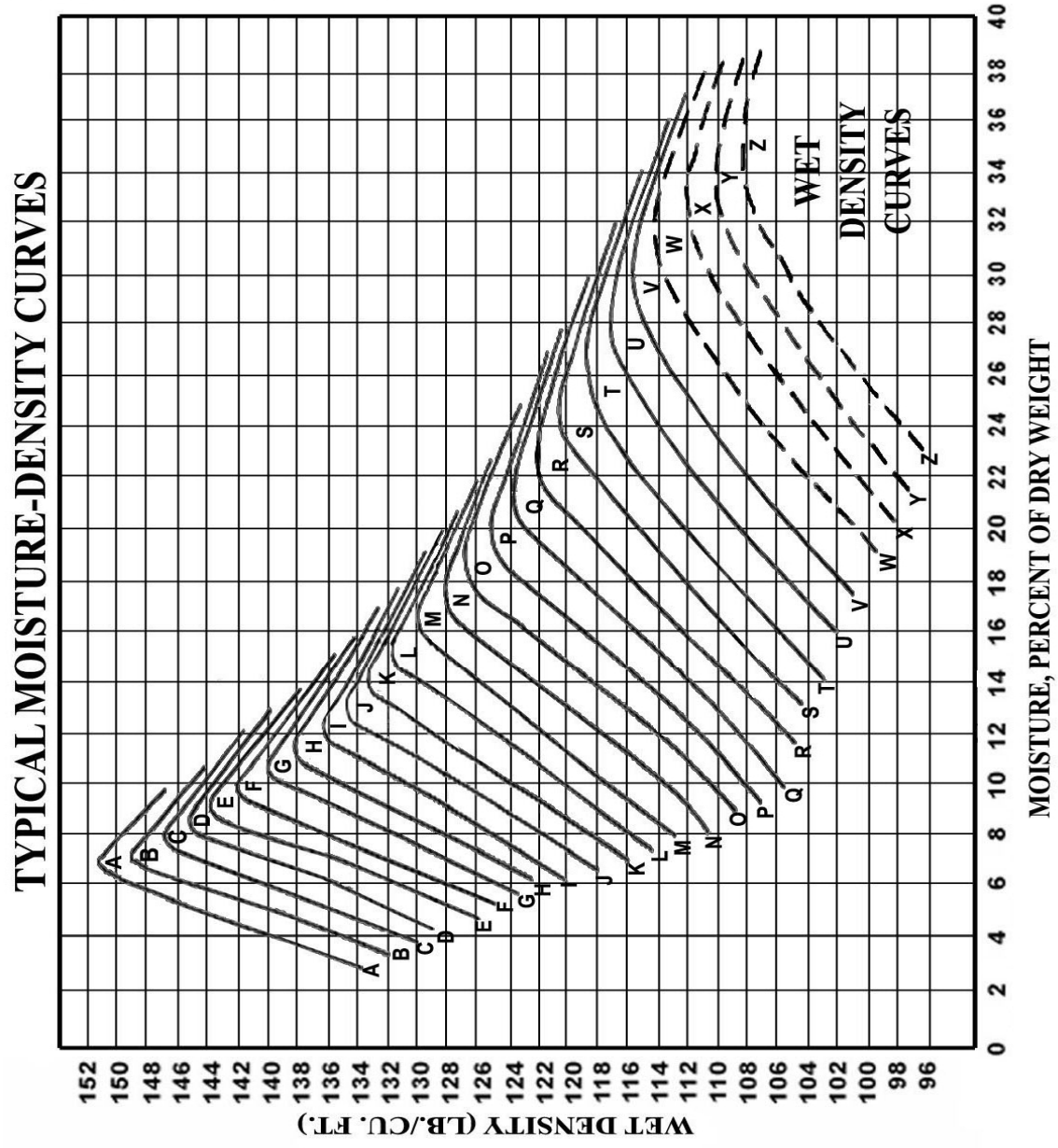


FIGURE 2

ONE POINT PROCTOR DENSITY

Lab. No: _____ Org No.: _____ Date: _____
Project No. _____ Tracs No. _____
Original Source: _____ Type of Material: _____
Coarse Agg. % Absorp.: _____ Coarse Agg. Bulk O.D. Sp. Gr.: _____
Proctor Method Used: Method A _____ Alternate Method D **X**
Test Operator: _____ Date: _____
Supervisor: _____ Date: _____

Wet Density Determination

Volume of Mold = VM = **0.0758** Cu. ft.
Weight of Mold = M2 = **6608** grams _____ pounds
Weight of Sample and Mold = M1 = **10820** grams _____ pounds

$$\text{Wet Density} = WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb.)}^*} = \mathbf{122.5} \text{ lb./cu.ft.}$$

*If M1 and M2 are in pounds, eliminate "453.6 (grams/lb.)" from denominator in above equation.

Percent Moisture Determination

For either Method A or Alternate Method D, when sample is oven dried:

Wet Weight of Moisture Sample = WW = _____ grams
Dry Weight of Moisture Sample = DW = _____ grams

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100 = \_\_\_\_\_ \%$$

For Method A, when Speedie Moisture Tester is used:

% Moisture = _____ %

For Alternate Method D, when Speedie Moisture Tester is used:

