ASPHALT TECHNICIAN CERTIFICATION

WORKBOOK

ARIZONA TECHNICAL TESTING INSTITUTE

Revised November 2019

FORWARD

The Arizona Technical Testing Institute (ATTI) is a nonprofit organization formed to promote the highest standard in highway construction materials sampling and testing through certification of technicians. ATTI certifications emphasize a hands-on approach, that is, applicants must satisfactorily demonstrate test methods as well as pass a written exam to receive certification.

The organization is represented by members from the Arizona Department of Transportation (ADOT), highway contractors, material suppliers, materials testing laboratories, Arizona Rock Products Association (ARPA), Federal Highway Administration (FHWA), and Arizona General Contractors (AGC).

ATTI certifications satisfy ADOT and federal requirements which specify that technicians performing materials sampling and testing on ADOT projects are properly qualified.

ATTI provides the following certifications:

ATTI FIELD TECHNICIAN – field sampling and testing of soils, aggregates, asphalt, and asphaltic concrete,

ATTI LABORATORY SOILS/AGGREGATE TECHNICIAN – laboratory sampling and testing of soils and aggregate,

ATTI ASPHALT TECHNICIAN – laboratory sampling and testing of asphaltic concrete.

TABLE OF CONTENTS

CERTIFICATION INFORMATION SECTION

INTRODUCTION

The ATTI Asphalt Technician Certification program evaluates the competency of applicants performing testing of bituminous mixtures (asphaltic mixes) and aggregates in a laboratory. Certification is based on satisfactory demonstration of all specified sampling and testing methods, as well as passing a written examination. Applicants are advised to receive training or have experience performing the test methods and calculations before attempting to obtain certification.

This workbook provides information regarding the requirements for ATTI Asphalt Technician Certification, administration of the certification process, and topics covered during the certification examinations. Brief coverage is given to safety issues, representative samples, record keeping, and soils and aggregates properties. Most importantly, the workbook contains copies of the applicable testing methods which a certified ATTI Soils/Aggregate Technician must be able to perform.

PERFORMANCE EXAMINATION

As Stated earlier, the emphasis of this certification program is technician demonstration of proficiency in performing all test methods which have been specified above.

Technicians may not use any notes or books while taking the performance exam. The examiner will maintain possession of all examination paperwork.

The examiner will use standardized checklists to verify proper procedure by the technician. During the performance examination, the examiner will indicate a technician's compliance with each identified item on the individual test method checklist with a "Yes" or "No" in the space provided. If any significant deficiencies are observed during the exam, the examiner must indicate "No" for that item. Any "No" will constitute failure of that test method. All checklist items must be performed correctly or the test method is considered failed.

Once completed, the examiner will inform the technician if the test method was passed or failed. If failed, the examiner will indicate the step or steps that were not performed properly. The failed test method may be demonstrated a second time at the discretion of the examiners. The retest should be performed after all other tests have been completed, the technician has studied the failed test method, and the examiner is available. If a test method is failed a second time, the applicant must schedule a retest within 1 year at a cost of $50.00.

If the technician requests to start over a test method once they have begun, the examiner will allow the technician to restart the test method and disregard findings of the incomplete test. The technician will be allowed to restart a test method one time only.

It is recommended that technicians perform all test methods during an examination period. Any test methods not performed will be considered failed.

WRITTEN EXAMINATION

The written examination has a 3 hour time limit to complete. The questions and calculations are derived directly from the previously mentioned test methods and from information presented in the first few chapters of this manual. Eighty (80) percent of the written examination questions must be answered correctly and all calculations performed correctly to achieve a passing score.

Notes and books may not be used while taking the written examination. The examiner will maintain possession of all examination paperwork.

RETESTING

If a technician fails to successfully demonstrate a test method as prescribed, the technician may be allowed to demonstrate the failed test method a second time during the same examination period at the discretion of the examiners. The retest should be performed after all other tests have been completed, the technician has studied the failed test method, and the examiner is available. Failed test methods must be re-demonstrated within twelve months of the original examination date. All retesting is at the discretion of the examiners.

A technician failing the written or calculations examination is required to retake the entire written or calculations examination within twelve months of the original test date.

If a technician fails the performance and /or written examinations a second time, a fee will be charged for additional testing that must be performed within twelve months of the original examination date. If the failed items are not successfully passed the third try, the technician will be required to register and retake the entire certification examination.

CERTIFICATION

To receive certification, the technician must successfully demonstrate **all** test methods as well as correctly answer **at least 80 percent** of the written exam questions and correctly perform **all** calculations. Certification is granted for a period of five years. Successful completion of the entire examination program is required for re-certification.

CANCELLATION OR NO-SHOW

The cancellation policy is detailed in the ATTI Administration Manual which is available on the ATTI website at www.attiaz.org.

APPEALS

ATTI certification examinations, policies, procedures, requirements, and materials are developed through a cooperative effort of the ATTI technical advisory board and industry experts. The ATTI Board of Directors approves and provides oversight of the certification program. If a technician feels that the certification exams have not been correctly administered or if the technician desires to appeal their exam scores, they may do so.

Appeals should be made in the following sequence:

1. Senior Examiner
2. Executive Director
3. Technical Advisory Board
4. ATTI Board of Directors

If there is not consensual resolution at any level, the technician may escalate their appeal to the next level. The decision of the Board of directors is final.

Technicians are encouraged to provide feedback to ATTI on any portion of the examinations, manual content, exam administration, or requirements of the ATTI certification process. The comments received will be discussed by the technical advisory board and, if merited, revisions to the program will be initiated.

TECHNICAL SECTION

SAFETY

Some of the test methods in this manual may involve hazardous materials operations, and/or equipment. This manual does not claim to address all relevant safety issues which may be encountered or which may be associated with its use or with the performance of test procedures introduced here. It is the responsibility of the technician to determine, establish, and follow appropriate health and safety practices. The technician must also determine the applicability of any regulatory limitations of test equipment and chemicals.

THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA)

OSHA has established safety requirements for individuals working in various environments. In the field and laboratory these requirements include such measures as wearing hard hats, eye protection, and protective footwear as well as the need to observe certain precautions when operating machinery and other equipment. There are also regulations pertaining to the handling and storage of chemicals, nuclear devices, and other hazardous materials. This short discussion on safety is not meant to preclude or to include OSHA requirements. **It is up to the individual technician to be acquainted with OSHA regulations that apply to their particular job assignment.**

SAFETY IN THE LABORATORY

Most work environments have initiated and have a set of safety standards in place. It is imperative that you become familiar with and follow the procedures. This discussion on safety is not meant to replace “on the job” safety guidelines, but merely to augment and reiterate them. The intent of safety as presented here is toward prevention - the identification of safety issues and their appropriate resolution.

Most on the job accidents involve human error. Therefore, it is important that you constantly be on the alert for potential safety risks and hazards both in the field and in the laboratory.

NUCLEAR GAUGES AND RADIATION SAFETY

Some tests included in this manual may involve the use of nuclear devices. Individuals who handle these devices MUST be qualified in the proper handling, usage, and storage of these devices. Do not handle or operate nuclear gauges without first completing the proper qualification requirements. See your Nuclear Safety Regulatory Officer. The source has been removed from the gauge used in the class training.

REPRESENTATIVE SAMPLES

As should be apparent, acceptance or rejection of materials is highly dependent on the representativeness of a small sample that is tested to determine the quality of a large quantity of material. If the sample is not truly representative of the larger quantity, acceptable material might be rejected or unacceptable material might be accepted. Unbiased samples must be obtained in a way that the true nature of the material is represented. For example, aggregate stockpiles should not be sampled at the surface where coarser slough material is present. Similarly, all material from an asphaltic concrete plate sample should be obtained with single strokes of the sampling device through the middle of the plate, excluding material that sloughs onto the plate after initial sampling.

RANDOM SAMPLING

A random sample is any sample which has an equal chance as any other sample of being selected from a population. In other words, there is an equal chance for all locations and all fractions of materials to be sampled.

Samples should not be obtained on a predetermined basis or based on the quality of the material in a certain area. If sampling is not performed on a random basis, the quality of the sample can be artificially modified and the sample will no longer be representative of the larger quantity.

When a sample is not representative, it is said to be biased. Examples of biased sampling that should not be used include sampling a roadway at a given interval such as 1500 feet; sampling asphaltic concrete production at a given frequency, such as every 500 tons; or taking samples at a given time, such as every hour on the hour.

Random sampling is usually accomplished with the use of random number generators or tables of random numbers. Most calculators and computers contain a random number generator that merely requires the operator to hit a button. The automated random number generators use programmed tables of random numbers similar to the table shown in figure 3. Random number tables are simply random arrangements of numbers of any table length.

.72	.51	.98	.45	.01	.55	.25	.24	.73	.43
.99	.13	.69	.59	.88	.35	.07	.66	.82	.78
.68	.40	.08	.83	.11	.48	.56	.19	.46	.31
.03	.96	.49	.10	.74	.38	.22	.87	.33	.57
.70	.28	.04	.63	.27	.15	.60	.44	.03	.37
.16	.53	.85	.09	.39	.91	.47	.30	.77	.42

Figure 3. Table of random Numbers

ASTM D3665 - "Standard Practice for Random Sampling of Construction Materials" is a reference used by the industry for determining random locations or timing at which samples of construction materials are to be taken. The ASTM method uses a table of random numbers and details the procedures for determining random times for belt sampling, random lengths for windrow sampling, random sampling of in-place paved materials, and random truck load number sampling.

To obtain a group of random numbers, select a starting number in a random number table, never repeating the same starting number, and proceed from the starting number reading left to right, top to bottom, bottom to top, right to left or diagonally. Each number will then correspond to a sampling frequency.

Example 1:

Four samples are required for a 12 feet wide pavement with a lot size determined to be 4000 linear feet. The lot begins at station 100+00. Use the random number table in Figure 3 to determine the sample locations.

Step 1, from the given information:
Lot begins at station 100+00
Lot ends at station 140+00
Length of lot = 4,000 feet

Step 2, determine the sample location:

Using the random number table, obtain two sets of 4 random numbers each.

Set 1 will be used to determine stationing (X) of the samples by multiplying the random numbers by 4,000 feet.

Set 2 will be used to determine the sampling distance from the right edge of pavement (Y) by multiplying the random numbers by 12 feet.

Step 2a, random numbers chosen from table:

Set 1:	.13	.69	.59	.88
Set 2:	.73	.82	.46	.33

Step 2b, sample coordinate locations determined:

Sample #1:
X= .13 X 4000 = 520 feet
Y= .73 X 12 = 8.8 feet

Sample #2:
X= .69 X 4000 = 2760 feet
Y= .82 X 12 = 9.8 feet

Sample #3:
X= .59 X 4000 = 2360 feet
Y= .46 X 12 = 5.5 feet

Sample #4:
X= .88 X 4000 = 3520 feet
Y= .33 X 12 = 4.0 feet

Step 2c, samples located by stationing and offset:

Sample #1:
Station 100+00 + 520 feet = Station 105+20 @ 8.8 feet from right edge of pavement

Sample #2:
Station 100+00 + 2760 feet = Station 127+60 @ 9.8 feet from right edge of pavement

Sample #3:
Station 100+00 + 2360 feet = Station 123+60 @ 5.5 feet from right edge of pavement

Sample #4:
Station 100+00 + 3520 feet = Station 135+20 @ 4.4 feet from right edge of pavement

When obtaining samples from a large area (or lot), divide the area into sublots if necessary and obtain samples from each sublot using stratified random sampling. Stratified random sampling assures that samples are taken from throughout the entire lot and are not concentrated in one area of the lot. See Figure 4.

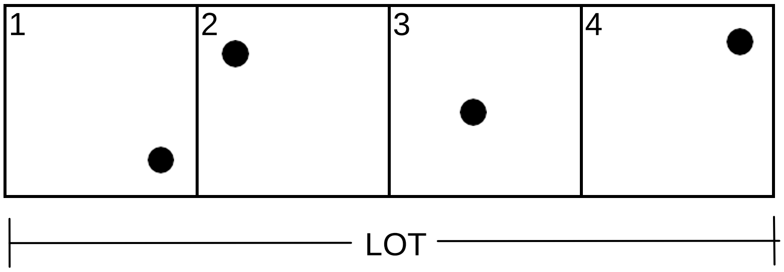


Figure 4. Sublots for stratified sampling.

SAMPLING AND TESTING RECORDS

All data collected during the sampling and testing processes should be documented electronically or retained on paper. This documentation provides:

- Records pertaining to individual samples.
- A process to trace samples and test results.
- Control of samples as they are processed and tested.
- Who did the sampling and testing.
- What testing was done.
- Permanent record of test data and test results.

Sample tickets used for sample identification, work instruction cards directing which tests to perform, logs of samples and tests performed, test data worksheets, and test result reporting forms are all routinely used records which a technician must have familiarity.

Test methods provided in AASHTO Standard Specifications, Part I/tests and in the ADOT Materials Testing Manual define which data to collect, calculations to perform, and what information to report. They also have guidelines for determining if test results are reasonable.

SAMPLE TICKETS

Sample tickets need to be attached to or accompany all samples. A sample ticket is the document which identifies an individual sample. Sample tickets will usually contain information such as:

- Project number or code.
- Name of the person who obtained sample.
- Type of material.
- Date and time the sample was obtained.
- Purpose of the sample.
- Where the sample was taken
- Sample number.
- Type of testing to be performed.

TEST RESULTS

Field sampling and testing must always be done according to test methods. Precise and reliable sampling and testing directly impacts the acceptance and payment of a product. If sampling and testing are not performed correctly, a substandard product could be accepted at full compensation or an acceptable product could be rejected. Test methods used most frequently are contained in the ADOT Materials Testing Manual and the AASHTO Standard Specifications, Part II, Tests. These methods describe how large a sample should be, step-by-step procedures, what data is to be collected, what calculations are to be performed, and what test results are reported.

The reliability of testing is often checked with the use of split samples which are tested by two different technicians. If individual test results or the comparison of split samples do not seem reasonable, an investigation should be conducted to establish why. Usually the discrepancy will be due to procedural or equipment deficiencies, errors in calculations, incorrect transposition of data, or the use of procedural shortcuts. Poor equipment calibration or equipment malfunction and improper handling of samples can also cause unreliable test results. Retesting should be performed only after the discrepancies have been corrected.

Occasionally, an unreasonable test result may be encountered. Unreasonable test results should not simply be labeled as outliers and discarded. Results should only be discarded if they are outside of the range of possible results or if they are determined statistically to be outliers. ASTM E178 gives a common method for determining outliers in the highway construction industry.

All test reports should clearly identify the individual who performed the test and the date the test was completed. Test reports should also include the signature of the individual taking responsibility for the validity of the testing. All revisions made to a test report must identify the person making the changes and the date the changes were made. Example copies of test report forms are included in some of the test methods presented in this workbook.

CONTROL CHARTS

Control charts enable us to visually observe and check test data. They are referred to as both run control charts and statistical charts. When used by a contractor, these charts show the trends of production. When used with specification limits, they show specification compliance. Control charts provide many benefits including:

- A method for discovering production problems early.
- A decrease in the frequency of inspections.
- A basis for revising specification limits.
- A permanent record of quality.

Control charts also help to decrease variability, help establish process capability and make everyone involved more aware of quality.

Run charts, also known as trend charts, are the simplest form of control charts. They can be used to plot single values and to verify that test results are within specification or production limits. Run charts provide an indication of trends, but are not statistically based. A production process that is in excellent control and is producing very desirable material is illustrated in Figure 5.