WT = **5736** WR4 = **1274** PR4 = $\frac{WR4}{WT} \times 100$ = **22** %

% Moisture in Pass No. 4 material from Speedie = W = **23.7** %

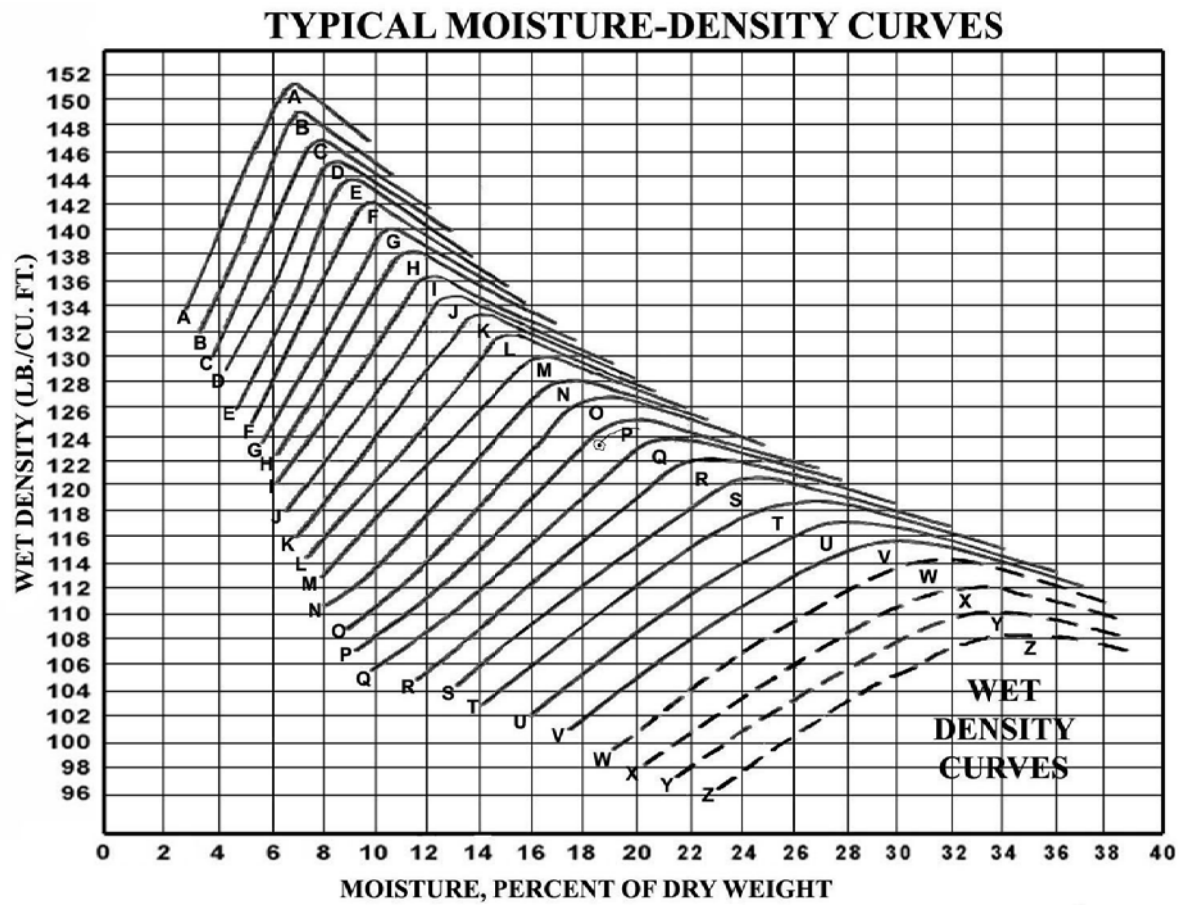
$$\text{Total \% Moisture} = TW = \frac{W(100 - PR4) + PR4}{100} = \mathbf{18.7} \%$$

From Typical Moisture-Density Curves:
Maximum Dry Density = MD = **104.2** lb./cu. ft.
Percent Optimum Moisture = OM = **19.4** %

REMARKS: _____

FIGURE 3

FIGURE 4



Curve	Max Dry Wt. lbs/cu.ft.	Optimum Moisure
A	141.8	6.6
B	139.1	7.2
C	136.3	7.9
D	134.1	8.5
E	132.	9.0
F	129.3	9.7
G	126.6	10.5
H	124.2	11.2
I	121.7	11.9
J	119.3	12.7
K	117.0	13.5
L	114.6	14.6
M	112.0	15.8
N	109.6	16.9
O	107.1	18.1
P	104.7	19.2
Q	102.4	20.3
R	99.9	21.5
S	97.4	22.7
T	94.6	24.4
U	92.1	25.8
V	89.9	27.4
W	87.5	29.5
X	85.0	30.5
Y	83.0	31.5
Z	81.1	32.5

Approx. 20% Below Curve P

Interpolated Max. Dry Density: 104.7 (Curve P)
- 102.4 (Curve Q)
2.3 X 0.20 = 0.5 lb./cu. ft.

104.7 - 0.5 = 104.2 lb. / cu. ft.

Interpolated % Optimum Moisture: 20.3 (Curve Q)
- 19.2 (Curve P)
1.1 X 0.20 = 0.2%

19.2 + 0.2 = 19.4%

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SERIES 400

BITUMINOUS MIXTURES

The following test methods shall be performed in accordance with the respective designation:

ARIZONA TEST METHODS:

TITLE	DESIGNATION
Moisture Content of Bituminous Mixtures…….	ARIZ 406c
Compaction and Testing of Bituminous Mixtures Utilizing 101.6 mm (Four Inch) Marshall Apparatus……	ARIZ 410c
Determination of Transverse Distributor Spread Rate…….	ARIZ 411
Density of Compacted Bituminous Mixtures by the Nuclear Method……	ARIZ 412b
Extraction of Asphalt from Bituminous Mixtures by Soxhlet Extraction……..….	ARIZ 413
Bulk Specific Gravity and Bulk Density of Compacted Bituminous Mixtures……..….	ARIZ 415c
Preparing and Splitting Field Samples of Bituminous Mixtures for Testing……..……..…	ARIZ 416d
Maximum Theoretical Specific Gravity of Field Produced Bituminous Mixtures (Rice Test)……...	ARIZ 417b
Bituminous Material Content of Asphaltic Concrete Mixtures by the Nuclear Method……..…	ARIZ 421
Compaction and Testing of Bituminous Mixtures Utilizing 152.4 mm (Six Inch) Marshall Apparatus…….	ARIZ 422

ARIZONA TEST METHODS: (continued)

TITLE	DESIGNATION
Determination of Air Voids in Compacted Bituminous Mixtures……..	ARIZ 424a
Asphalt Binder Content of Asphaltic Concrete Mixtures by the Ignition Furnace Method……	ARIZ 427

AASHTO TEST METHODS:

TITLE	DESIGNATION
Quantitative Extraction of Bitumen from Bituminous Paving Mixtures……..	T 164
Preparing and Determining the Density of Hot-Mix Asphalt (HMA) Specimens by Means of the Superpave Gyratory Compactor ..……..	T 312

NOTE: It shall be assured that the appropriate test methods as given in the project requirements are being adhered to.

ARIZ 412b
November 14, 2008
(4 Pages)

DENSITY OF COMPACTED BITUMINOUS MIXTURES - NUCLEAR METHOD

(An Arizona Method)

SCOPE

1. (a) This method is used to determine the in-place density of compacted layers of bituminous mixtures by use of nuclear apparatus.

(b) This test method involves hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

(c) Safety procedures for operation, transport and storage of nuclear gauges shall be in accordance with the manufacturer's recommendations and the applicable regulations of the Arizona Radiation Regulatory Agency (ARRA).

APPARATUS

2. The apparatus shall consist of the following:

(a) Moisture/Density Nuclear gauge capable of determining densities by the backscatter method. Calibration of the gauge shall be performed in accordance with AASHTO T310, Annexes A1, A2 and A3, on an annual basis.

(b) Reference standard block or test stand to obtain standard counts for moisture and density which are used to check the gauge stability.

(c) Nuclear gauge transport case and labels which comply with A.R.R.A. Regulations.

(d) Charging cord, if applicable.

(e) Radiation exposure badge (if required by license .with A.R.R.A.)

(f) Information packet for the nuclear gauge which shall contain the following items:

(g) Moisture/Density Calibration Tables (if required), and a standard count log book.

(h) Manufacturer's Gauge Operation Manual for the nuclear gauge.

(i) Applicable documentation necessary to meet requirements of ARRA for gauge safety.

(j) Blank test forms for use on the applicable nuclear gauge.

(k) Calculator for necessary computations.

(l) Miscellaneous equipment including watch, pencils, writing paper, ruler, eraser, clip board, and hand cart as required.

GAUGE STABILITY CHECK

3. A density standard count and moisture standard count shall be taken at the beginning of each day of testing at the project where the field density testing is to be performed. The gauge stability check shall be performed as follows:

(a) Place the reference standard block on any asphalt, concrete, compacted aggregate or similar surface which is dry and level. The reference standard block should be at least at least 15 feet away from any large object, or vehicle, and at least 50 feet away from another nuclear gauge.

(b) Seat the nuclear gauge on the reference block in accordance with the gauge operation manual. It is very important that the gauge is seated properly on the standard reference block.

(c) Remove the lock on the source handle and make sure the source handle is in the safe or stored position (the top notch on the index rod).

(d) Turn the gauge on (in standby power condition) and allow it to warm-up, if necessary, for the recommended time as given in the gauge operation manual.

(e) After the warm-up period, take a standard moisture count and a standard density count in accordance with the gauge operation manual.

(f) Record the moisture and density standard counts in the proper columns of the standard count log book along with the appropriate additional information, such as date, time, temperature, and location.

(g) Return the gauge to the standby power condition. The gauge should be left in the standby mode for subsequent testing.

(h) Determine if the standard counts are within the limits for normal operation in accordance with the gauge operation manual. This is usually done by comparing the standard counts to the average of the four previous standard counts or utilizing an internal statistical test which is available on some gauges. Additional standard counts may be necessary if initially the gauge does not appear to be operating properly. If the gauge does not meet the normal operating parameters as specified by the Standard Count procedure in the gauge operation manual, the gauge should not be used for testing. It should be sent in for servicing to determine the problem.

NOTE: Some gauges will store standard counts for later use in calculations performed by the gauge itself. The most recent standard counts will usually be stored automatically over pre-existing standard counts

(i) On a weekly basis, compare the average of the four most recent standard counts with the average of four standard counts immediately after gauge calibration or at least three months previous, whichever is shorter. If the accumulative shift in standard count exceeds 2% for moisture or 3% for density, the nuclear gauge should be recalibrated.

PROCEDURE

4. (a) At each location to be tested, two one-minute readings shall be obtained by taking the first reading and recording the wet density to the nearest 0.1 lb. per cu./ft. then rotating the gauge 180° (making sure that the gauge is set in the same footprint as the first reading) and taking another reading and again recording the wet density to the nearest 0.1 lb. per cu./ft. The two reading are then averaged.

(b) Normally the preparation of the surface for taking readings at each location shall not include the removal of any material for the purpose of making it more

smooth, except that particles which are completely unattached and merely lying loose on top of the compacted and bound mixture shall be brushed away. Not more than one pound of dry fine sand (minus #10 material) shall be spread over each location and then scraped away with a straightedge so that the mixture is visible over the majority of the surface.

PRECAUTIONS

5. (a) Except when actually in use performing tests, the gauge and its accessories are to be kept within the A.R.R.A. (Arizona Radiation Regulatory Agency) approved carrying case, to protect it from damage and to provide better radiation shielding for persons in its vicinity

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SERIES 800

DESIGN

The following methods shall be performed in accordance with the respective designation:

ARIZONA TEST METHODS:

TITLE	DESIGNATION
Evaluation of Profiles…….……..	ARIZ 801a
Effect of Water on Strength of Compacted Bituminous Mixtures (Immersion Compression Test)…….	ARIZ 802g
Centrifuge Kerosene Equivalent of Aggregate, Including K-Factor…….	ARIZ 805b
Maximum Theoretical Specific Gravity of Laboratory Prepared Bituminous Mixtures (Rice Test)……..……	ARIZ 806e
Design of Slurry Seal……	ARIZ 807
Design of Asphaltic Concrete Friction Course…….	ARIZ 814a
Marshall Mix Design Method for Asphaltic Concrete…….	ARIZ 815c
Design of Exposed Aggregate Seal Coats……..	ARIZ 819a
Determination of Additive or Asphalt Blend Required for Modification of Asphalt Viscosity…….	ARIZ 822
Method of Test for Determining the Quantity of Asphalt Rejuvenating Agent Required for an Asphaltic Pavement……..	ARIZ 825a
Evaluation of Pavement Smoothness…….……..	ARIZ 829a
Marshall Mix Design Method For Asphaltic Concrete (Asphalt-Rubber) [AR-AC]……..	ARIZ 832

NOTE: It shall be assured that the appropriate methods as given in the project requirements are being adhered to.

ARIZ 103a
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(2 Pages)

SAMPLING BITUMINOUS MATERIALS

(An Arizona Method)

SCOPE

1. (a) This procedure covers best practices for sampling of Bituminous materials (paving grade asphalt, crumb rubber asphalt and emulsions) in the field.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) For the purpose of this test method Bituminous materials other than Emulsions will be referred to as “Asphalt Binder”, and Emulsified Bituminous material i.e. (RS-1, SS-1, CSS-1, etc…) will be referred to as “Emulsions”.

SIZE OF SAMPLES

2. (a) A minimum of 1 gal. of Asphalt Binder.

(b) A minimum of two ½ gal. containers per sample of Emulsions.

CONTAINERS

3. (a) Containers for Asphalt Binder, shall be double friction top cans.

(b) Containers for Emulsion samples shall be wide mouth containers made of plastic.

PROTECTION AND PRESERVATION OF SAMPLES

4. (a) Containers shall be new and free of any moisture, contaminants, or residue from any manufacturing process. The top and container shall fit together tightly.

(b) The container shall be tightly sealed immediately after obtaining the sample.

(c) The filled sample container shall not be cleaned using a solvent. If cleaning is necessary use a clean dry cloth.

(d) Samples of Emulsion shall be protected from freezing.

(e) Transferring samples from one container to another shall be avoided if possible.

(f) Sample containers shall be identified using sample tags that are securely fastened to the side of the container so they will not be lost in transit, and shall be clearly marked for identification with a suitable permanent marker on the side of the container itself.

PROCEDURE

5. (a) Samples of Asphalt Binder shall be taken from the last possible point before the bituminous material is introduced into the hot plant. This is usually from a spigot or faucet on the circulation line.