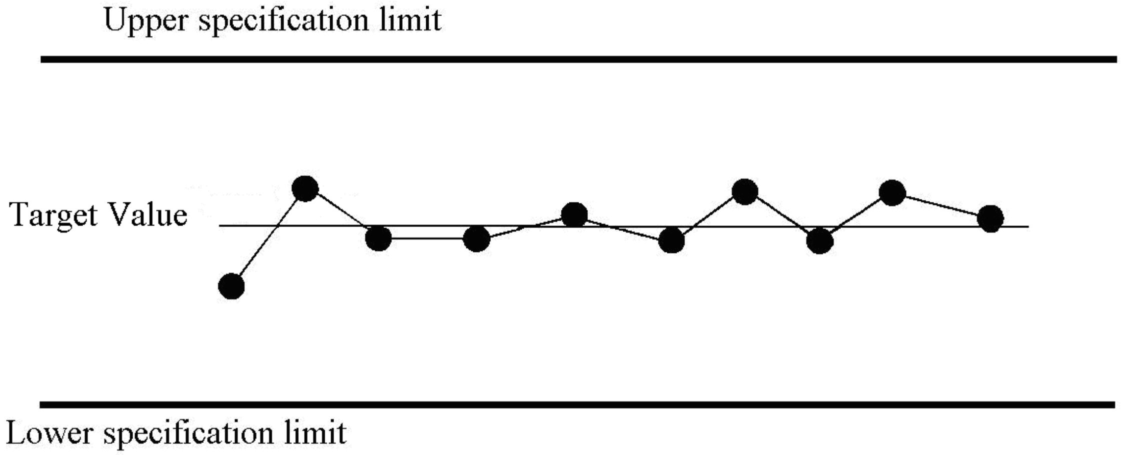


***Figure 5. Run Chart Illustrating process in control*.**

The two most common statistical control charts used in highway construction are the x-bar chart which plots average values and the R chart which plots the spread, or range, of the actual values. These charts are used together to determine when an assignable cause is influencing a change in the process. Assignable causes are due to something that can be identified and corrected. Eight consecutive points lying on either side of the target value or a single point outside of the control limits are two readily apparent conditions of the statistical x-bar control chart that indicate a process may not be in control. Figure 6 illustrates both of these conditions.

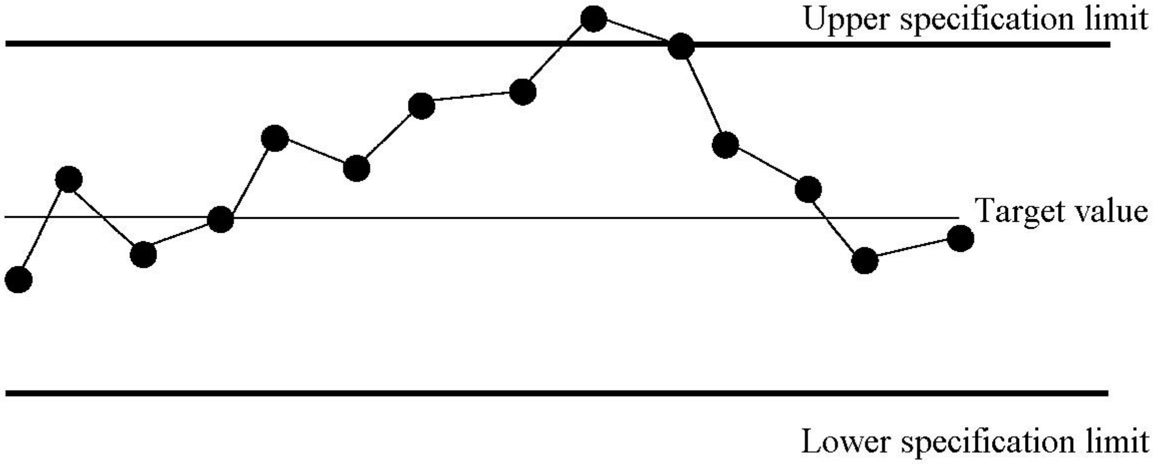


Figure 6. eight points on one side of the target value and one point outside of the upper specification limit indicate a problem with this production.

TEST METHODS

ARIZ 103b
December 4, 2015
(2 Pages)

SAMPLING BITUMINOUS MATERIALS

(An Arizona Method)

1. SCOPE

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

1.2 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.

1.3 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”.

2. SIZE OF SAMPLES

2.1 A minimum of 1 gal. of Asphalt Binder.

2.2 A minimum of two ½ gal. containers per sample of Emulsions.

3. CONTAINERS

3.1 Containers for Asphalt Binder, shall be double friction top cans.

3.2 Containers for Emulsion samples shall be wide mouth containers made of plastic.

4. PROTECTION AND PRESERVATION OF SAMPLES

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

4.2 The container shall be tightly sealed immediately after obtaining the sample.

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

4.4 Samples of Emulsion shall be protected from freezing.

4.5 Transferring samples from one container to another shall be avoided if possible.

4.6 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.

5. PROCEDURE

5.1 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.

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

5.3 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.

5.4 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.

5.5 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.

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

ADOT
Infrastructure Delivery and Operations

ARIZ 104f
November 8, 2017
(6 Pages)

SAMPLING ASPHALTIC CONCRETE MIXTURES

(An Arizona Method)

1. SCOPE

1.1 This procedure describes the methods which are to be used when sampling asphaltic concrete mixtures in order to best assure representative samples of the materials being placed.

1.2 Sampling asphaltic concrete mixtures by this procedure may involve hazardous material, operations, or equipment. This procedure 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.

1.3 For the purpose of this method, asphaltic concrete mixtures are referred to as either Asphaltic Concrete (AC) or Asphaltic Concrete Friction Course (ACFC), regardless of the asphalt binder type.

2. APPARATUS

2.1 Sampling Plate - A 4 foot x 1 foot x 1/16 inch steel plate, which has been prepared with a 1/8 inch hole at each corner of one end and a sufficient length of wire tied through each hole to form a loop approximately 4 feet in length. The sampling plate may be used when sampling AC mixtures.

2.2 Cookie-Cutter Template - As an alternate to obtaining the sample from the sampling plate, a rectangular metal template ("cookie cutter") and metal plate of sufficient size may be used to sample the AC mixture. The metal template and plate shall be of sufficient size so that the desired amount of material is obtained by a single use of the template and plate at any one location. The metal plate shall be prepared with a wire(s) of sufficient length attached to each corner on one side of the metal plate (the short side when the plate is not square) so the metal plate may be located by raising the wire(s) after the laydown machine has passed.

2.3 Miscellaneous Brushes - May be helpful when obtaining the entire amount of AC mixture from a cookie-cutter template.

2.4 Flat Square Point Shovel - A flat square point shovel shall be used when sampling AC mixtures. A flat square point shovel may also facilitate sampling ACFC mixtures and when sampling by other procedures as described below.

2.5 5-Gallon Bucket, or other suitable container - Shall be used when sampling AC mixtures and ACFC mixtures.

3. SIZE OF SAMPLES

3.1 For AC mixtures designed with Marshall design procedures, minimum 75 pounds.

3.2 For AC mixtures designed with Gyratory design procedures, minimum 130 pounds.

3.3 For ACFC mixtures, minimum 50 pounds.

4. SAMPLING AC MIXTURES

4.1 The sampling plate shall be placed on the roadway just ahead of the laydown machine. Except for wider mats when a sample is being taken from the middle of the mat, the sampling plate is placed so that the end with the wire is approximately one foot in from the right or left edge of the mat being laid. The sampling should be alternated between the right and left edges when practical. The wire attached to the end of the plate shall be held to the ground to allow the laydown machine to pass over the plate and wire.

4.2 After the laydown machine has passed, locate the plate by raising the wire.

4.3 The sample shall be taken from the plate using a flat square point shovel. The sample shall consist of the full depth of material for one shovel width from the center portion of the plate over its entire length. Material covering the entire plate shall not be taken. A single pass of the shovel shall be made, moving along the surface of the plate until the shovel is full. Carefully deposit the AC mixture into a 5-gallon bucket, or other suitable container. Material which has sloughed into the resultant trench shall not be obtained. At the next undisturbed area of material on the plate, repeat shoveling and placing the material into the container. If necessary, additional material may be obtained by using an additional plate(s) in the immediate vicinity and combining all material. The use of an additional plate(s) cannot be used in lieu of splitting.

Note: When sampling with the "cookie cutter", the metal plate shall be placed on the roadway at the location where the sample is to be taken, just ahead of the laydown machine. If the metal template is not square, it shall be placed on the roadway so that the longest side is in a transverse direction across the roadway. The wire(s) shall be held to the ground to allow the laydown machine to pass over the plate and wire(s). After the laydown machine has passed, locate the plate by raising the wire(s). The template is pressed through the AC mixture until it rests squarely upon the plate. The entire amount of AC mixture is removed from the interior of the template and carefully placed into a 5-gallon bucket, or other suitable container. Obtaining multiple samples cannot be used in lieu of splitting.

5. SAMPLING ACFC MIXTURES

5.1 When sampling ACFC mixtures, an adequate amount of material shall be taken from the truck at the mixing plant and placed into a 5-gallon bucket, or other suitable container. The sample shall be taken from at least 3 random locations, approximately 12" below the surface, within five minutes from the time the loading of the truck is completed.

5.2 Material that is to be tested immediately after it has been sampled shall be protected to avoid heat loss while it is being transported to the laboratory.

6. SAMPLING FINISHED AC PAVEMENT

6.1 Samples of AC from finished pavement shall be taken through the complete thickness of the pavement or lift, in such a manner which causes minimum disturbance to the sample.

6.2 If a coring apparatus is used, the coring bit shall be subjected to enough vertical pressure to penetrate the pavement without causing damage to equipment or disturbance of the sample. The minimum core diameter shall be 4 inches.

6.3 If coring equipment is not available, the sample may be taken with the use of a saw, pick, jackhammer, or other suitable means if a suitable specimen can be obtained for the intended testing.

6.4 All samples shall be handled carefully so that they maintain their original form. The samples shall be transported on a relatively flat surface, and adequately protected to preserve their shape and to prevent damage.

6.5 The use of ice may be found helpful in obtaining and/or preserving the condition of the specimen.

6.6 Samples shall be delivered to the laboratory for testing as expeditiously as reasonably possible. Samples shall be transported carefully in a covered container out of extreme environmental conditions.

7. SAMPLING MISCELLANEOUS PLACEMENT OF AC MIXTURES

7.1 When required, samples of AC mixtures placed in miscellaneous areas shall be obtained from locations and by means to provide appropriate representation of the AC mixture being placed. Miscellaneous areas are locations where representative samples would be difficult to obtain in-place due to geometry, paving area size, limited access, or other factors. These areas could include paving slopes, median islands, utility trenches, tapers, radius paving and any other area designated by the Engineer.

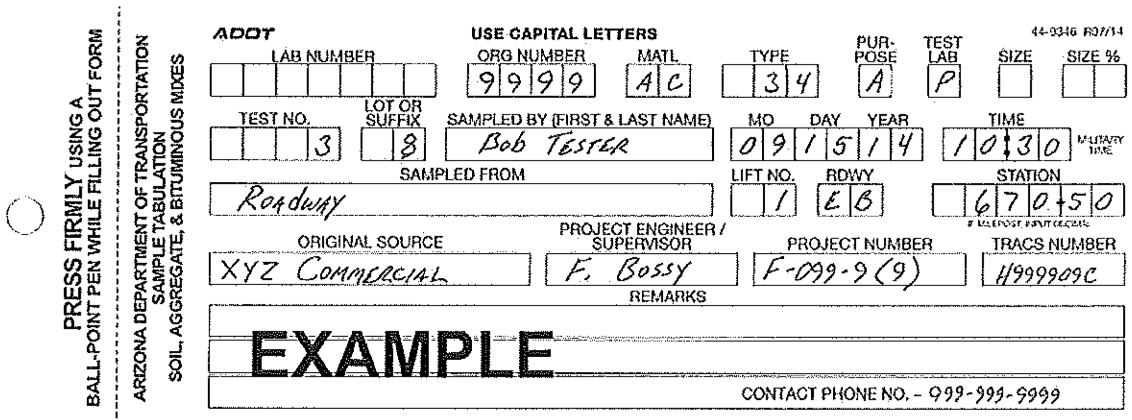
8. SAMPLE IDENTIFICATION

8.1 Each sample shall be identified by an accompanying sample ticket. Sample tickets shall be filled out as required to provide necessary information. The remarks area of the sample ticket shall be used as necessary to provide additional information, including the phone number of an individual who can be contacted regarding the sample.

8.2 The source of the sample shall be the "original source" of the material, as indicated on the sample ticket.

8.3 An example of a completed sample ticket used by ADOT for construction projects is shown in Figure 1. Commonly used codes for filling out the sample ticket are shown on the back side of the sample ticket (see Figure 2).

8.4 The sample ticket consists of three copies. The center copy is 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 is clear and easily read on all three copies.



PRESS FIRMLY USING A
BALL-POINT PEN WHILE FILLING OUT FORM

ARIZONA DEPARTMENT OF TRANSPORTATION
SAMPLE TABULATION
SOIL, AGGREGATE, & BITUMINOUS MIXES

ADOT **USE CAPITAL LETTERS** 44-9346 R07/14

LAB NUMBER	ORG NUMBER	MATL	TYPE	PUR-POSE	TEST LAB	SIZE	SIZE %
	9999	AC	34	A	P		

TEST NO.	LOT OR SUFFIX	SAMPLED BY (FIRST & LAST NAME)	MO	DAY	YEAR	TIME	
3	8	Bob TESTER	09	15	14	10:30	MILITARY TIME

SAMPLED FROM	LIFT NO.	RDWY	STATION
Roadway	1	EB	670+50

IF MILEPOST, INPUT DECIMAL

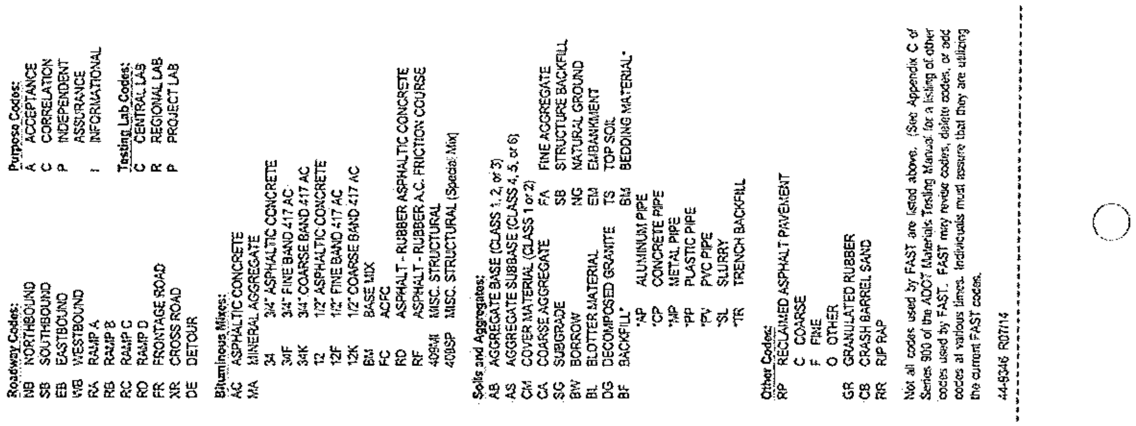
ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER
XYZ COMMERCIAL	F. Bossy	F-099-9(9)	H999909C

REMARKS

EXAMPLE

CONTACT PHONE NO. – 999-999-9999

FIGURE 1



Roadway Codes:

NB	NORTHBOUND
SB	SOUTHBOUND
EB	EASTBOUND
WB	WESTBOUND
RA	RAMP A
RB	RAMP B
RC	RAMP C
RD	RAMP D
FR	FRONTAGE ROAD
XR	CROSS ROAD
DE	DETOUR

Purpose Codes:

A	ACCEPTANCE
C	CORRELATION
P	INDEPENDENT ASSURANCE
I	INFORMATIONAL

Testing Lab Codes:

C	CENTRAL LAB
R	REGIONAL LAB
P	PROJECT LAB

Bituminous Mixes:

AC	ASPHALTIC CONCRETE	
MA	MINERAL AGGREGATE	
	34	3/4" ASPHALTIC CONCRETE
	34F	3/4" FINE BAND 417 AC
	34K	3/4" COARSE BAND 417 AC
	12	1/2" ASPHALTIC CONCRETE
	12F	1/2" FINE BAND 417 AC
	12K	1/2" COARSE BAND 417 AC
	BM	BASE MIX
	FC	ACFC
	RD	ASPHALT - RUBBER ASPHALTIC CONCRETE
	RF	ASPHALT - RUBBER A.C. FRICTION COURSE
	409MI	MISC. STRUCTURAL
	409SP	MISC. STRUCTURAL (Special Mix)

Soils and Aggregates:

AB	AGGREGATE BASE (CLASS 1, 2, or 3)		
AS	AGGREGATE SUBBASE (CLASS 4, 5, or 6)		
CM	COVER MATERIAL (CLASS 1 or 2)		
CA	COARSE AGGREGATE	FA	FINE AGGREGATE
SG	SUBGRADE	SB	STRUCTURE BACKFILL
BW	BORROW	NG	NATURAL GROUND
BL	BLOTTER MATERIAL	EM	EMBANKMENT
DG	DECOMPOSED GRANITE	TS	TOP SOIL
BF	BACKFILL*	BM	BEDDING MATERIAL*

*AP	ALUMINUM PIPE
*CP	CONCRETE PIPE
*MP	METAL PIPE
*PP	PLASTIC PIPE
*PV	PVC PIPE
*SL	SLURRY
*TR	TRENCH BACKFILL

Other Codes:

RP	RECLAIMED ASPHALT PAVEMENT	
	C	COARSE
	F	FINE
	O	OTHER
GR	GRANULATED RUBBER	
CB	CRASH BARREL SAND	
RR	RIP RAP	

Not all codes used by FAST are listed above. (See Appendix C of Series 900 of the ADOT Materials Testing Manual for a listing of other codes used by FAST. FAST may revise codes, delete codes, or add codes at various times. Individuals must assure that they are utilizing the current FAST codes.

44-9346 R07/14

FIGURE 2

Infrastructure Delivery and Operations

ARIZ 247c
November 2, 2018
(8 Pages)

PARTICLE SHAPE AND TEXTURE OF FINE AGGREGATE USING UNCOMPACTED VOID CONTENT

(A Modification of AASHTO T 304)

1. SCOPE

1.1 This method covers the determination of the "Uncompacted Void Content" of a fine aggregate for use as a measure of its angularity and texture.

1.2 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 whoever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 This procedure provides a numerical result in terms of percent void content, determined under standardized conditions, which correlates with the particle shape and texture properties of a fine aggregate. An increase in void content indicates greater angularity and rougher texture. Lower void content results are associated with more rounded smooth particles.

1.4 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.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 A funnel having a volume of at least 200 cm^3, or being equipped with a supplemental container to provide the required volume. (See Figure 1)

2.3 Funnel Stand - A support capable of holding the funnel firmly in position with its axis vertically in line with the axis of the measure, and the funnel opening 4.5 ± 0.1 inches above the top of the cylinder. A suitable arrangement is shown in Figure 1.

2.4 Measure - A cylinder of approximately 100 cm^3 capacity. (See Figure 2)

2.5 A flat metal or plastic pan of sufficient size for containing the funnel stand, and preventing loss of material that overflows the measure during filling and strike off. The pan shall not be warped so as to prevent rocking of the apparatus during testing.

2.6 A straight metal spatula at least 1” greater than the diameter of the measure and at least 1/2" wide. The end shall be cut at a right angle to the edges. The straight edge of the spatula is used to strike off the fine aggregate. (See Figure 3)

2.7 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

2.8 Sieves of sizes No. 8, No. 16, No. 30, No. 50 and No. 100, conforming to the requirements of ASTM E11.

3. CALIBRATION OF MEASURE

3.1 Determine and record the weight of the dry, empty measure and a flat, glass plate slightly larger than it's diameter. Fill the measure with water at a temperature of 77 ± 1 °F. Place the glass plate on the measure, being sure that no air bubbles remain. It may be necessary to lightly coat the top edge of the measure with grease prior to determining the weight of the empty measure and glass plate. Dry the outer surfaces of the measure and determine and record the combined weight of measure, glass plate, and water.

3.2 Determine and record the volume of the measure to the nearest 0.01 cm^3 by the following calculation:

$$V = \frac{w}{0.997}$$

Where: V = volume of cylinder in cm^3
w = net weight of water in grams
0.997 g/cm^3 = the density of water at 77 ± 1 °F

4. SAMPLE PREPARATION

4.1 Obtain a sample of Minus No. 8 Material of sufficient size (but not less than 500 grams) to yield the quantities required in Subsection 4.3 below. The sample used for this test may either be virgin aggregate, or aggregate obtained from the extraction of a bituminous mixture.

4.2 Utilizing either a No. 100 or a No. 200 sieve, wash the sample in accordance with either Section 6 or 7 of Arizona Test Method 201. Dry the material to constant weight and sieve into size fractions as indicated in Subsection 4.3 below. Maintain the material in a dry condition in separate containers for each of the sizes specified. The sieving is to be accomplished in accordance with Arizona Test Method 201.

Note: Processing additional material may be required.

4.3 Weigh out and combine the following quantities of dry fine aggregate from each of the sizes below:

PASS	RETAINED	WEIGHT IN GRAMS	ACCUM. WEIGHT
# 8	# 16	44 ± 0.2	44 ± 0.2
# 16	# 30	57 ± 0.2	101 ± 0.4
# 30	# 50	72 ± 0.2	173 ± 0.6
# 50	# 100	17 ± 0.2	190 ± 0.8

5. PROCEDURE

5.1 If the fine aggregate has become moist, dry to constant weight and cool to room temperature.

5.2 Record the weight of the empty measure to the nearest 0.1 gram, place the funnel and measure in the funnel stand, and place the assembly in the pan described in Subsection 2.5.

5.3 Mix the test sample until it appears homogeneous. Using a finger to block the opening, pour the test sample into the funnel. Lightly level the top of the material using the end of the spatula. Remove the finger and allow the sample to fall freely into the measure.

5.4 After the funnel empties, remove excess fine aggregate from the measure by a single pass of the spatula with the edge of the blade vertical and in light contact with the top of the measure. Until this operation is complete, exercise care to avoid vibration or disturbance that could cause compaction of the fine aggregate in the measure. After strike-off, tap the measure lightly to compact the sample to make it easier to transfer the measure to the balance without spilling any of the sample. Brush adhering material from the outside of the measure and determine and record the weight of the measure and contents to the nearest 0.1 gram. (See Figure 3)

Note: The intent of this process is to allow the sample to flow freely into the measure without any vibrations or disturbance of the cylinder until the operation is complete. The cylinder may be held during strikeoff as long as there is no vibration or disturbance from the strike off process.

5.5 Collect all of the fine aggregate from the pan and measure, and repeat the procedure again.

5.6 For each determination, record the net weight of the fine aggregate in the measure. If the two net weights differ by 0.5 gram or less, average the two weights and record to the nearest 0.1 gram as the "average net weight of fine aggregate in measure", (W). If the two weights differ by more than 0.5 gram, the procedure shall be repeated until any two results are achieved which differ by 0.5 gram or less. The average of these two results is recorded to the nearest 0.1 gram as the "average net weight of fine aggregate in measure", (W).

6. CALCULATION

6.1 Determine and record the "Uncompacted Void Content" (U), to the nearest 0.1% by the following calculation:

$$U = \frac{V - (W/G)}{V} \times 100$$

Where: U = Uncompacted Void Content, percent.

V = volume of measure in cm^3.

W = average net weight of fine aggregate in measure.

G = bulk oven dry specific gravity of fine aggregate, measured in accordance with Arizona Test Method 211, "Specific Gravity and Absorption of Fine Aggregate".

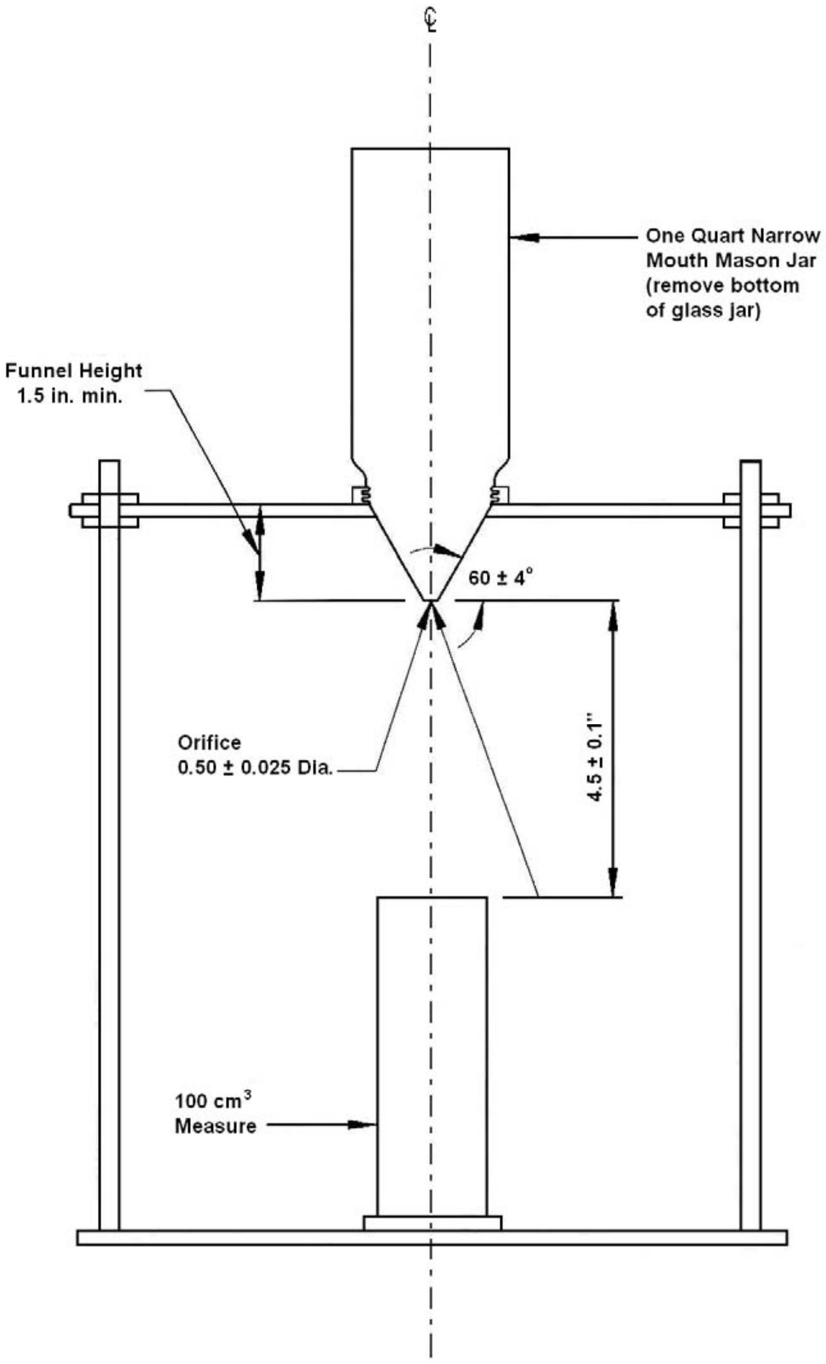
6.2 For most aggregate sources the fine aggregate specific gravity does not vary much from sample to sample. It is intended that the value used in the above calculation be from a routine specific gravity test which is representative of the fine aggregate. A difference in specific gravity of 0.05 will change the calculated "Uncompacted Void Content" about one percent.

7. REPORT

7.1 The "Uncompacted Void Content" (U), to the nearest 0.1%.

7.2 The bulk oven dry specific gravity of the fine aggregate (G), to the nearest 0.001.

FUNNEL, FUNNEL STAND, AND MEASURE



Section Through Center of Apparatus

FIGURE 1

MEASURE

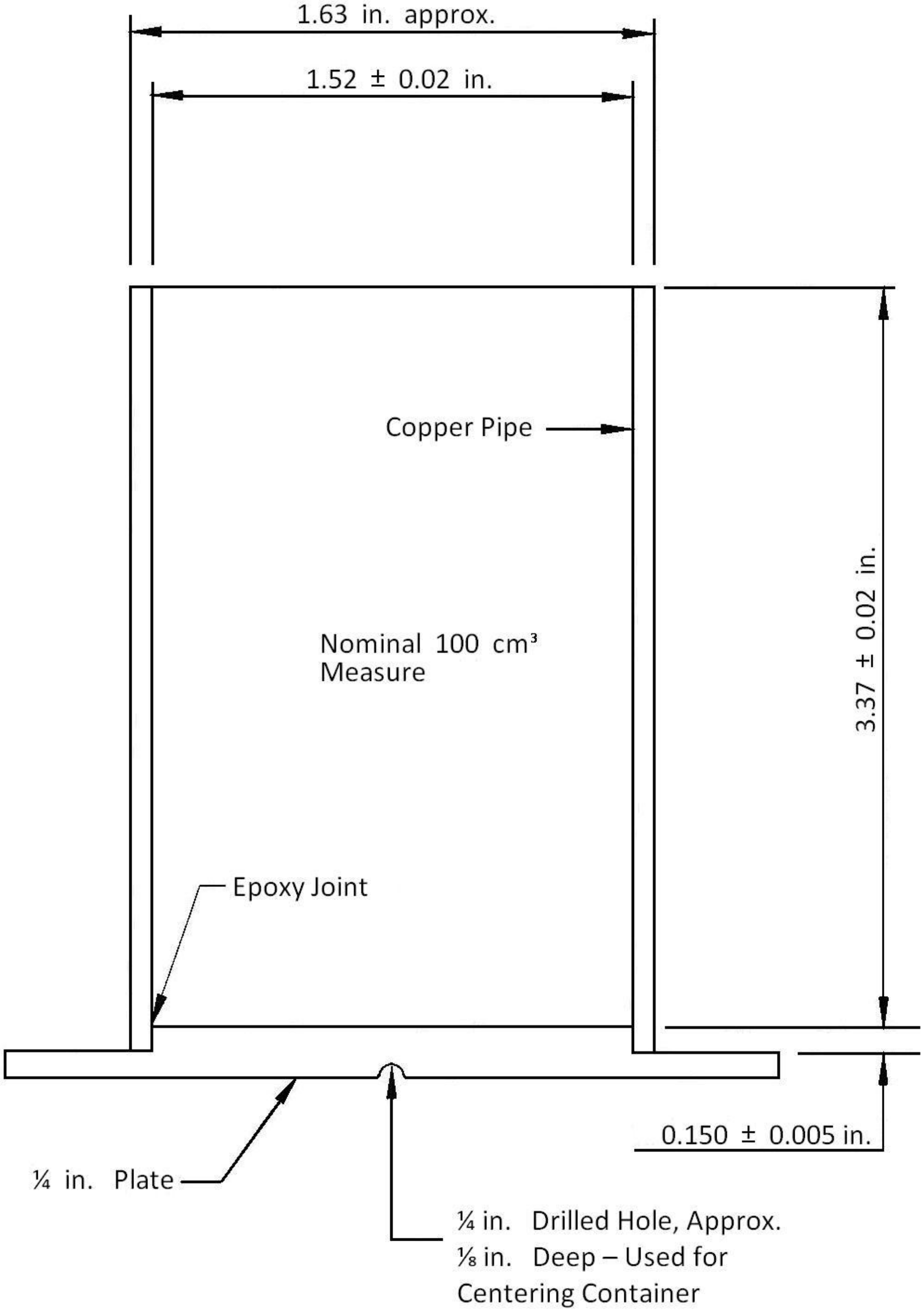
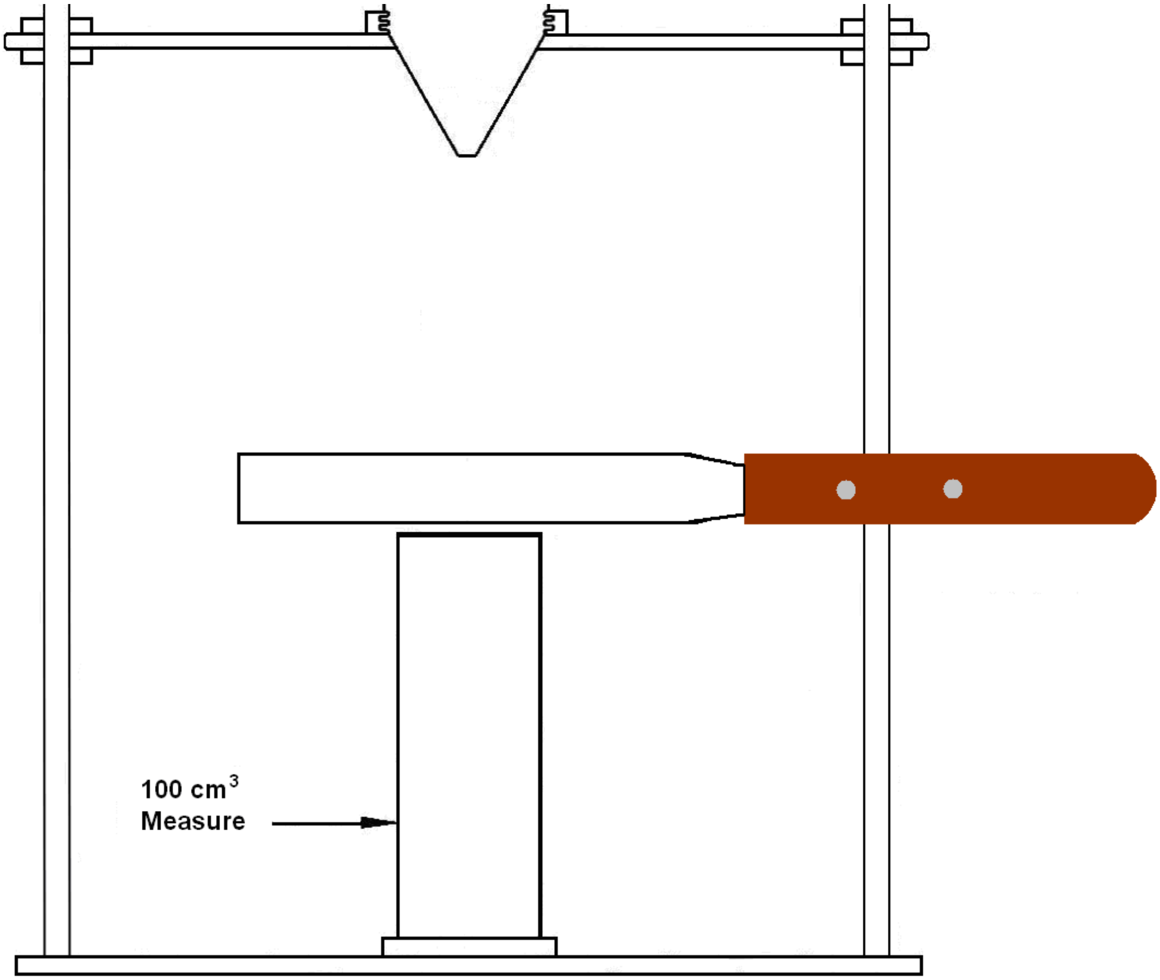


FIGURE 2



Straight Metal Spatula

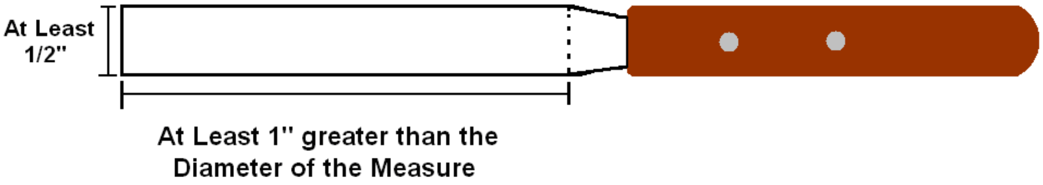


FIGURE 3

ARIZ 406d
December 4, 2015
(3 Pages)

MOISTURE CONTENT OF BITUMINOUS MIXTURES

(An Arizona Method)

1. SCOPE

1.1 This method is used to determine the percent moisture in bituminous mixtures. The option of using a conventional oven or a microwave oven is provided. In case of dispute, the conventional oven shall be utilized.