(b) Bituminous materials applied to pavement surfaces, i.e. Tack Coat, Fog Coat shall be sampled from the distributor truck at the project.

(c) Clearly identify the side (not the lid) of a new clean container of appropriate size with the sample number, date, project number, type of material, and any other pertinent information.

(d) To ensure the sample is representative, draw off and discard a minimum of 1 gal. of Bituminous material prior to obtaining the sample from the sampling valve.

(e) From the sampling valve draw off the minimum amount of Bituminous material required for the type of material being sampled. Care should be taken to avoid spilling any material on the outside of the container or over filling the container. The container should be filled to no closer than one inch from the top.

(f) Immediately after obtaining the sample, the clearly identified container shall be tightly and positively sealed.

ARIZ 832
November 14, 2008
(18 Pages)

MARSHALL MIX DESIGN METHOD FOR ASPHALTIC CONCRETE (ASPHALT-RUBBER) [AR-AC]

(An Arizona Method)

SCOPE

1. (a) This method is used to design Asphaltic Concrete (Asphalt-Rubber) [AR-AC] mixes using 4-inch diameter Marshall apparatus.

(b) This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

APPARATUS

2. This test method is used in conjunction with the test methods listed below. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. The required apparatus is shown in the individual test methods, as appropriate.

ARIZ 201	Sieving of Coarse and Fine Graded Soils and Aggregates
ARIZ 205	Composite Grading
ARIZ 210	Specific Gravity and Absorption of Coarse Aggregate
ARIZ 211	Specific Gravity and Absorption of Fine Aggregate
ARIZ 212	Percentage of Fractured Coarse Aggregate Particles
ARIZ 238	Percent Carbonates in Aggregate
ARIZ 247	Particle Shape and Texture of Fine Aggregate Using Uncompacted Void Content
ARIZ 410	Compaction and Testing of Bituminous Mixtures Utilizing 101.6 mm (Four-Inch) Marshall Apparatus

ARIZ 415	Bulk Specific Gravity and Bulk Density of Compacted Bituminous Mixtures
ARIZ 416	Preparing and Splitting Field Samples of Bituminous Mixtures for Testing
ARIZ 806	Maximum Theoretical Specific Gravity of Laboratory Prepared Bituminous Mixtures (Rice Test)
AASHTO T 96	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
AASHTO T 176	Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
AASHTO T 228	Specific Gravity of Semi-Solid Bituminous Materials

MATERIALS

3. (a) Mineral Aggregate - The mineral aggregate used in the design shall be produced material from the source(s) for the project. Use of natural sand is not permitted in AR-AC mixtures.

1) Mineral aggregate from each source shall be tested for compliance to the project requirements for Abrasion (AASHTO T 96).

2) The composited gradation of the aggregate and the composited gradation of the aggregate-mineral admixture blend shall comply with the grading limits of the specifications.

3) The composited mineral aggregate shall conform to the requirements of the specifications for Sand Equivalent (AASHTO T 176), Fractured Coarse Aggregate Particles (ARIZ 212), Uncompacted Void Content (ARIZ 247), and Percent Carbonates (ARIZ 238) when applicable.

(b) Bituminous Material - The bituminous material used in the design shall be asphalt-rubber material [hereinafter Crumb Rubber Asphalt (CRA)], conforming to the requirements of Section 1009 of the specifications, which is to be used in the production of the AR-AC. The specific gravity of the CRA and of the asphalt cement used in the CRA shall be determined in accordance with AASHTO T 228.

(c) Mineral Admixture - Mineral admixture is required. The mineral admixture used in the design shall be the same type of material to be used in production of the AR-AC. The mineral admixture shall conform to the requirements of the specifications.

DETERMINATION OF COMPOSITE GRADATION

4. (a) The gradation of the aggregate from each individual component stockpile or bin shall be determined in accordance with ARIZ 248 using washed sieve analysis Alternate #4 or Alternate #5. For alternate #5, washing of the coarse aggregate may be performed on the composite Plus No. 4 material and applied to the composite percent pass the minus No. 200 determined from the unwashed coarse sieving and washed fine sieving of the individual stockpiles.

(b) The composite gradation of the mineral aggregate is determined using desired percentages of each component based on washed sieve analysis. Mix designs may be developed based on bin or stockpile material, as appropriate for the respective mix production facility to be used.

(c) The mineral aggregate composite shall be determined in accordance with ARIZ 205.

(d) The aggregate-mineral admixture blend composite is determined by adjusting the mineral aggregate composite (percent passing) for mineral admixture by performing the calculation in Equation 1 for each sieve:

Equation 1:

$$\begin{pmatrix} \text{\% passing each sieve [Adjusted for Mineral Admixture]} \end{pmatrix} = \frac{\begin{pmatrix} \text{\% passing each sieve in the aggregate composite} \end{pmatrix} + \begin{pmatrix} \text{\% Mineral Admixture} \end{pmatrix}}{(100) + (\text{\% Mineral Admixture})} \times 100$$

(e) The composited gradation of the aggregate and the composited gradation of the aggregate-mineral admixture blend shall be shown on the design report, along with the percentage of each material.

PREPARING AGGREGATE SAMPLES FOR MIX DESIGN TESTING

5. Based on the stockpile or bin composite aggregate gradation, the aggregate samples needed for mix design tests are prepared as follows.

(a) Representative samples of material which are retained on the individual No. 8 and larger sieve sizes and the minus No. 8 material from each stockpile or bin are used to prepare the aggregate samples for mix design testing.

(b) Table 1 shows the aggregate sample sizes, the number of samples required for each test listed, and which samples include mineral admixture. The aggregate weight shown for Maximum Theoretical Specific Gravity will provide 3 Rice test specimens and the amount shown for Density-Stability/Flow will produce 3 Marshall specimens.

Table 1

Test	Sample Size	Number of Samples
Fine Aggregate Specific Gravity/ Absorption (ARIZ 211)	1200 grams of Mineral Aggregate [No mineral admixture]	1
Coarse Aggregate Specific Gravity/Absorption (ARIZ 210)	2000 grams of Mineral Aggregate [No mineral admixture]	1
Maximum Theoretical Specific Gravity (Rice Test) (ARIZ 806, as modified in Section 10)	3000 grams of Mineral Aggregate [Plus 30 grams of mineral admixture]	1 [Yields 3 test specimens]
Density-Stability/Flow (ARIZ 415 and ARIZ 410, as modified in Sections 8 and 9 respectively)	3000 grams of Mineral Aggregate (See Note 1) [Plus 30 grams of mineral admixture]	3 (See Note 2) [Each sample yields 1 set of 3 Marshall Specimens]

Note 1: Generally 3000 grams of mineral aggregate will provide specimens of acceptable heights, but adjustments may be necessary in some cases. Use Equation 2 to adjust aggregate weights as necessary to conform to specimen height requirements of 2.50 ± 0.20 inches.