1.2 This test method may involve hazardous material, 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 the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Suitable sample containers for use in testing with the conventional oven or microwave oven.

2.3 Oven - A thermostatically controlled oven capable of maintaining a temperature of 290 ± 10 °F; or, a microwave oven capable of variable heat intensity settings.

2.4 A balance or scale capable of measuring the maximum weight to be determined, accurate to at least 0.1 gram.

3. PROCEDURE (CONVENTIONAL OVEN)

3.1 Obtain a representative 1000 ± 50 gram sample in accordance with ARIZ 416.

3.2 Record the tare weight of the container to the nearest 0.1 gram.

3.3 Place sample in the container and weigh. Determine and record the wet weight of sample to the nearest 0.1 gram as "f".

3.4 Place container and sample in a 290 ± 10 °F oven and initially dry for a minimum of 1 hour. Weigh the container and sample. Record the weight to the nearest 0.1 gram.

3.5 Continue drying and weighing until a constant weight is obtained; being the weight at which further drying does not alter the weight more than 0.1 gram at intervals of a minimum of 30 minutes.

3.6 After constant weight is obtained, cover sample and allow to cool 30 ± 10 minutes at room temperature. Weigh and determine and record the dry weight of sample to the nearest 0.1 gram as "g".

3.7 Proceed to section 5 for moisture content calculation.

4. PROCEDURE (MICROWAVE OVEN)

4.1 Obtain a representative 1000 ± 50 gram sample in accordance with ARIZ 416.

4.2 Record tare weight of the container to the nearest 0.1 gram.

4.3 Place sample in the container and weigh. Determine and record the wet weight of sample to the nearest 0.1 gram as "f".

4.4 Dry sample until a constant weight is obtained. The sample is considered to be at constant weight when further drying causes, or would cause, a difference in weight of not more than 0.1 gram. The sample shall be heated in such a manner that controls the intensity of heat generated to prevent splattering, aggregate breakage, and asphalt being "burned off". The method used with a microwave oven shall give results similar to those achieved with a conventional oven.

4.5 After constant weight is obtained, cover sample and allow to cool 30 ± 10 minutes at room temperature. Weigh and determine and record the dry weight of sample to the nearest 0.1 gram as "g".

5. CALCULATION

5.1 Calculate the percent moisture, "h", and record to the nearest 0.01% as shown below.

$$h = \frac{f - g}{f} \times 100$$

Where: h = Percent Moisture
f = Wet weight of sample
g = Dry weight of sample

ADOT
Intermodal Transportation

ARIZ 410f
December 4, 2015
(8 Pages)

COMPACTION AND TESTING OF BITUMINOUS MIXTURES UTILIZING FOUR INCH MARSHALL APPARATUS

(A Modification of AASHTO T 245)

1. SCOPE

1.1 This method covers the procedure for compacting and testing bituminous mixtures utilizing four inch Marshall apparatus.

1.2 This procedure is used for bituminous mixtures with a mix design gradation target of at least 85% passing the 3/4 inch sieve.

1.3 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.

1.4 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.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Compaction Mold Assembly 4 inch diameter cylindrical mold, baseplate, and extension collar constructed of steel and conforming to the requirements of Figure 1. (Three compaction mold assemblies are normally utilized.)

2.3 Specimen Extruding Device - Extrusion jack or press for extruding specimens from molds.

2.4 Compaction Hammer:

2.4.1 The compaction hammer shall either be a mechanical or hand compaction hammer having a flat, circular tamping face with a nominal diameter of (3-7/8 inches), and a (10 ± 1/4 pound) sliding weight with a free fall of (18 ± 1/2 inches).

2.4.2 Compaction hammers must be monitored through the ADOT proficiency sample program. To be qualified, compaction hammers must produce specimens with an average density of no greater than ± 1.0 lb./cu. ft. from the average bulk density for the most recent set of proficiency samples. If two samples are required for the proficiency samples, both of the bulk density sets must meet the ± 1.0 lb./cu. ft. criteria, if not, the hammer is not qualified.

2.4.3 As an alternate to qualifying a compaction hammer through the proficiency sample program, a compaction hammer may be qualified by correlating with a hammer which has been approved through comparison with proficiency sample results. When qualified in this manner, results must be no greater than ± 0.5 lb./cu. ft.

2.4.4 Hammers which have had adjustments or repairs made to them after being qualified, must be requalified by correlating with another qualified hammer and yield results within ± 0.5 lb./cu. ft.

Note: Marshall compaction equipment can go out of calibration at any time, and each laboratory is encouraged to establish a method of ensuring that their equipment remains in calibration. Alternate methods that can be used include regular comparisons with other approved hammers or compaction of samples which have a known density.

2.4.5 Hammers which do not meet the above requirements may be adjusted by modifying the weight, or the height of fall, within the given criteria; by adjusting the number of blows a maximum of ± 10 from the specified 75 blows; or by a combination of adjustments to weight, height of fall, or number of blows.

2.4.6 Should a compacton pedestal be moved or replaced, the compaction hammer(s) shall be requalified.

2.5 Compaction pedestal - The compaction pedestal shall consist of a 8" x 8" x 18" wooden post capped with a 12" x 12" x 1" steel plate. The steel cap shall be firmly fastened to the post. The wooden post shall have a dry weight of 42 to 48 lbs./cu. ft. and shall rest squarely on, and be firmly secured to, a solid concrete slab. The pedestal assembly shall be installed so that the post is plumb and the cap is level.

2.6 Specimen Mold Holder - Mounted on the compaction pedestal so as to center the compaction mold over the center of the post. It shall hold the compaction mold, collar, and base plate securely in position during compaction of specimen.

2.7 Oven for heating bituminous mixtures and specimen mold assemblies at required temperature.

2.8 Hot plate for heating compaction hammer, spoon and spatula.

2.9 A flat spatula with blade approximately 1 inch wide and at least 6 inches long, stiff enough to penetrate the entire bituminous mixture.

2.10 Calibrated/verified thermometers, for determining temperatures of bituminous mixtures, with a range of 50 to 400 °F and increments of not greater than 5 °F. For digital thermometers, increments shall not be greater than 1 °F.

2.11 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least one gram.

2.12 If Marshall stability and flow are to be determined, the following additional apparatus is required:

2.12.1 Breaking Head and Water Bath, conforming to the requirements specified in AASHTO T 245.

2.12.2 Marshall stability and flow testing apparatus, with operating instruction manual. The apparatus shall be capable of applying a load with a constant rate of travel of 2.0 ± 0.1 inches per minute.

2.12.3 Height gauge capable of measuring the height of specimens to the nearest 0.001 inch.

3. PROCEDURE

3.1 Obtain three representative samples for Marshall specimens, as described in Arizona Test Method 416. If the Combined Aggregate Bulk (O.D.) Specific Gravity is known, the weight calculated by the following equation (± 50 grams) will normally give specimens which meet the height requirement of 2.300 to 2.700 inches. (1150 ± 50 grams is generally adequate.)

$$\begin{bmatrix}\text{Weight of}\\\text{each Sample}\end{bmatrix}=\frac{\begin{bmatrix}\text{Combined Aggregate}\\\text{Bulk (O.D.) Specific Gravity}\end{bmatrix}}{2.520}\text{x}\,1150$$

3.2 Before placing the mixture in the mold, the mixture and a mold assembly (baseplate, mold, and collar) shall be at approximately 290 °F. The face of the compaction hammer shall be thoroughly cleaned and heated on a hot plate set at approximately 290 °F. The temperature of the laboratory during compaction of the specimens shall be between 68 and 86 °F.

3.3 Place a 4-inch paper disc in the bottom of the mold before the mixture is introduced. Place the entire batch in the mold in one lift. Care should be taken to avoid segregation of material in the mold. Spade the mixture vigorously, penetrating the entire mix, with the heated spatula 15 times around the perimeter and 10 times at random into the mixture. Smooth the surface of the mix to a slightly rounded shape.

3.4 The compaction temperature shall be the laboratory compaction temperature shown on the mix design.

3.5 If necessary, the mixture and mold assembly shall be returned to an oven at the required temperature for the minimum time necessary to achieve the laboratory compaction temperature ± 5 °F; however, in no case shall the mixture be reheated longer than 60 minutes.

3.6 Place a 4-inch paper disc on top of material, place the mold assembly on the compaction pedestal in the mold holder, and apply 75 blows [or adjusted number, as determined in Subsection 2.4] with the compaction hammer. When a hand hammer is utilized, the operator shall hold the handle by one hand so that the axis of the compaction hammer is as nearly perpendicular to the base of the mold assembly as possible while compaction is accomplished. Care shall be taken not to add body weight to the hammer by leaning or pressing down on the hammer. When using a hand hammer, no mechanical device of any kind is to be used to restrict movement of the handle during compaction. Compaction shall be performed at a minimum rate of 40 blows per minute. The compaction hammer shall apply only one blow with each fall, that is, there shall not be a rebound impact. Remove the base plate and collar, and reverse and reassemble the mold. Apply 75 (or adjusted number) compaction blows to the face of the reversed specimen.

3.7 Remove collar, baseplate, and paper discs, and allow specimen to cool. Cooling may be accomplished at room temperature, in a 77 °F air bath, or if more rapid cooling is desired the mold and specimen may be placed in front of a fan until cool.

3.8 Extrude the specimen from the mold. Care shall be taken in extruding the specimen from the mold, so as not to develop tensile stresses in the specimen or tear the sides of the specimen.

4. SPECIMEN TESTING

4.1 If Marshall stability and flow are to be determined, measure height of specimens to the nearest 0.001 inch. Prior to measurement of height, excess material shall be brushed from the edges of the specimens. Compacted specimens shall be 2.300 to 2.700 inches in height. If this criteria is not met, the entire set of specimens shall be discarded and a new set prepared after necessary adjustments in sample weight have been made.

4.2 Determine the specific gravity of the specimens in accordance with Arizona Test Method 415, Method A. (Assume specimen is at constant weight after cooling.)

4.3 Determine the bulk density of each of the specimens, by multiplying the respective specific gravity by 62.3 lbs./cu. ft. Record the individual bulk densities to the nearest 0.1 lb./cu. ft. The densities of the three specimens shall not differ by more than 2.5 lbs./cu. ft. for 1/2", 3/4", or recycle mixes; and 3.0 lbs./cu. ft. for Base mixes. If this density requirement is not met, the entire set of specimens shall be discarded and a new set of specimens prepared.

4.4 Determine the average specific gravity of the specimens and record to the nearest 0.001. Calculate the average bulk density of the specimens, by multiplying the average specific gravity by 62.3 lbs./cu. ft. Record the average bulk density to the nearest 0.1 lb./cu. ft.

4.5 If the stability and flow are to be determined, the steps in Subsections 4.6 through 4.11 below are followed, utilizing the apparatus in accordance with the operating instructions for that apparatus.

4.6 Bring the specimens to 140 ± 2 °F by immersing in the water bath 30 to 40 minutes. Prior to testing, it shall be assured that the inside of the test heads are clean, and that the guide rods are clean and lubricated so that the upper test head slides freely over them.

4.7 The breaking head temperature shall be maintained between 70 to 100 °F, using a water bath when required. Remove the specimen from the water bath, quickly towel dry specimen and place in the lower segment of the breaking head. Place the upper segment of the breaking head on the specimen, and place the complete assembly in position on the testing machine.

4.8 Apply the load to the specimen with a constant rate of 2.0 ± 0.1 inches per minute until the maximum load is reached and the load decreases. The maximum load is defined as the last point in the load/time curve before the load decreases. The elapsed time for the test from removal of the test specimen from water bath to maximum load determination shall not exceed 30 seconds.

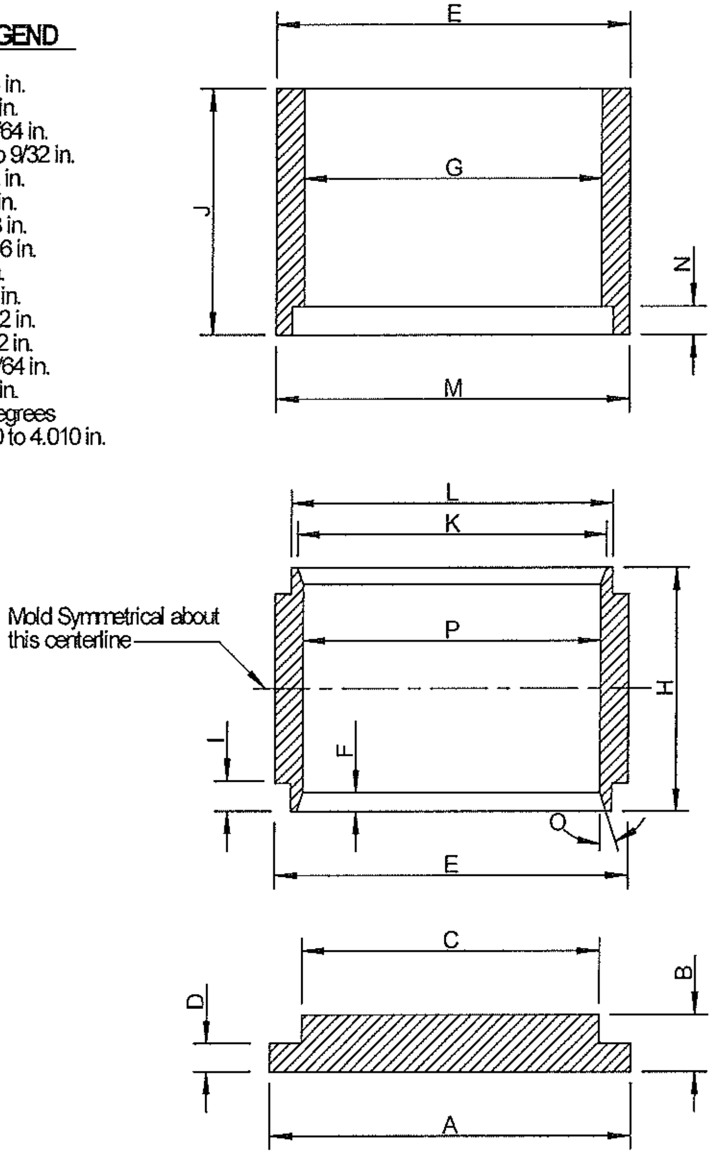
4.9 Record the stability of each specimen to the nearest 10 pounds force, and the flow to the nearest 0.01 inch.

4.10 Correct the stability obtained for each specimen, for the height of the specimen, by the table in Figure 2. Record the corrected stability to the nearest 10 pounds force.

4.11 Determine and record the average corrected stability to the nearest 10 pounds force, and the average flow to the nearest 0.01 inch.

LEGEND

A: 4-3/4 in.
B: 9/16 in.
C: 3-63/64 in.
D: 1/8 to 9/32 in.
E: 4-1/2 in.
F: 3/16 in.
G: 4-1/8 in.
H: 3-7/16 in.
I: 1/4 in.
J: 2-3/4 in.
K: 4-5/32 in.
L: 4-9/32 in.
M: 4-19/64 in.
N: 9/32 in.
O: 20 degrees
P: 3.990 to 4.010 in.



All dimensions are nominal, except where tolerances are indicated.

Four Inch Compaction Mold, Extension Collar, and Baseplate

FIGURE 1

STABILITY CORRELATION RATIOS*

For 4 inch Diameter Specimens

Height of Specimen (Inches)	Correlation Ratio
2.300 - 2.306	1.15
2.307 - 2.319	1.14
2.320 - 2.332	1.13
2.333 - 2.344	1.12
2.345 - 2.357	1.11
2.358 - 2.369	1.10
2.370 - 2.381	1.09
2.382 - 2.393	1.08
2.394 - 2.405	1.07
2.406 - 2.417	1.06
2.418 - 2.430	1.05
2.431 - 2.445	1.04
2.446 - 2.461	1.03
2.462 - 2.477	1.02
2.478 - 2.492	1.01
2.493 - 2.507	1.00
2.508 - 2.522	0.99
2.523 - 2.537	0.98
2.538 - 2.553	0.97
2.554 - 2.573	0.96
2.574 - 2.594	0.95
2.595 - 2.615	0.94
2.616 - 2.634	0.93
2.635 - 2.649	0.92
2.650 - 2.663	0.91
2.664 - 2.679	0.90
2.680 - 2.697	0.89
2.698 - 2.700	0.88

* The measured stability of a specimen multiplied by the correlation ratio for the height of the specimen equals the corrected stability for a 2-1/2 inch specimen.

FIGURE 2

ARIZ 415d
December 4, 2014
(8 Pages)

BULK SPECIFIC GRAVITY AND BULK DENSITY OF COMPACTED BITUMINOUS MIXTURES

(A Modification of AASHTO Designation T 166 and PP 75)

1. SCOPE

1.1 This procedure covers the determination of bulk specific gravity and bulk density of specimens of compacted bituminous mixtures.

1.2 This test procedure consists of three methods for determining bulk specific gravity and bulk density. These methods are referred to as "Method A", "Method C (Rapid Test)", and "Vacuum Method".

Note: If it is desired to use "Method B", which is not included in this procedure, AASHTO T 166 shall be referred to. Method B should not be used with samples that contain open or interconnecting voids and/or absorb more than 2.0 percent water by volume. Method B is not acceptable for specimens that have more than six percent air voids.

1.3 Method A should not be used with samples that contain open or interconnecting voids and/or absorb more than 2.0 percent water by volume as determined in Subsection 7.4. If the percent water absorbed by the specimen exceeds 2.0 percent, either Method C, Vacuum Method, or AASHTO T 275 "Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens" shall be used.

1.4 Referee testing shall be performed in accordance with "Method C".

1.5 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.

1.6 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.

2. TEST SPECIMENS

2.1 Test specimens may be either laboratory molded specimens or samples from an existing bituminous pavement.

2.2 Size of specimens - It is recommended that: (1) the diameter of cylindrically molded or cored specimens, or the length of the sides of sawed specimens, be at least four times the maximum size of the aggregate and, (2) the thickness of specimens be at least one and one half times the maximum size of the aggregate.

2.3 Specimens obtained from bituminous pavements shall be taken with a core drill, diamond or carborundum saw, or by other suitable means.

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

2.5 Test specimens shall be free from paper, tape, soil, and other foreign materials not intended to be tested as part of the specimen.

2.6 If desired, specimens may be separated from other pavement layers by sawing or other suitable means. Care shall be exercised to ensure that specimens are not damaged during the separation process.

3. APPARATUS

3.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

3.1.1 Balance - A balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.1 gram. The balance shall be equipped with a suitable suspension apparatus and holder to permit weighing the specimen while suspended from the center of the balance.

3.1.2 Suspension Apparatus - The wire(s) suspending the holder shall be the smallest practical size to minimize any possible effects of a variable immersed length. The suspension apparatus shall be constructed to enable the container to be immersed to a depth sufficient to cover it and the test sample during weighing.

3.1.3 Water bath - The water bath for immersing the specimen in water while suspended under the balance shall be equipped with an overflow outlet or a clearly marked "fill line" for maintaining a constant water level. The level of the water shall be adjusted before testing each specimen, if necessary, to maintain a constant water level.

3.1.4 Oven - An oven capable of drying specimens at either 125 ± 5 °F (Method A) or 290 ± 10 °F (Method C).

3.1.5 Vacuum Drying Device (For Vacuum Method) – Conforming to the requirements of AASHTO PP 75. Automatic controls of the unit shall be calibrated by the manufacturer prior to initial use.

METHOD A

4. PROCEDURE

4.1 Dry the specimen to constant mass. Constant mass shall be defined as the mass at which further drying at 125 ± 5 °F does not alter the mass by more than 0.1 gram. Samples saturated with water shall initially be dried overnight at 125 ± 5 °F and then weighed at two-hour drying intervals. Recently molded laboratory samples, which have not been exposed to moisture, do not require drying.

4.2 Cool the specimen to room temperature at 77 ± 9 °F and record the dry mass to the nearest 0.1 gram as "A".

4.3 Immerse the specimen in water at 77 ± 2 °F for 4 ± 1 minutes and record the immersed mass to the nearest 0.1 gram as "C". Care shall be exercised to ensure that no trapped air bubbles exist under the specimen.

4.4 Remove the specimen from the water, quickly damp dry the specimen surface by blotting with a damp towel, and as quickly as possible determine and record the surface-dry mass to the nearest 0.1 gram as "B". Any water that seeps from the specimen during the surface-dry weighing operation is considered as part of the specimen. The determination of the immersed mass and surface-dry mass of each specimen will be completed before the next specimen is submerged for its immersed mass determination.

Note: A terry cloth towel has been found to work well. Damp is considered to be when no water can be wrung from the towel.

Note: If desired, the sequence of testing operations may be changed to expedite the test results. For example, first the immersed mass, "C", can be taken, then the surface-dry mass, "B", and finally the dry mass, "A".

4.5 Calculate the bulk specific gravity, bulk density, and percent water absorption by volume in accordance with Section 7.

METHOD C (RAPID TEST)

5. PROCEDURE

5.1 This procedure can be used for testing specimens which are not required to be saved and which contain a substantial amount of moisture. Specimens obtained by methods that introduce moisture, such as wet coring or sawing, can generally be tested the same day by this method.

5.2 Ensure the specimen is at room temperature (77 ± 9 °F).

5.3 Immerse the specimen in water at 77 ± 2 °F for 4 ± 1 minutes and record the immersed mass to the nearest 0.1 gram as "C". Care shall be exercised to ensure that no trapped air bubbles exist under the specimen.

5.4 Remove the specimen from the water, quickly damp dry the specimen surface by blotting with a damp towel, and as quickly as possible determine and record the surface-dry mass to the nearest 0.1 gram as "B". Any water that seeps from the specimen during the surface-dry weighing operation is considered as part of the specimen. The determination of the immersed mass and surface-dry mass of each specimen will be completed before the next specimen is submerged for its immersed mass determination.

5.5 Place the specimen in a large, flat-bottom drying pan of known weight. Place the pan and specimen in a 290 ± 10 °F oven. Leave the specimen in the oven until it can be easily separated to the point where particles of the fine aggregate portion are not larger than 1/4 inch. During separation of material, ensure that no material is lost. Place the separated specimen in the 290 ± 10 °F oven and dry to constant mass. (Constant mass shall be determined as follows: Dry the sample for a minimum of 1 hour at 290 ± 10 °F. Record the weight of the sample to the nearest 0.1 gram. Continue drying and weighing until the weight does not change more than 0.1 gram at drying intervals of a minimum of 30 minutes.)

5.6 Cool the pan and specimen to room temperature at 77 ± 9 °F. Weigh the pan and specimen, subtract the mass of the pan, and record the dry mass of the specimen to the nearest 0.1 gram as "A".

Note: For Method C, the drying of specimens to constant weight may be accomplished in a microwave oven, as described in Arizona Test Method 719.

5.7 Calculate the bulk specific gravity, bulk density, and percent water absorption by volume in accordance with Section 7.

VACUUM METHOD

6. PROCEDURE

6.1 This procedure can be used for testing specimens, which are to be saved, and which contain a substantial amount of moisture. Specimens obtained by methods that introduce moisture, such as wet coring or sawing, can generally be tested the same day by this method.

6.2 Turn on the vacuum drying device. Follow the manufacturer's recommendations for warm up and self-test procedures.

6.3 Run the vacuum drying device without any specimens. The pressure reading on the display should indicate a known dry point value as recommended by the manufacturer. If the indicated dry point is not achieved, refer to the manufacturer's trouble shooting instructions.

6.4 Ensure the specimen is at room temperature (77 ± 9 °F).

6.5 Remove any standing water from the surface of the specimen by using a paper towel or an absorptive cloth.

6.6 Dry the cold trap and the specimen chamber. Place the specimen inside the vacuum chamber.

Note: Two 4-inch diameter specimens, that are less than 3-inches in thickness can be placed side-by-side in the chamber during a single drying cycle. Larger specimens shall be placed in the chamber individually.

Note: Water and/or ice may buildup in the moisture trap during a drying cycle. Wipe off any free standing water in the moisture trap between drying specimens. This will expedite specimen drying.

6.7 Place the lid on the vacuum chamber and press the lid down to ensure secure contact between the lid and the chamber. Press the appropriate key on the vacuum drying device to begin the drying process.

6.8 The vacuum drying device will automatically stop when the specimen is dry. The unit shall be calibrated to sense the “dry specimen condition”. The “dry specimen condition” shall be determined from the calibrated pressure at which no water remains in the chamber. The pressure is monitored throughout the drying process to ensure that the “dry specimen condition” pressure is achieved in the device.

6.9 Remove the specimen from the vacuum drying device. Weigh the specimen and record the dry mass of the specimen to the nearest 0.1 gram as "A".

6.10 Immerse the specimen in water at 77 ± 2 °F for 4 ± 1 minutes and record the immersed mass to the nearest 0.1 gram as "C". Care shall be exercised to ensure that no trapped air bubbles exist under the specimen.

6.11 Remove the specimen from the water, quickly damp dry the specimen surface by blotting with a damp towel, and as quickly as possible determine and record the surface-dry mass to the nearest 0.1 gram as "B". Any water that seeps from the specimen during the surface-dry weighing operation is considered as part of the specimen. The determination of the immersed mass and surface-dry mass of each specimen will be completed before the next specimen is submerged for its immersed mass determination.

Note: If desired, the sequence of testing operations may be changed to expedite the test results. For example, first the immersed mass, "C", can be taken, then the surface-dry mass, "B", and finally the dry mass, "A".

6.12 Calculate the bulk specific gravity, bulk density, and percent water absorption by volume in accordance with Section 7.

7. CALCULATION

7.1 Calculate and record the bulk specific gravity of the specimen to the nearest 0.001 as follows:

$$\text{Bulk Specific Gravity} = \frac{A}{B - C}$$

Where: A = mass of dry specimen
B = mass of surface-dry specimen
C = mass of immersed specimen

7.2 Calculate and record the bulk density of the specimen to the nearest 0.1 lb/cu ft by multiplying the bulk specific gravity by 62.3 lbs/cu ft.

7.3 For laboratory molded specimens of 1/2-inch or 3/4-inch asphaltic concrete mixes, the range of bulk density results for three replicate specimens shall not differ by more than 2.5 lbs/cu ft. For laboratory molded specimens of asphaltic concrete Base Mixes, the range of bulk density results for three replicate specimens shall not differ by more than 3.0 lbs/cu ft. If the respective requirement is not met, the entire set of specimens shall be discarded and a new set of specimens shall be prepared and tested.

7.4 Calculate and record the percent water absorbed by the specimen to the nearest 0.01 percent (on volume basis) as follows:

$$\text{Percent Water Absorption by Volume} = \frac{B - A}{B - C} \times 100$$

8. REPORT

8.1 The method that was used.

8.2 The bulk specific gravity to the nearest 0.001.

8.3 The bulk density to the nearest 0.1 lb/cu ft.

8.4 The absorption to the nearest 0.01 percent.

ARIZ 416e
December 4, 2015
(5 Pages)

PREPARING AND SPLITTING FIELD SAMPLES OF BITUMINOUS MIXTURES FOR TESTING

(An Arizona Method)

1. SCOPE

1.1 This procedure describes the preparation and splitting of field samples of bituminous mixtures for testing.

1.2 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 consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

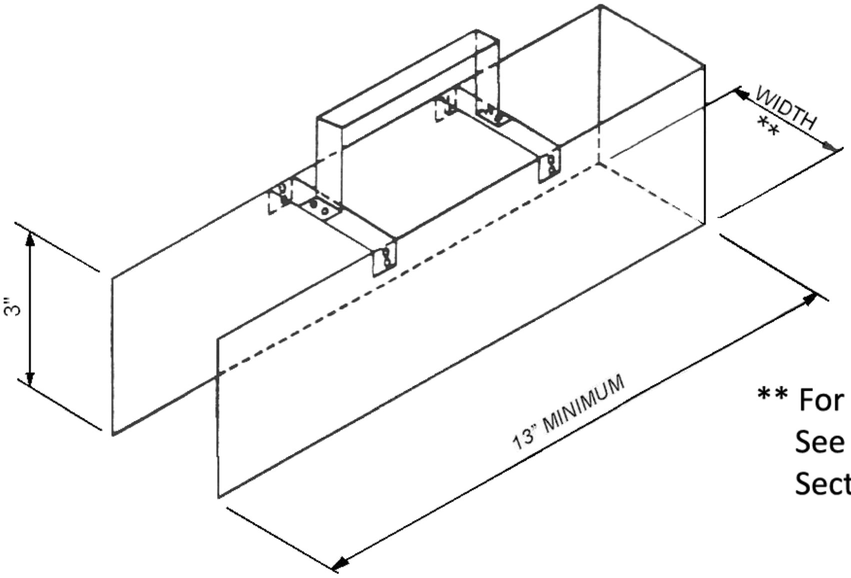
2.2 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

2.3 Oven capable of maintaining a temperature of 290 ± 10 °F.

2.4 Closed-end samplers as illustrated in Figure 1 (or similiar), constructed of 16 to 18 gauge sheet metal, having a height of 3 inches, a minimum length of 13 inches, and widths of approximately 2-1/2 inches, 3 inches, or 3-1/2 inches.

2.5 A concrete trowel or hand float. If desired, a straightedge of sufficient length to span the final diameter of the circular mass may be used.

2.6 Small scoop, spatulas, and suitable size containers.



** For Width,
See APPARATUS
Section 2

FIGURE 1

3. PREPARATION OF SAMPLE

3.1 Samples may be stored for indefinite periods of time at temperatures not exceeding 140 °F.

3.2 The material shall be easily workable and pliable when splitting. If necessary, the sample may be heated at 290 ± 10 °F for a maximum of 3 hours. The 3-hour time period begins when the oven reaches the specified temperature.

3.3 If necessary, the material shall be reduced in size to provide a workable amount of material from which to obtain all required samples by thoroughly mixing and quartering, splitting with a mechanical (clam-shell) splitter, or using a four-way splitter such as a “Quartermaster”. When utilizing a mechanical (clam-shell) splitter, the width of the individual chute openings shall be approximately 1-1/2 to 2-1/2 times larger than the largest particles in the sample to be split. Generally it will only be necessary to reduce the material one time by quartering or splitting. A light coat of vegetable cooking spray may be sprayed on the equipment to help shed the asphaltic concrete. In no case shall diesel fuel or similar solvent be used. Individual samples for testing shall not be obtained by quartering or splitting, but rather as described in Section 4.

3.4 Place the hot material on a tarp or a sheet of heavy paper large enough to manipulate the sample. In a rolling motion thoroughly mix the material. Leave the mound in a circular shape after rolling is completed.