Equation 2: $$\text{Adjusted Wt. of Aggregate} = \frac{\left(\begin{array}{l}\text{Combined Bulk O.D.}\\ \text{Agg. Specific Gravity}\end{array}\right)}{2.650} \text{ x } 3000$$

Note 2: Requires one (1) sample for each CRA binder content to be tested (minimum of 3 contents, with 3 Marshall specimens at each content).

(c) After the aggregate samples for the Rice and Marshall specimens have been composited, add 1% mineral admixture by weight of the aggregate, and mix thoroughly. Add 3% water by dry weight to each sample and mix thoroughly to wet the mineral admixture and aggregate surfaces. After mixing, dry to constant weight in accordance with paragraph 7(a).

AGGREGATE SPECIFIC GRAVITIES AND ABSORPTION

6. Determine the Bulk Oven Dry, S.S.D., Apparent Specific Gravities and Absorption for the fine aggregate (Minus No. 4) and the coarse aggregate (Plus No. 4) in accordance with ARIZ 211 and ARIZ 210 respectively.

(a) Using Equation 3, calculate the Combined Bulk Oven Dry (Gsb), S.S.D., and Apparent Specific Gravities of the aggregate-mineral admixture blend.

Equation 3:

$$\begin{pmatrix}\text{Combined Specific Gravity}\\ \text{of Aggregate and Mineral}\\ \text{Admixture Blend}\end{pmatrix} = \frac{P_c + P_f + P_{admix}}{\frac{P_c}{G_c} + \frac{P_f}{G_f} + \frac{P_{admix}}{G_{admix}}}$$

Where:

P_c, P_f = Weight percent of coarse aggregate and fine aggregate respectively. Determined from the aggregate composite without mineral admixture.

P_{admix} = Percent mineral admixture by weight of the aggregate.

$P_c + P_f$ = 100

$P_c + P_f + P_{admix}$ = 100 + % Mineral Admixture

G_c, G_f = Specific gravity of the coarse and the fine aggregate respectively.

G_{admix} = Specific gravity of the mineral admixture.

- Type II Cement = 3.14
- Type IP Cement = 3.00
- Hydrated Lime = 2.20

(b) Using Equation 4, calculate the Combined Absorption of the aggregate-mineral admixture blend.

Equation 4:

$$\begin{pmatrix}\text{Combined Absorption}\\ \text{of Aggregate and Mineral}\\ \text{Admixture Blend}\end{pmatrix} = \frac{(P_c \times A_c) + (P_f \times A_f) + (P_{admix} \times A_{admix})}{P_c + P_f + P_{admix}}$$

Where:	P_c, P_f	=	Weight percent of coarse aggregate and fine aggregate respectively. Determined from the aggregate composite without mineral admixture.
	P_{admix}	=	Percent mineral admixture by weight of the aggregate.
	$P_c + P_f$	=	100
	$P_c + P_f + P_{admix}$	=	100 + % Mineral Admixture
	A_c, A_f	=	Percent water absorption of the coarse aggregate and the fine aggregate respectively.
	A_{admix}	=	Percent water absorption of mineral admixture (assumed to be 0.0%).

PREPARATION OF SPECIMENS FOR DENSITY AND MARSHALL STABILITY/FLOW DETERMINATION

7. Marshall specimens shall be prepared as follows.

NOTE: Normally a range of 3 different CRA binder contents at 1.0% increments will provide sufficient information, although in some cases it may be necessary to prepare additional sets of samples at other CRA binder contents. Two series of CRA binder contents are customarily used: either 6.0, 7.0, and 8.0% CRA by total mix weight; or 6.5, 7.5, and 8.5% CRA by total mix weight.

NOTE: Although a wide range of mixers may provide the desired well-coated homogeneous mixture, commercial potato mashers or dough mixers with whips are often used. Minimum recommended capacity of the mixing bowl is 10 quarts.

(a) The aggregate-mineral admixture blend shall be dried to constant weight at 325 ± 3 ºF and shall be at this temperature at the time of mixing with the CRA. If necessary, a small amount of proportioned Pass No. 8 aggregate make-up material shall be added to bring samples to the desired weight.

(b) Before each batch of AR-AC is mixed, the CRA shall be heated in a loosely covered container in a forced draft oven for approximately 2 hours or as necessary to reach a temperature of 330 ± 5 ºF. Upon removal from the oven, the CRA shall be thoroughly stirred using a stiff-bladed flat spatula with blade approximately 1-inch wide, 1/8-inch thick, and long enough to reach the bottom of the container. (As an alternate to a stiff-bladed spatula, flat bar stock meeting the dimensional requirements may be used.) Use combined circular, vertical, and radial stirring motions to uniformly distribute the rubber particles throughout the CRA before adding the designated proportion to the aggregate-mineral admixture blend. If there is any delay before beginning of mixing the CRA with the aggregate-mineral admixture blend, thoroughly stir the CRA again immediately before pouring.

CAUTION: ***To avoid damage to the CRA, do not use a hot plate or open flame to bring it to temperature. Once the CRA temperature has reached 330 ± 5 ºF, the container may briefly be moved to a hot plate for no more than 5 minutes to maintain temperature. If a hot plate is utilized, the CRA shall be constantly stirred to avoid sticking or scorching. Do not heat the CRA longer than necessary to complete batching and mixing operations (approximately three hours total heating time), or damage may occur.***

NOTE: Before each batch is mixed, the mixing bowl and whip shall be heated to 325 ± 3 ºF, and the weight of CRA required to provide the desired content shall be calculated.

(c) The aggregate-mineral admixture blend and the appropriate amount of CRA shall be mixed together as quickly as possible in order to maintain the required mixing temperature of 325 ± 3 ºF while producing a well-coated homogeneous AR-AC mixture. **Mechanical mixing is required.**

NOTE: After mechanical mixing, hand mixing may be used as needed to obtain more thorough coating of the aggregate.

(d) Immediately after mixing, each batch of AR-AC shall be placed on a tarp or sheet of heavy paper and in a rolling motion thoroughly mixed and spread according to the procedures described in ARIZ 416. The circular mass shall be cut into 6 equal pie-shaped segments. Take opposite segments for each individual specimen and use up the entire batch.

(e) Each AR-AC specimen shall be spread in a large pan at nominal single-stone thickness. Avoid stacking particles as feasible. Allow specimen to cure for 2 hours ± 10 minutes at 300 ± 5 ºF.