3.5 Spread the material into a circular mass. Spreading may be accomplished either by leveling the mound of material with a concrete trowel or hand float; or by placing a straightedge of sufficient length to span the final diameter of the circular mass over the center of the material and rotating it until the desired height is obtained. Whichever method is utilized, the operator shall assure that the material is evenly distributed with as little segregation as possible. The thickness of the circular mass shall not exceed 3 inches. Generally a depth of 1-1/2 to 2 inches will provide acceptable size samples.

3.6 At any time during obtaining test samples, the material may be reheated for a maximum of 1 hour at a temperature not exceeding 300 °F to restore pliability.

4. OBTAINING TEST SAMPLES

4.1 The required samples for testing, with the exception of moisture content, shall be obtained as described in Subsections 4.2 through 4.6 below. For obtaining test samples for moisture content, see Subsection 4.7 below. The samples may be obtained in any sequence as long as the sample for moisture content is taken immediately before or after the sample for determination of asphalt content. The width of sampler to be used is dependent upon the size of aggregate in the sample and/or the amount of material needed.

4.2 The samples shall be obtained by placing the closed end of the sampler as near the center of the mass as possible with the open end of the sampler extending beyond the edge of the circular mass (see Figure 2). Force the sampler down to the bottom of the pile and remove the contents that are captured by sliding the sampler out of the pile, and placing the contents into a tared container.

4.3 Obtain additional material, as necessary, by repeating the procedure in Subsection 4.2, at a different location in the pile so that a cut does not overlap a previous cut (see Figure 3).

4.4 If small amounts of material are needed, slide the sampler out and to the side of the pile. Lift the sampler up and turn it perpendicular to the material. Force the sampler down through the full width of the material, starting at the closed end portion of the material. (Figure 4 provides an illustration of this procedure.) If necessary, additional material may be obtained by taking multiple cuts. Utilize the entire portion(s) taken and do not attempt to obtain an exact weight.

4.5 If excess material is obtained, the sample shall be returned to a place not disturbing the rest of the circular mass. If the remaining mass is large enough, and is undisturbed, obtain another sample for the test, if necessary utilizing a smaller width sampler. Alternatively, the sample may be returned to the circular mass and the material re-rolled and spread to a thinner depth.

4.6 If the remaining mass is not large or uniform enough to obtain required samples, re-roll and spread the material in the same manner described in Subsection 3.5.

4.7 Test samples for determining moisture content may be obtained by use of the sampler as described in Subsections 4.2 through 4.6 above, or by taking several small portions with a small scoop at random locations throughout the mass.

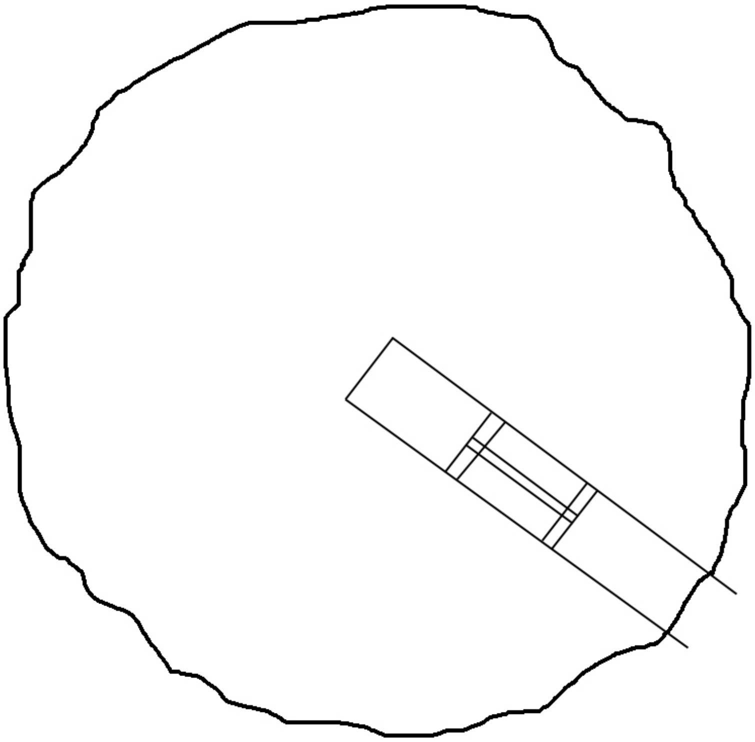


FIGURE 2

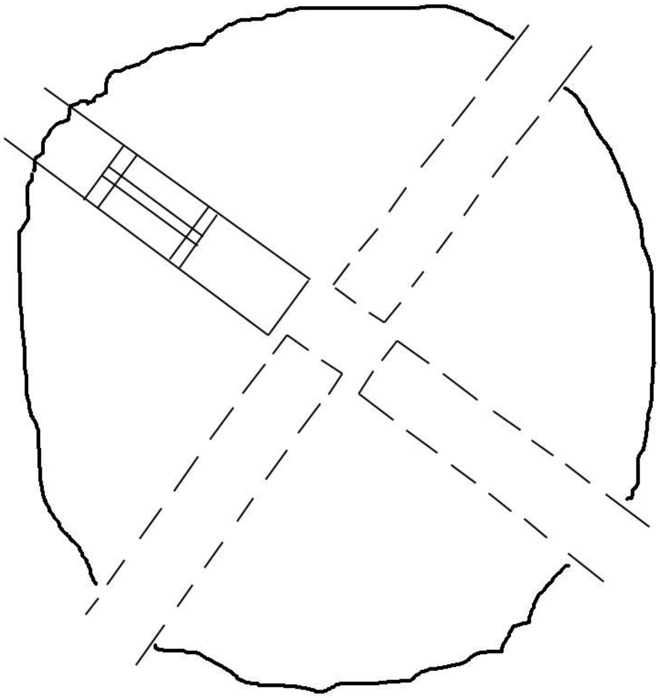


FIGURE 3

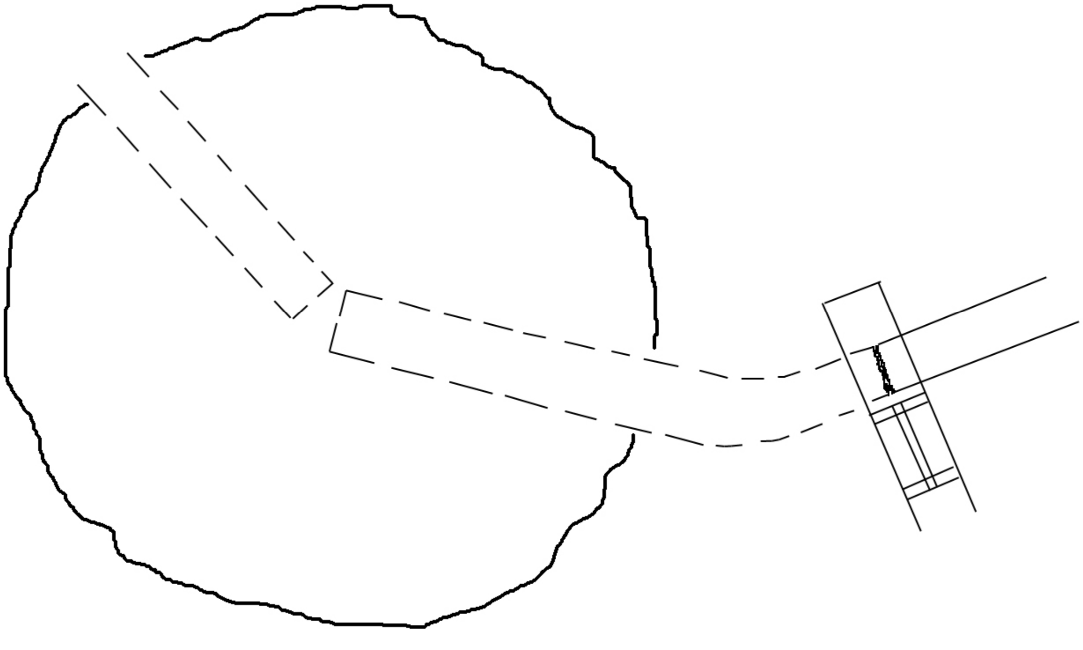


FIGURE 4

ARIZ 417f
November 2, 2018
(8 Pages)

MAXIMUM THEORETICAL SPECIFIC GRAVITY AND DENSITY OF FIELD PRODUCED BITUMINOUS MIXTURES (RICE TEST)

(A Modification of AASHTO T 209)

1. SCOPE

1.1 This method of test is intended for determining the maximum specific gravity and density of uncompacted bituminous mixtures that have been field produced.

Note: Two methods are provided for determining the maximum specific gravity. The method given in Section 6 is for determining results without fan drying the samples. Section 7 describes the procedure which is used when fan drying is necessary. For the first four samples taken at the beginning of production on a project the maximum specific gravity shall be determined in accordance with Section 6 and also shall be fan dried and maximum specific gravity determined in accordance with Section 7. If the difference in resultant air voids, when determined as described in Arizona Test Method 424 is greater than 0.2% subsequent samples will be subjected to fan drying. During the course of the project comparisons should be made on approximate 10 sample intervals to determine need for fan drying. In case of dispute, fan drying shall be used.

1.2 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.

1.3 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.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Balance - A balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.1 gram.

2.3 Container - A heavy walled Erlenmeyer flask having a capacity of at least 1500 mL and strong enough to withstand a partial vacuum; the cover shall consist of a rubber stopper with a tight hose connection. A small piece of No. 200 wire mesh covering the hose opening shall be used to minimize the possibility of loss of fine material.

Note: If a procedure which subjects multiple flasks to a vacuum simultaneously is used, the vacuum gauge shall be placed beyond the last bottle to insure that all the bottles are being subjected to the same amount of vacuum.

2.4 Flat glass plate large enough to cover mouth of the flask.

2.5 Vacuum pump for evacuating air from the container.

2.6 All water used in this procedure shall be distilled or de-mineralized water.

3. CALIBRATION OF FLASK

3.1 Record the weight of the flask and flat glass plate separately to the nearest 0.1 gram on the work card. Using water at a temperature of 77 ± 1 °F, fill the flask with water to approximately one inch below the top of the flask. Using a long narrow rod, remove air bubbles adhering to the walls of the flask. Confirm that the temperature of the water is at 77 ± 1 °F. Fill to the top and slide the flat glass plate over the mouth of the flask. Verify that no air is trapped under the flat glass plate. Dry the outside of the flask and glass plate and weight to the nearest 0.1 gram. Subtract the weight of the glass plate and record the weight of the "flask and water" as "B".

4. PREPARATION OF SAMPLES

4.1 Obtain 3 representative 1050 ± 50 gram samples of the material, as described in Arizona Test Method 416.

Note: If necessary, heat the sample for not more than one hour at a maximum temperature of 285 °F ONLY until it is pliable enough to allow separation of the coated aggregate.

4.2 Spread each sample on a sheet of heavy paper or in a large flat bottom pan. Before the samples are completely cooled, separate the particles of the mixture, taking care not to fracture the coarse aggregate particles, so that the particles of the fine aggregate portion are not larger than 1/4 inch. Allow the samples to cool to room temperature.

5. PROCEDURE

5.1 Place the sample in the flask and determine the weight to the nearest 0.1 gram. Subtract the weight of the flask and record the "weight of sample in air" as "Wmm".

5.2 Add sufficient water to cover the sample. The water shall be at a temperature of approximately 77 °F and shall have been treated with a wetting agent.

Note: Aerosol OT in a concentration of 0.01%, or one mL of 10% solution per 1000 mL of water, has been found to be a suitable wetting agent and shall be used to facilitate the release of entrapped air.

5.3 Remove entrapped air by subjecting the contents of the flask to a partial vacuum with a minimum of 20 inches of mercury (gauge) for 15 ± 2 minutes, agitating the contents of the flask four times at evenly spaced intervals throughout this period.

CAUTION: Do not agitate the sample too frequently or vigorously, as that can cause stripping of the asphalt film from some particles, resulting in erroneous specific gravities.

5.4 After the evacuation period, fill the flask with water to approximately one inch below the top of the flask. Gently stir the sample with a long narrow rod in such a way to release any trapped air bubbles, avoiding breakage of the aggregates. Using the long narrow rod, carefully remove any air bubbles adhering to the walls of the flask. Fill completely to the top and confirm that the temperature is at 77 ± 2 °F. Slide the pre-weighed flat glass plate over the mouth of the flask. Verify that no air is trapped under the flat glass plate. Dry the outside of the flask and glass plate and weigh immediately to the nearest 0.1 gram. Subtract the weight of the glass plate and record the weight of the "flask + water + sample" as "C".

6. CALCULATIONS

6.1 The Volume of Voidless Mix, "Vvm", in mL, and Maximum Specific Gravity, "Gmm" is determined for each sample by the following:

$$\mathrm{Vvm} = \mathrm{Wmm} + \mathrm{B} - \mathrm{C}$$

$$\mathrm{Gmm} = \frac{\mathrm{Wmm}}{\mathrm{Vvm}}$$

Where: Wmm = Wt. of Sample in Air
B = Wt. of Flask + Water
C = Wt. of Flask + Water + Sample

6.2 Compare the three individual values for maximum specific gravity. If the range of the three is within 0.024, all are used to determine the average maximum specific gravity as shown in Subsection 6.4. If the range is greater than 0.024, the average of two may be used if they are within a range of 0.012. If values are not achieved within the above criteria, the samples shall be discarded and a set of three new samples shall be tested. If material is not available, results should be used cautiously in the analysis of the bituminous mix. If results are used for specification compliance, additional material must be obtained for retesting.

6.3 The average maximum specific gravity of the bituminous mix is determined for the samples with acceptable maximum specific gravity values, and recorded to the nearest 0.001.

6.4 To determine the maximum density, the average maximum specific gravity is multiplied by 62.3 lbs./cu. ft.

7. PROCEDURE FOR FAN DRYING SAMPLES

7.1 The entire contents of the flask shall be poured into a nest of sieves consisting of a No. 40 and a No. 200 screen.

Note: If stripping has occurred, as evidenced by discoloration of water in the flask, significant loss of Minus No. 200 material may be expected. Provisions for the recovery and addition of this material to the Plus No. 200 material shall be made.

7.2 Allow the mix to drain through the sieves until excess moisture is removed from the mix. Separate the sieves and place both sieves in a tared pan. Place the pan in front of a fan (see Note below) and dry the material retained on the No. 40 and No. 200 sieves until the material can be easily removed from the sieves. Remove the material from the sieves and spread it in the pan. Determine and record the initial weight of the pan and the material.

Note: The air through the fan shall be at room temperature and no heat shall be used to dry the material.

7.3 Continue fan drying the material, determining and recording the weight of the pan and the material at 15 minute intervals. When the weight loss is 0.5 gram or less for a 15 minute interval, the mix is considered to be surface dry. Record the surface dry weight as "Wsd". Intermittent stirring of the sample is required during the drying period. Conglomerations of the mix shall be broken by hand. Care must be taken to prevent loss of particles of the mixture.

Note: If the "Wsd" weight for any of the three samples is less than its corresponding "Wmm" weight, the samples shall be discarded and a set of three new samples shall be tested. If material is not available, the maximum specific gravity shall be determined utilizing the "Wmm" weight and results should be used cautiously in the analysis of the bituminous mix. If results are used for specification compliance, additional material must be obtained for retesting.

7.4 To calculate the fan dried "Vvm" and maximum specific gravity, "Gmm", of each sample, the surface dry weight, "Wsd", is substituted for "Wmm" in the equation given for "Vvm" in Subsection 6.1, as shown in the example below.

$$Vvm = Wsd + B - C$$

$$G_{mm} = \frac{W_{mm}}{V_{vm}}$$

Where: Wmm = Wt. of Sample in Air
Wsd = Wt of Fan Dried Sample
B = Wt. of Flask + Water
C = Wt. of Flask + Water + Sample

8. EXAMPLE

8.1 An example of the completed form is shown in Figure 1 and an example of the blank form is shown in Figure 2.

Arizona Department of Transportation
ARIZONA TEST METHOD 417

Lab#: 15-3456 Date: 08/05/2015 Project #: F-III-1(1) TRACS#: H99990IC
Project Name: Big Gulch - Big Mountain Material Type: 3/4" AC
Lot#: 1 Sample #: 4 Maximum Specific Gravity Range: 0.003
Tested By: Lisa Tester Checked By: A. A.

If samples were fan dried, the maximum density is determined utilizing the "Wsd" weight as shown below:

Flask Number or I. D.	"Wf" Wt. of Flask	"Wmm" Wt. of Sample in Air	"B" Wt. of Flask + Water	"C" Wt. of Flask + Sample + Water	Vvm" Volume of Voidless Mix	"Gmm" Maximum Specific Gravity	Maximum Density (lbs./cu. ft.)	"Wsd" Surface Dry Weight	Vvm" Volume of Voidless Mix	"Gmm" Maximum Specific Gravity	Maximum Density (lbs./cu. ft.)
		Wfs - Wf		Wa - Wp	Wmm + B - C	$\frac{Wmm}{Vvm}$	Gmm X 62.3	(See Below)	Wsd + B - C	$\frac{Wmm}{Vvm}$	Gmm X 62.3
1	998.7	1064.9	3215.7	3848.7	431.9	2.466		1067.7	434.7	2.450	
2	977.6	1076.5	3178.7	3819.2	436.0	2.469		1080.5	440.0	2.447	
3	~~994.3~~	~~1067.4~~	~~3194.1~~	~~3825.1~~	~~436.4~~	~~2.446~~		~~1071.2~~	~~440.2~~	~~2.425~~	
AVERAGE						2.468	153.8			2.449	152.6

Flask Number or I. D.	1	2	3
Wt. of Flask + Sample, "Wfs"	2063.6	2054.1	2061.7
Wt. of Flask + Sample Water + Glass Plate, "Wa"	3931.1	3901.6	3907.5
Wt. of Glass Plate, "Wp"	82.4	82.4	82.4

Remarks: *Flask #3 eliminated from the average due to Specific Gravity being outside specified 0.024 allowable range*

Specific Gravity Range:	**Range of 3:**	**Range of 2:**
Non Fan Dried:	0.023	0.003
Fan Dried:	0.025	0.003

Maximum Specific Gravity (Rice) Fan Dry Weigh backs

Flask Numer or I.D.	1	2	3
Tare weight of Pan	453.7	502.4	499.6
Weight of Pan and Sample	1536.3	1597.8	1585.7
Weight of Pan and Sample	1529.2	1590.7	1578.6
Weight of Pan and Sample	1523.2	1584.7	1572.6
Weight of Pan and Sample	1522.5	1584.0	1571.9
Weight of Pan and Sample	1521.9	1583.4	1571.2
Weight of Pan and Sample	1521.4	1582.9	1570.8
Weight of Pan and Sample			
Weight of Pan and Sample			
Surface Dry Weight (Wsd)	*1067.7*	*1080.5*	*1071.2*

Air Voids Calculations

$$\left[1 - \frac{\text{A.C. Mix Bulk Density}}{\text{Maximum Density From Rice Test}}\right] \times 100 =$$

Non Fan Dried $\left[1 - \frac{145.5}{153.8}\right] \times 100 =$ 5.4 %

Fan Dried $\left[1 - \frac{145.5}{152.6}\right] \times 100 =$ 4.6 %

Difference in Air Voids = [Air Voids (Sample Not Fan Dried)] - [Air Voids (Sample Fan Dried)] = 0.8 %

44-3941 R12/15

FIGURE 1

Arizona Department of Transportation
ARIZONA TEST METHOD 417

Lab#: ____________ Date: ____________ Project #: ____________ TRACS#: ________
Project Name: ____________ Material Type: ____________
Lot#: ____________ Sample #: ______ Maximum Specific Gravity Range: ____________
Tested By: ____________ Checked By: ____________

If samples were fan dried, the maximum density is determined utilizing the "Wsd" weight as shown below:

Flask Number or I. D.	"Wf" Wt. of Flask	"Wmm" Wt. of Sample in Air Wfs - Wf	"B" Wt. of Flask + Water	"C" Wt. of Flask + Sample + Water Wa - Wp	Vvm" Volume of Voidless Mix Wmm + B - C	"Gmm" Maximum Specific Gravity $\frac{Wmm}{Vvm}$	Maximum Density (lbs./cu. ft.) Gmm X 62.3	"Wsd" Surface Dry Weight (See Below)	Vvm" Volume of Voidless Mix Wsd + B - C	"Gmm" Maximum Specific Gravity $\frac{Wmm}{Vvm}$	Maximum Density (lbs./cu. ft.) Gmm X 62.3
AVERAGE											

Flask Number or I. D.			
Wt. of Flask + Sample, **"Wfs"**			
Wt. of Flask + Sample Water + Glass Plate, **"Wa"**			
Wt. of Glass Plate, **"Wp"**			

Remarks:

Specific Gravity Range: Range of 3: Range of 2:
Non Fan Dried:
Fan Dried:

Maximum Specific Gravity (Rice) Fan Dry Weigh backs

Flask Numer or I.D.			
Tare weight of Pan			
Weight of Pan and Sample			
Weight of Pan and Sample			
Weight of Pan and Sample			
Weight of Pan and Sample			
Weight of Pan and Sample			
Weight of Pan and Sample			
Weight of Pan and Sample			
Weight of Pan and Sample			
Surface Dry Weight (Wsd)			

Air Voids Calculations

$$\left[1 - \frac{\frac{\text{A.C. Mix}}{\text{Bulk Density}}}{\frac{\text{Maximum Density}}{\text{From Rice Test}}}\right] \times 100 =$$

Non Fan Dried $\left[1 - \frac{\qquad}{\qquad}\right]$ x 100 = ________ %

Fan Dried $\left[1 - \frac{\qquad}{\qquad}\right]$ x 100 = ________ %

Difference in Air Voids = [Air Voids (Sample Not Fan Dried)] - [Air Voids (Sample Fan Dried)] = ________ %

44-3941 R12/15

FIGURE 2

ARIZ 421
September 5, 1996
(14 Pages)

BITUMINOUS MATERIAL CONTENT OF ASPHALTIC CONCRETE MIXTURES BY THE NUCLEAR METHOD

(An Arizona Method)

SCOPE

1. (a) This procedure describes a method for determining the percent bituminous material content of asphaltic concrete mixtures, by testing a sample with a device that utilizes neutron thermalization techniques.

(b) Modifications to this procedure for Asphaltic Concrete Friction Course, Asphaltic Concrete (Asphalt-Rubber), and Asphaltic Concrete Friction Course (Asphalt-Rubber) are given in Section 7.

(c) 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.

(d) 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).

(e) If recommended by the manufacturer, equipment operators should wear an approved form of radiation dosimetry film badge capable of monitoring the occupational radiation exposure.

(f) 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.

(g) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) Nuclear asphalt content gauge and manufacturer's instruction manual. While exact details of the manufacture of the apparatus may vary, the system shall consist of the following items and meet the criteria for variability given below. The equipment shall be so constructed as to be licensable in accordance with applicable health and safety regulations.

1) Neutron Source - An encapsulated and sealed radioactive source such as "Americium-241: Beryllium", or "Californium-252".

2) Detectors - Any type of thermal neutron detector, such as helium-3 or boron tri-floride.

3) Read-Out Instrument, such as a scaler or a direct-reading digital device calibrated in percent asphalt cement.

4) A minimum of four standard stainless steel sample pans [approximately 230 mm long by 185 mm wide by 100 mm deep (9" x 7-1/4" x 4")].

5) The variability of the gauge shall be no greater than ± 0.05 percent asphalt for a four-minute count. The variability shall be determined utilizing a three point calibration for a conventional asphaltic concrete mix with a design asphalt content of approximately five percent. The variability of the gauge is determined from the slope of the calibration curve and the standard deviation of the measured counts of the calibration sample at the mix design percent asphalt. If the gauge fails to meet the variability requirement shown above for a four-minute count, the variability may be determined utilizing either 8-minute or 16-minute counts as necessary. If the variability is determined using an increased count time, that count time is the minimum that is to be used for testing subsequent field samples [See paragraphs 6(g) and 6(i)]. In lieu of an increased count time, a new set of calibration samples may be prepared and tested with greater care. If the gauge fails to meet the variability requirement after increased count times or preparation of additional calibration samples, the gauge must be returned to the manufacturer for necessary repair and recalibration. Variability is

calculated as shown below. The variablity of the gauge should be checked at minimum 12 month intervals. Documentation of the variability determination shall be kept on file.

$$V = \frac{S.D.}{S}$$

Where: V = apparatus variability, in percent asphalt.
S = slope of the calibration curve, in counts (y-axis) per percent asphalt cement (x-axis). [See note below.]
$S.D.$ = standard deviation, in counts. The standard deviation is calculated from 20 individual four-minute readings (8-minute or 16-minute counts if used) taken on the calibration sample at the mix design percent asphalt content.

NOTE: The slope of the calibration curve, as calculated and given by the gauge may not be the actual numerical value for the slope, and in addition, the slope may not be given in counts (y-axis) per percent asphalt (x-axis). For instance, the Troxler Nuclear Asphalt Content Gauge (Model 3241-C) gives a numerical value for slope which is actually 1000 times the actual slope, and in addition, the value given by the Troxler gauge is given for percent asphalt (y-axis) per counts (x-axis). The following is an example of the slope of the calibration curve as given by the Troxler gauge and the determination of the corrected slope value to be used in the Apparatus Variability equation given above:

Troxler gauge reported slope = 5.220075
[Slope based on percent asphalt (y-axis) per counts (x-axis).]

Determination of corrected slope:

$$\frac{5.220075}{1000} =$$

0.005220075 (percent asphalt/counts)

Reciprocal of slope to obtain slope based on counts (y-axis) per percent asphalt (x-axis):

$$\frac{1}{0.005220075} =$$

191.568 (counts/percent asphalt)

In this case, the value of 191.568 is the slope of the calibration curve and is the value which is to be used for "S" in the equation for Apparatus Variability given above.

(b) Scale(s) or balance(s) capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be as shown below:

1) The scale or balance to be used for preparing calibration samples shall have a readability and sensitivity of at least 1 gram.

2) The scale or balance to be used for testing field samples shall have a readability and sensitivity of at least 5 grams.

(c) Oven(s), capable of heating and maintaining temperatures to 177 °C (350 °F). Two ovens may be required.

(d) Steel straightedge, approximately 300 mm (12 inches) in length.

(e) Either a piece of plywood of at least 20 mm (3/4 inch) nominal thickness, or a metal plate of at least 6 mm (1/4 inch) nominal thickness, having an area slightly larger than the top of the sample pans.

(f) Mixing apparatus - Mechanical mixing is recommended; 19 liter (20 quart) capacity mixer is required. (Hand mixing may be performed if desired.)

(g) Miscellaneous pans, bowls, spoons, and spatulas.

(h) Thermometer with temperature range 10 to 260 °C (50 to 500 °F).

(i) Hot plate(s) capable of heating and maintaining temperatures to 177 °C (350 °F).

(j) Flat bottom metal scoop at least 50 mm wide by 150 mm long (2 inches x 6 inches).

PRECAUTIONS

3. (a) Since nuclear equipment measures the total amount of hydrogen in the sample, this procedure is sensitive to changes in moisture content. It must be remembered that both bituminous material and water contain hydrogen.

(b) Keep any other source of neutron radiation at least 10 meters (30 feet) from the equipment.

(c) Do not place the equipment where the amount of hydrogenous material may change during the calibration or testing procedures. Hydrogenous materials are those containing hydrogen, for example, water or plastic materials.

(d) Moving the gauge to a new location may have an effect on the results. Therefore, a new background count and/or calibration is required if the gauge is moved. If the original calibration specimens are retested, they shall be heated in an oven at 121 to 149 °C (250 to 300 °F) for at least one hour to drive out any condensation or absorbed moisture and to bring them to testing temperature.

SAMPLING

4. (a) For preparing calibration samples, aggregate samples are obtained in accordance with Arizona Test Method 105. Samples shall be adequately dried, if necessary, to a free-flowing condition in the portion passing the 4.75 mm (No. 4) sieve. A maximum of approximately 45 kg (100 pounds) of aggregate, representative of the mix design gradation, will normally be required.

(b) When testing field samples of Asphaltic Concrete, a sample of the freshly produced mix is obtained in accordance with Arizona Test Method 104.

CALIBRATION

5. (a) A calibration must be performed for each asphaltic concrete mixture that is to be used on the project. Test results on asphaltic concrete mixtures may vary with changes in the type and gradation of aggregate, (percentage and source of

mineral admixture, if used), and percentage and source of bituminous material. Accordingly, a calibration curve must be developed for each mix design. The calibration curve shall be established with three or more points. The calibration procedure consists of preparing and testing one dry aggregate blank sample, and a minimum of three asphaltic concrete calibration samples at varying bituminous material contents.

(b) Before a calibration is performed, a 16-minute background count shall be taken and recorded.

(c) For the dry aggregate blank sample, weigh up one approximate 10 kg (22 pound) aggregate sample representative of the mix design aggregate gradation. Thoroughly blend the aggregate and dry to constant weight at 121 to 149 °C (250 to 300 °F), and then place in a tared sample pan in at least two approximately equal depth layers. After placing each layer in the pan, gently spade the aggregate with the scoop or wide blade-like tool. The coarse and fine material shall be uniformly distributed. Too much manipulation of the material can result in segregation of the material, causing the fines to migrate to the bottom. Fill the pan slightly above the top rim. Place the straightedge firmly across the rim and, using a sawing motion, strike off the surface of the sample so that it is flush with the rim. Gaps between the straightedge and the sample shall be filled with fine aggregate and the sample leveled. Do not further compact the sample. Determine and record the weight of the dry aggregate blank sample to the nearest 5 grams.

(d) Place the dry aggregate blank sample in an oven at 121 to 149 °C (250 to 300 °F). A count will be determined on this sample, as described in paragraph 5(l), at the completion of the testing of the asphaltic concrete calibration samples.

(e) For the asphaltic concrete calibration samples, weigh up a minimum of three aggregate samples representative of the mix design aggregate gradation. These aggregate samples shall weigh at least 500 grams more than the dry aggregate blank sample weight determined in paragraph 5(c). If mineral admixture is used, the appropriate type and amount shall be added to the aggregate and thoroughly blended. Dry the samples to constant weight at the mixing temperature required as shown in paragraph (g) below.

(f) Bituminous material of the same source, grade, and type as that which will be used in production of the asphalt concrete mixture shall be used in the calibration samples. Normally three samples are prepared; one at the design bituminous material content, one at 1.0% above, and one at 1.0% below. The percent of bituminous material is based on the weight of total mix. The weight of bituminous material to be added for each percent of bituminous material is determined by the following:

$$\begin{bmatrix}\text{Weight of}\\ \text{Bituminous}\\ \text{Material}\end{bmatrix} = \frac{\begin{bmatrix}\text{Weight of Aggregate}\\ \text{(and mineral admixture when used)}\end{bmatrix}}{100 - \begin{bmatrix}\text{Percent of}\\ \text{Bituminous}\\ \text{Material}\end{bmatrix}} \times \begin{bmatrix}\text{Percent of}\\ \text{Bituminous}\\ \text{Material}\end{bmatrix}$$

(g) All bowls, sample pans, and mixing tools shall be heated to approximately 149 °C (300 °F). It is recommended that a "butter mix" be utilized to condition the mixing equipment. If a "butter mix" is utilized, the mixing equipment shall be scraped consistently clean with a spatula after each batch. As an alternate to a "butter mix", the mixing equipment shall be scraped as clean as possible with a spatula after each batch. All samples shall be mixed at the same mixing temperature, ± 6 °C (10 °F). During mixing, a hot plate shall be placed under the mixing bowl to reduce loss of heat while mixing. The sample shall be sufficiently mixed to ensure thorough coating. Unless otherwise indicated on the mix design, the temperature of the bituminous material and aggregate (and mineral admixture when used) at the time mixing begins shall be in accordance with the following:

BITUMINOUS MATERIAL	TEMPERATURE RANGE
AC 10, AC-20	149 ± 6 °C (300 ± 10 °F)
AC-30, AC-40	152 ± 6 °C (305 ± 10 °F)
PG 58-XX, PG 64-XX	149 ± 6 °C (300 ± 10 °F)
PG 70-XX, PG 76-XX	152 ± 6 °C (305 ± 10 °F)
Polymer Modified Asphalt	160 ± 6 °C (320 ± 10 °F)
Asphalt-Rubber	163 ± 6 °C (325 ± 10 °F)

(h) At the time of beginning the fabrication of each asphaltic concrete calibration sample, the mixture shall be 121 to 149 °C (250 to 300 °F). The mix with the lowest bituminous material content shall be prepared first. Fill the tared sample pan in approximately equal depth layers (two layers minimum), uniformly distributing the sample in the pan. After placing each layer in the pan, gently spade the mix with a spatula, wide blade-like tool, or scoop and lightly press the mix down. Add mix until the top of the material is mounded approximately 25 to 38 mm (1 to 1-1/2 inches) above the top of the pan. Using a spatula or trowel, round the top of the mixture so that it is at the interior edges of the pan but not on the top rim of the pan. Use the metal plate or plywood to consolidate the asphaltic concrete mixture. If necessary, this can be done by placing the pan on a clean floor, placing the metal plate or plywood on top of the sample pan and standing on the plate. If desired, a piece of waxed paper or other suitable material may be placed on the top of the mix to avoid sticking. If necessary, fill any voids and consolidate the mix with the metal plate of plywood until the pan is completely full and the mix is even with the top of the pan. Determine and record the weight of this asphaltic concrete calibration sample to the nearest gram. This weight is identified as the asphaltic concrete calibration sample weight and is used (± 5 grams) for the remaining calibration samples.