(f) A mold assembly (base plate, mold, and collar) shall be heated to approximately 325 ± 3 ºF. The face of the compaction hammer shall be thoroughly cleaned and heated on a hot plate set at 325 ± 3 ºF.

(g) Place a 4-inch diameter paper disc in the bottom of the mold before the mixture is introduced. Place the entire specimen in the mold with a heated spoon. Spade the mixture vigorously with a heated flat metal spatula, with a blade approximately 1-inch wide and 6-inches long and stiff enough to penetrate the entire layer of material, 15 times around the perimeter and 10 times at random into the mixture, penetrating the mixture to the bottom of the mold. Smooth the surface of mix to a slightly rounded shape.

NOTE: To ease removal of the end papers after compaction, they may be sprayed with a light application of aerosol based vegetable oil. PAM brand cooking spray has been found to work well for this application.

(h) Before compaction, put the mold containing the AR-AC specimen in an oven for approximately one hour or as needed to heat the mixture specimen to the proper compaction temperature of 325 ± 3 ºF.

(i) Immediately upon removing the mold assembly loaded with mix from the oven, place a paper disc on top of mixture, place the mold assembly on the compaction pedestal in the mold holder, and apply 75 blows with the compaction hammer. Remove the base plate and collar, and reverse and reassemble the mold. Apply 75 compaction blows to the face of the reversed specimen.

NOTE: The compaction hammer shall apply only one blow after each fall, that is, there shall not be a rebound impact. The compaction hammer shall meet the requirements specified in Section 2(c) of ARIZ 410.

(j) Remove the collar and top paper disc. Remove the base plate and remove the bottom paper disc while the specimen is still hot. Replace the base plate immediately, making sure to keep the mold and specimen oriented so that the bottom face of the compacted specimen remains directly in contact with, and is fully supported by, the base plate.

NOTE: Paper discs need to be removed while the AR-AC specimen is hot. The discs are very difficult to remove after the specimens have cooled.

(k) If any part of the top surface of a compacted specimen is visually observed to increase in height (rise or swell in the mold) after compaction, stop testing and discard the prepared specimens. Adjust the gradation of the aggregate-mineral admixture blend to provide additional void space to accommodate the CRA, then batch and compact new trial AR-AC specimens. If no visible increase in height occurs, proceed with paragraphs 7(l) through 7(o).

(l) Allow each compacted specimen to cool in a vertical position in the mold (with the base plate on the bottom and the top surface exposed to air) until they are cool enough to be extruded without damaging the specimen. Rotate the base plate occasionally to prevent sticking.

NOTE: Generally specimens can be extruded without damage when they are at a temperature of approximately 77 to 90 ºF.

NOTE: Cooling may be accomplished at room temperature, or in a 77 ºF air bath. If more rapid cooling is desired, the mold and specimen may be placed in front of a fan until cool, ***but do not turn the mold on its side***.

(m) Orienting the mold and specimen so that the ram pushes on the bottom face (base plate face) of the specimen, extrude the specimen.

NOTE: Care shall be taken in extruding the specimen from the mold, so as not to deform or damage the specimen. If any specimen is deformed or damaged during extrusion, the entire set of specimens at that CRA binder content shall be discarded and a new set prepared.

(n) Immediately upon extrusion, measure and record the height of the specimen to the nearest 0.001 inch and determine and record its weight in air to the nearest 0.1 gram.

NOTE: Compacted AR-AC specimens shall be 2.50 ± 0.20 inches in height. If this criteria is not met for the specimens at each CRA binder content, the entire set of specimens at that CRA binder content shall be discarded and a new set prepared after necessary adjustments in the aggregate weight have been made using Equation 2 (see Note 1 in Table 1).

(o) Repeat the procedures in paragraphs 7(e) through 7(n) for the required specimens.

BULK SPECIFIC GRAVITY/BULK DENSITY OF SPECIMENS

8. (a) Determine the bulk specific gravity of the three compacted AR-AC specimens at each CRA binder content in accordance with ARIZ 415, Method A, except that the paraffin method shall not be used. The determination of the “Weight in Water” and “S.S.D. Weight" of each specimen will be completed before the next specimen is submerged for its "Weight in Water" determination.

NOTE: Specimens fabricated in the laboratory that have not been exposed to moisture do not require drying after extrusion from the molds. The specimen weight in air obtained in paragraph 8(a) is its dry weight.

(b) Determine the density in pounds per cubic foot (pcf) by multiplying the specific gravity of each specimen by 62.3 pcf.

NOTE: For each CRA binder content, the densities of individual compacted specimens shall not differ by more than 2.0 pcf. If this density requirement is not met, the entire set of specimens at that CRA binder content shall be discarded and a new set of specimens prepared.

(c) Determine the average bulk specific gravity (G_{mb}) and/or average bulk density values for each CRA binder content and plot on a separate graph versus CRA binder content. Connect the plotted points with a smooth curve that provides the “best fit” for all values as shown in Figure 1.

STABILITY AND FLOW DETERMINATION

9. The stability, stability corrected for height, and flow of each specimen shall be determined according to ARIZ 410. (Stability and stability corrected for height are recorded to the nearest 10 pounds, and flow is recorded to the nearest 0.01 inch.)

(a) Determine and record the average values for stability corrected for height (to the nearest 10 pounds) and flow (to the nearest 0.01 inch) for each CRA binder content, and plot each on a separate graph using the same scale for CRA binder content as used in 8(c). Connect the plotted points with a smooth curve that provides the “best fit” for all values as shown in Figure 1.

NOTE: Flow values may be high compared to conventional asphaltic concrete mixtures.

MAXIMUM THEORETICAL SPECIFIC GRAVITY (RICE TEST)

10. The maximum theoretical specific gravity of the mixture shall be determined in accordance with ARIZ 806 at 6.0% CRA binder content with the following modifications.

(a) Prepare the AR-AC specimens including mineral admixture according to the procedures described in Section 5 and paragraphs 7(a) through 7(c) using 6.0% CRA by total mix weight. A liquid anti-stripping agent is not used.

(b) Spread the entire Rice sample in a large pan at nominal single-stone thickness. Avoid stacking particles as feasible.

(c) Oven cure the entire Rice sample for 2 hours ± 10 minutes at 300 ± 5 ºF.

(d) Immediately upon removal from the oven, place the sample on a tarp or sheet of paper and break up fine particle agglomerations. Then, in a rolling motion thoroughly mix and spread the sample according to the procedures described in ARIZ 416. The circular mass shall be cut into 6 equal pie-shaped segments. Take opposite segments for each individual test sample and use up the entire batch.

(e) Using Equation 5, calculate the effective specific gravity of the aggregate-mineral admixture blend (G_{se}).

Equation 5:

$$G_{se} = \frac{100 - P_{br}}{\frac{100}{G_{mm}} - \frac{P_{br}}{G_b}}$$

Where:
G_{se} = Effective specific gravity of the aggregate-mineral admixture blend.
G_{mm} = Maximum theoretical specifc gravity of the AR-AC at CRA binder content P_{br}.
P_{br} = CRA binder content at which the Rice test was performed.
G_b = Specific gravity of the CRA.

(f) Using Equation 6, calculate the maximum theoretical specific gravity (G_{mm}) for different CRA binder contents.

NOTE: G_{se} is considered constant regardless of binder content.

Equation 6:

$$G_{mm} = \frac{100}{\frac{P_s}{G_{se}} + \frac{P_b}{G_b}}$$

Where:
G_{mm} = Maximum theoretical specific gravity of the AR-AC at CRA binder content P_b.
P_s = Aggregate and mineral admixture content, percent by total weight of mix (100-P_b).
P_b = CRA binder content, percent by total weight of mix.
G_{se} = Effective specific gravity of the aggregate-mineral admixture blend.
G_b = Specific gravity of the CRA.

DETERMINATION OF DESIGN CRA BINDER CONTENT

11. The design CRA binder content is determined as follows in paragraphs 11(a) through 11(e).

(a) For each CRA binder content used, calculate effective voids (V_a), percent absorbed CRA (P_{ba}), voids in mineral aggregate (VMA), and voids filled with CRA (VFA) using the following equations.

1) Using Equation 7, calculate the effective voids (V_a). The calculated G_{mm} values for the respective CRA binder contents are used to determine the corresponding effective voids content of the compacted Marshall specimens at each CRA binder content level.

Equation 7:

$$V_a = \left(\frac{G_{mm} - G_{mb}}{G_{mm}} \right) \times 100$$

Where:
V_a = Effective voids in the compacted mixture, percent of total volume.
G_{mm} = Maximum theoretical specifc gravity of the AC-AR at CRA binder content P_b.
G_{mb} = Bulk specific gravity of compacted mixture specimens.

2) Using Equation 8, calculate the percent absorbed CRA (P_{ba}).

Equation 8: $$P_{ba} = \left(\frac{G_{se} - G_{sb}}{G_{sb} \times G_{se}} \right) \times G_b \times 100$$

Where: P_{ba} = Absorbed CRA, percent by total weight of mix.
G_{se} = Effective specific gravity of the aggregate-mineral admixture blend.
G_b = Specific gravity of the CRA.
G_{sb} = Bulk oven dry specific gravity of the aggregate-mineral admixture blend.

3) Using Equation 9, calculate voids in mineral aggregate (VMA).

Equation 9: $$VMA = 100 - \left(\frac{G_{mb} \times P_s}{G_{sb}} \right)$$

Where: VMA = Voids in the mineral aggregate, percent of bulk volume.
G_{sb} = Bulk oven dry specific gravity of the aggregate-mineral admixture blend.
G_{mb} = Bulk specific gravity of compacted mixture specimens.
P_s = Aggregate and mineral admixture content, percent by total weight of mix ($100-P_b$).

4) Using Equation 10, calculate voids filled with CRA (VFA).

Equation 10: $$VFA = \left(\frac{VMA - V_a}{VMA} \right) \times 100$$

Where: VFA = Voids filled with CRA.
VMA = Voids in the mineral aggregate, percent of bulk volume.
V_a = Effective voids in the compacted mixture, percent of total volume.

(b) Using a separate graph for each of the volumetric properties calculated in paragraph 11(a), plot the average value for each set of three specimens versus CRA binder content. Connect the plotted points with a smooth curve that provides the “best fit” for all values as shown in Figure 1.

NOTE: The percentage of absorbed CRA (P_{ba}) and the effective specific gravity of the aggregate-mineral admixture blend (G_{se}) do not vary with CRA binder content.

(c) The design CRA binder content shall be the CRA binder content which meets the Mix Design Criteria requirements of the specifications, and provides effective voids as close as possible to the middle of the specified range.

(d) Use the effective voids (V_a) plot or interpolation to select the CRA binder content that yields the target effective voids content in the specifications. Use interpolation or the other plots to determine the values of bulk specific gravity (G_{mb}) and/or bulk density, VMA, VFA, stability and flow that correspond to the selected CRA binder content, and compare these with the limits in the specifications. Properties for which limits are not specified are evaluated by the Engineer for information only.

(e) If it is not possible to obtain specification compliance within the range of CRA binder contents used, a determination must be made to either redesign the mix (different aggregate gradation or source) or prepare additional specimens at other CRA binder contents for bulk specific gravity (G_{mb}) and/or bulk density, stability/flow testing, and volumetric analyses.

(f) Using Equation 6, calculate the maximum theoretical specific gravity (G_{mm}) for the design CRA design content. The maximum theoretical density is determined by multiplying the calculated G_{mm} by 62.3 pounds per cubic foot.

(g) For information, calculate the following volumetric properties at the design CRA binder content.

1) Using Equation 11, calculate the percent effective CRA binder content (P_{be}) of the AR-AC mixture.

Equation 11:

$$P_{be} = P_b - \left(\frac{P_{ba} \times P_s}{100} \right)$$

Where:
- P_{be} = Percent effective CRA binder content of the mixture (free binder not absorbed).
- P_b = CRA binder content, percent by total weight of mix.
- P_{ba} = Absorbed CRA, percent by total weight of mix.
- P_s = Aggregate and mineral admixture content, percent by total weight of mix (100-P_b).

2) Using Equation 12, calculate the effective CRA volume (V_{be}).

Equation 12:

$$V_{be} = \frac{P_{be} \times G_{mb}}{G_b}$$

Where: V_{be} = Effective CRA volume, percent of bulk volume.
P_{be} = Percent effective CRA binder content of the mixture (free binder not absorbed).
G_{mb} = Bulk specific gravity of compacted mixture specimens.
G_b = Specific gravity of the CRA.

MIX DESIGN GRADATION TARGET VALUES

12. The desired target values for the aggregate composite and the aggregate-mineral admixture blend composite in the AR-AC mixture shall be from the composited gradation and shall be expressed as percent passing particular sieve sizes as required by the specifications for the project.

REPORT

13. Report the test results and data obtained on the appropriate form. Liberal use of the remarks area to clarify and/or emphasize any element of the design is strongly recommended. Information required in the mix design report includes:

(a) Aggregate and Mineral Admixture:
  1) Aggregate source and identification
  2) Individual aggregate stockpile or bin gradations
  3) Mineral admixture type, source, and specific gravity
  4) Aggregate blend proportions and composite gradation for the mix design, with and without mineral admixture
  5) Fine and coarse aggregate specific gravities (Bulk Oven Dry, SSD, Apparent) and absorption
  6) Combined specific gravities [Bulk Oven Dry (G_{sb}), SSD, Apparent] and absorption of the aggregate-mineral admixture blend
  7) Aggregate quality
    a) LA Abrasion
    b) Sand Equivalent
    c) Fractured Coarse Aggregate Particles (Percentage with one fractured face and percentage with two fractured faces)

d) Uncompacted Void Content
e) Carbonates (When applicable)

(b) CRA Binder Design (from supplier), including:
1) Source and grade of base asphalt cement
2) Source and type of crumb rubber
3) Crumb rubber gradation
4) Proportions of asphalt cement and crumb rubber
5) CRA binder properties, in compliance with Section 1009 of the ADOT Specifications
6) CRA specific gravity (G_b)
7) Asphalt cement specific gravity

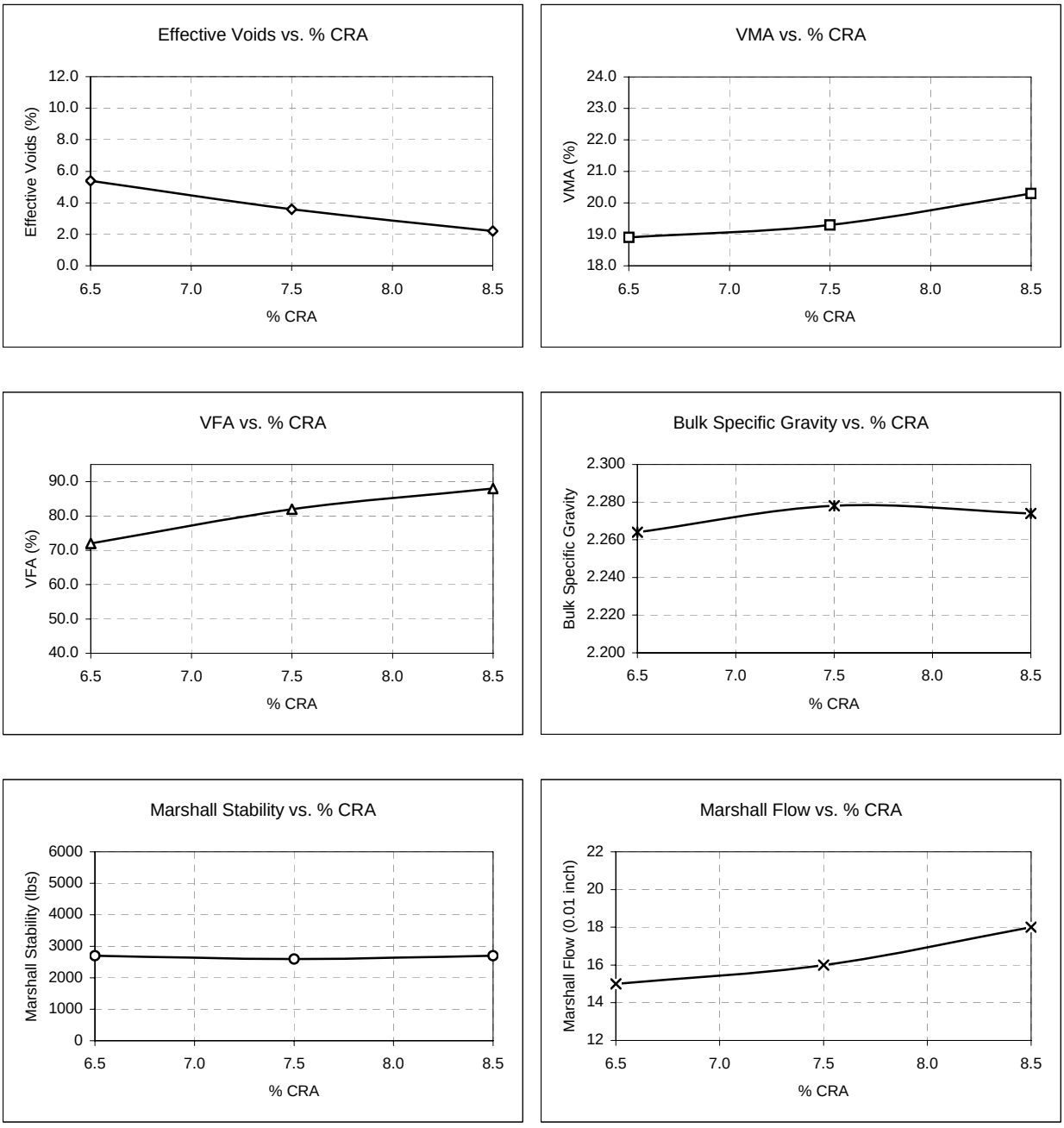
(c) Maximum theoretical specific gravity (G_{mm}) and density (pcf) at the CRA binder content at which the Rice test was performed (P_{br})

(d) Mixture Compaction Trials:
1) CRA binder content (P_b)
2) Aggregate and mineral admixture content (P_s)
3) Calculated maximum theoretical specific gravity (G_{mm}) and density (pcf)
4) Bulk specific gravity (G_{mb}) and bulk density (pcf) of Marshall specimens
5) Percent effective voids (V_a)
6) Percent voids in mineral aggregate (VMA)
7) Percent air voids filled (VFA)
8) Percent absorbed CRA (P_{ba})
9) Effective specific gravity of the aggregate-mineral admixture blend (G_{se})
10) Effective CRA binder contents (P_{be}) and volumes (V_{be})
11) Marshall stability (nearest 10 pounds)
12) Marshall flow (0.01 inch)

(e) Plots of the following properties versus CRA binder content:
1) Percent effective voids (V_a)
2) Percent voids in mineral aggregate (VMA)
3) Percent air voids filled (VFA)
4) Bulk specific gravity (G_{mb}) and/or bulk density
5) Marshall stability
6) Marshall flow

(f) Final Design:
1) CRA binder content (P_b)
2) Calculated maximum theoretical specific gravity (G_{mm}) and density (pcf)
3) Bulk specific gravity (G_{mb}) and bulk density (pcf) of Marshall specimens
4) Percent effective voids (V_a)

5) Percent voids in mineral aggregate (VMA)
6) Percent air voids filled (VFA)
7) Percent absorbed CRA (P_{ba})
8) Effective specific gravity of the aggregate-mineral admixture blend (G_{se})
9) Effective CRA binder contents (P_{be}) and volumes (V_{be})
10) Marshall stability (nearest 10 pounds)
11) Marshall flow (0.01 inch)



Example Plots of Effective Voids, VMA, VFA, Bulk Specific Gravity, Marshall Stability, and Marshall Flow versus CRA Binder Content

FIGURE 1