(i) Place the sample in the gauge and take a 16-minute count. Record the measured count.

(j) Repeat steps in paragraphs 5(h) and 5(i) to fabricate and test the remaining calibration samples. These samples shall be fabricated in the same manner as the first calibration sample and shall be within ± 5 grams of the asphaltic concrete calibration sample weight. If samples are not able to be tested immediately after fabrication, they shall be placed in an oven at 121 to 149 °C (250 to 300 °F) until they can be tested.

(k) Prepare a calibration curve in accordance with the manufacturer's calibration instructions. On some gauges this curve may be generated internal to the gauge. To be considered acceptable, a calibration curve should have a correlation coefficient greater than or equal to 0.995.

$$\text{Correlation Coefficient} = \sqrt{1 - \frac{\Sigma\,(y - y')^2}{\Sigma\,(y - \bar{y})^2}}$$

Where: y = Actual percent bituminous material value for each sample.
y' = Calculated percent bituminous material value for each sample, from curve.
$\bar{y}$ = Mean of the actual percent bituminous material values for all samples.

(l) Remove the dry aggregate blank sample from the oven. Place in the gauge take a minimum four-minute count. This count is recorded and may be used to determine if significant changes occur in the aggregate during asphaltic concrete production. [See paragraph 6(i).]

(m) Once a calibration has been performed for the asphaltic concrete mixture, other gauges from the same manufacturer may use a cross calibration for testing of the same asphaltic concrete mixture. Cross calibrations shall be performed in accordance with the gauge manufacturer's recommendations, and shall have been done within the preceding 12 months. In cases of dispute, the gauge derived calibration shall be the referee method. A new cross calibration is required after any gauge repair.

PROCEDURE (FIELD TEST SAMPLE)

6. (a) A 16-minute background count shall be taken and recorded each day before any test samples are run.

(b) Obtain a representative sample for determining the bituminous material content. Generally 8 kg (18 pounds) should be adequate.

(c) If desired, the entire sample for determining the bituminous material content may be dried to constant weight in an oven at 143 ± 6 °C (290 ± 10 °F) in lieu of obtaining a moisture content sample as described in paragraph (d) or (h) below. If a moisture sample is obtained, the percent moisture is determined in accordance with Arizona Test Method 406. The percent moisture is subtracted from the gauge percent bituminous material to obtain the corrected (actual) percent bituminous material.

(d) If the entire sample for determining the bituminous material content has not been dried to constant weight as described in paragraph (c) above, or the moisture content sample is not to be taken at the completion of testing of the bituminous material content sample as described in paragraph (h) below, a moisture content sample is taken immediately after the fabrication of the bituminous material content test sample as described in paragraph (e) below.

(e) If the field sample is at fabrication temperature at the time of obtaining the bituminous material content test sample, the bituminous material content test sample is fabricated immediately. If the field sample is not at fabrication temperature, enough material for both the bituminous material content test sample, and a moisture content sample when necessary, shall be obtained and placed in a single pan and brought to fabrication temperature.

(f) At the time of beginning the fabrication of the bituminous material test sample, the mixture shall be at a temperature of 121 to 149 °C (250 to 300 °F). Fill the tared sample pan in approximately equal depth layers, using the same number of layers as was used in fabrication of the calibration samples. Uniformly distribute each layer of the sample in the pan. After placing each layer in the pan, gently spade the mix with a spatula, wide blade-like tool, or scoop and lightly press the mix down. When the pan is nearly full, weigh the sample. Add enough mix until the sample weight is within ± 10 grams of the asphaltic concrete calibration sample weight as determined in paragraph 5(h). If necessary, the mix may be pressed down using the metal plate or plywood during addition of material. Using a spatula or trowel, round the top of the mixture so that it is at the interior edges of the pan but not on the top rim of the pan. Use the metal plate or plywood to consolidate the asphaltic concrete mixture until it is even with the top rim of the pan. If necessary, this can be done by placing the pan on a clean floor, placing the metal plate or plywood on top of the sample pan and standing on the plate. If desired, a piece of waxed paper or other suitable material may be placed on the top of the mix to avoid sticking. Reweigh the sample, and assure the weight is within ± 10 grams of the asphaltic concrete calibration sample weight. Record the weight of the test sample to at least the nearest 5 grams.

(g) Immediately after fabrication place the sample in the gauge. Take and record a minimum four-minute count, and determine the gauge percent bituminous material. If an increased count time (8-minute or 16-minute) was used to determine the variability of the gauge [paragraph 2(a)(5)], that count time is the minimum that is to be used.

(h) If the bituminous material content sample has not been dried to constant weight prior to testing, or if the moisture content sample has not been taken at the time of fabrication of the bituminous material content test sample, a representative 1000 ± 50 gram moisture content sample shall be immediately taken from the bituminous material content test sample upon determination of the bituminous material percent in the gauge.

> NOTE: Generally the samples taken for bituminous material content and moisture content are obtained from a larger field sample from which material for other tests, e.g., Marshall and Rice is also split out. In case there is a need for additional testing, it may be desirable to save material from the bituminous material content test sample along with excess material from the field sample.

(i) If desired during asphaltic concrete production, a dry aggregate blank sample may be prepared and tested to ensure that changes in aggregate do not occur unnoticed. Testing may be performed at any time that a change in the aggregate is suspected. This sample shall be dried to constant weight and fabricated in the manner described in paragraph 5(c). The weight of this sample shall be within ± 10 grams of the weight of the dry aggregate blank sample as determined in paragraph 5(c). Place sample in the gauge and take and record a minimum four-minute count. If an increased count time (8-minute or 16-minute) was used to determine the variability of the gauge [paragraph 2(a)(5)], that count time is the minimum that is to be used. If a significant change is noted in this count [greater than ± 1.0% of the calibration blank count determined in paragraph 5(l)], a new calibration may be warranted. The project supervisor should be notified immediately of a possible change in aggregate, pit conditions, and/or moisture retained in the aggregate.

MODIFICATIONS FOR ASPHALTIC CONCRETE FRICTION COURSE, ASPHALTIC CONCRETE (ASPHALT-RUBBER), AND ASPHALTIC CONCRETE FRICTION COURSE (ASPHALT-RUBBER)

7. The following modifications apply for Asphaltic Concrete Friction Course, Asphaltic Concrete (Asphalt-Rubber), and Asphaltic Concrete Friction Course (Asphalt-Rubber).

(a) In paragraph 3(d), the last sentence is changed to read: If the original calibration specimens are retested, they shall be heated in an oven at 104 ± 11 °C (220 ± 20 °F) for Asphaltic Concrete Friction Course, or at 149 ± 14 °C (300 ± 25 °F) for Asphaltic Concrete (Asphalt-Rubber) or Asphaltic Concrete Friction Course (Asphalt-Rubber), for at least one hour to drive out any condensation or absorbed moisture and to bring them to testing temperature.

(b) In the calbration procedure given in Section 5, the following changes are made:

1) In paragraph 5(g), a "butter mix" shall be used for preparing calibration samples.

2) In paragraph 5(h):

a) At the time of beginning the fabrication of calibration samples for Asphaltic Concrete Friction Course, the temperature of the mixture shall be 104 ± 11 °C (220 ± 20 °F).

b) At the time of beginning the fabrication of calibration samples for Asphaltic Concrete (Asphalt-Rubber) or Asphaltic Concrete Friction Course (Asphalt-Rubber), the temperature of the mixture shall be 149 ± 14 °C (300 ± 25 °F).

c) For Asphaltic Concrete Friction Course or Asphaltic Concrete Friction Course (Asphalt-Rubber), instead of adding mix until the top of the material is mounded approximately 25 to 38 mm (1 to 1-1/2 inches) above the top of the pan, mix shall be added so that the top of the mix is mounded slightly above the top of the pan.

3) In paragraph 5(j), the last sentence is changed to read: If samples are not able to be tested immediately after fabrication, they shall be placed in an oven at 104 ± 11 °C (220 ± 20 °F) for Asphaltic Concrete Friction Course, or at 149 ± 14 °C (300 ± 25 °F), for Asphaltic Concrete (Asphalt-Rubber) or Asphaltic Concrete Friction Course (Asphalt-Rubber).

(c) Paragraph 4 (b) is changed to read: When sampling Asphaltic Concrete Friction Course or Asphaltic Concrete Friction Course (Asphalt-Rubber), an adequate amount of material shall be taken from the truck at the mixing plant and placed into a 19 liter (5 gallon) bucket, or other suitable container, which has been conditioned with a "butter mix". The sample shall be taken at random locations, approximately 300 mm (12 inches) below the surface, within 5 minutes from the time the loading of the truck is completed. Representative samples of Asphaltic Concrete (Asphalt-Rubber) may be obtained either from the truck at the mixing plant, the windrow, or in accordance with Arizona Test Method 104.

(d) In the procedure for testing field samples (Section 6), the following changes are made:

1) At the beginning of the fabrication of field samples of Asphaltic Concrete Friction Course, the temperature of the mixture shall be 104 ± 11 °C (220 ± 20 °F).

2) At the beginning of the fabrication of field samples of Asphaltic Concrete (Asphalt-Rubber) or Asphaltic Concrete Friction Course (Asphalt-Rubber), the temperature of the mixture shall be 149 ± 14 °C (300 ± 25 °F).

CALIBRATION REPORT

8. The calibration report shall contain, as a minimum, the following information:

(a) Make, model, and serial number of the asphalt content gauge.

(b) ADOT project number.

(c) Type of mix.

(d) Calibration number.

(e) Name of test operator.

(f) Identification (type and source) of bituminous material and aggregate materials, (and mineral admixture when used).

(g) Calibration date and background count.

(h) Correlation coefficient of the calibration curve (Fit Coeff.).

(i) Weight and measured count of the dry aggregate blank sample prepared and tested during the calibration prodedure.

(j) Mix design percent bituminous material content.

(k) Percent of mineral admixture if used.

(l) Percentages of bituminous material in calibration samples.

(m) Weight of asphaltic concrete calibration samples.

(n) Measured count of each asphaltic concrete calibration sample.

FIELD SAMPLE TEST REPORT

9. The field sample test report shall, as a minimum, contain the following information:

(a) ADOT project number.

(b) Type of mix.

(c) Calibration number.

(d) Mix design percent bituminous material content.

(e) Date and location of field test sample.

(f) Test number and lot number, if applicable.

(g) Field sample test date and name of test operator.

(h) Background count.

(i) Weight of test sample.

(j) Count time (minutes) of test.

(k) Measured count of test sample.

(l) Gauge measured percent bituminous material.

(m) Percent moisture.

(n) Corrected (actual) percent bituminous material.

(o) When a dry aggregate blank sample is prepared and tested, the following information is also reported:

1) Weight and measured count of the dry aggregate blank sample prepared and tested during the calibration prodedure.

2) Weight and measured count of dry aggregate blank sample prepared and tested during production.

3) Percentage change in counts from the calibration dry aggregate blank sample count.

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DETERMINATION OF AIR VOIDS IN COMPACTED BITUMINOUS MIXTURES

(A Modification of AASHTO Designation T 269)

1. SCOPE

1.1 This procedure is used to determine the air voids in compacted bituminous mixtures. It is applicable for specimens which are either laboratory compacted or field compacted (for example, cores).

1.2 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.

2. CALCULATION

2.1 For specimens which are either Marshall laboratory compacted or field compacted (e.g., cores), the percent air voids shall be calculated using the bulk density of the compacted bituminous mixture (Arizona Test Method 415) and maximum density of the mixture from the Rice Test (Arizona Test Method 417).

2.1.1 The percent air voids are calculated by the following equation:

$$\text{Percent Air Voids} = \left[1 - \frac{\text{Bulk Density}}{\text{Maximum Density}}\right] \times 100$$

2.1.1.1 An example of the calculations is given in Figure 1.

2.1.1.2 A blank form for perfoming the calculations is given in Figure 3.

2.2 For specimens which are gyratory laboratory compacted, the percent air voids shall be calculated using the average relative density of the compacted bituminous mixture at N_{design} (AASHTO T 312).

2.2.1 The percent air voids are calculated by the following equation:

Percent Air Voids = (100) – (Average Relative Density, % G_{mm}, at N_{design})

2.2.1.1 An example of the calculations is given in Figure 2.

2.2.1.2 A blank form for perfoming the calculations is given in Figure 4.

3. REPORT

3.1 The percent air voids shall be reported to the nearest 0.1%.

CALCULATION OF AIR VOIDS FOR MARSHALL LABORATORY COMPACTED SPECIMENS OR FIELD COMPACTED SPECIMENS

Specimens Compacted by: Hand ☐ Mechanical ☒ 4 inch ☒ 6 inch ☐; Core ☐

Specimen I.D.	1	2	3	Average
Specimen Height	2.516	2.515	2.519	
Bulk Specific Gravity, Bulk Density, and Absorption (Arizona Test Method 415: Method A ☒, Method C ☐, or Vacuum Method ☐)				
A = Mass in grams of specimen in Air	1155.9	1155.4	1158.2	
B = Mass in grams of SSD specimen in Air	1156.9	1156.3	1159.2	
C = Mass in grams of specimen in Water	647.9	649.6	651.8	
G_{mb} = Bulk Specific Gravity = A/(B – C)	2.271	2.280	2.283	2.278
% Absorption = [(B – A)/(B – C)] x 100	0.20	0.18	0.20	
Bulk Density = (G_{mb} x 62.3 lbs./cu. ft.)	141.5	142.0	142.2	
Range of Bulk Density values (lbs./cu. ft.)	0.7			
Average Bulk Density = (Average G_{mb} x 62.3 lbs./cu. ft)				141.9
Maximum Density (lbs./cu. ft.) [from Rice Test]	149.4			

Notes:

The individual specimen heights are reported to the nearest 0.001 inch.

The individual specimen masses are reported to the nearest 0.1 gram.

The indivdual bulk specific gravities are reported to the nearest 0.001.

The average bulk specific gravity is calculated, and reported to the nearest 0.001, using the individual bulk specific gravities which have been reported to the nearest 0.001.

The individual bulk densities are reported to the nearest 0.1 lb./cu. ft.

The average bulk density is reported to the nearest 0.1 lb./cu. ft.

The maximum density [from Rice Test] is reported to the nearest 0.1 lb./cu. ft.

$$\textbf{Percent Air Voids} = \left[1 - \frac{\text{Average Bulk Density}}{\text{Maximum Density from Rice Test}}\right] \times 100 = \left[1 - \frac{141.9}{149.4}\right] \times 100 = 5.0\%$$

EXAMPLE AIR VOIDS CALCULATION FOR MARSHALL LABORATORY COMPACTED SPECIMENS

FIGURE 1

CALCULATION OF AIR VOIDS FOR GYRATORY LABORATORY COMPACTED SPECIMENS

Specimen I.D.	1	2	Average
h_{ini} = Height, in mm, of specimen at N_{ini} (8 gyrations)	128.7	129.3	
h_{des} = Height, in mm, of specimen at N_{des} (100 gyrations)	117.0	117.4	
h_{max} = Height, in mm, of specimen at N_{max} (160 gyrations)	115.6	116.0	
Bulk Specific Gravity and Absorption (Arizona Test Method 415: Method A ☐, Method C ☐, or Vacuum Method ☐)			
A = Mass, in grams, of specimen at N_{max} in Air	4747.4	4744.6	
B = Mass, in grams, of SSD specimen at N_{max} in Air	4759.4	4756.0	
C = Mass, in grams, of specimen at N_{max} in Water	2752.7	2751.2	
G_{mb} = Bulk Specific Gravity of specimen at N_{max} $= \frac{A}{B-C}$	2.366	2.367	
% Absorption = [(B – A)/(B – C)] x 100	0.60	0.57	
G_{mm} = Maximum Specific Gravity [from Rice Test]	2.449		
*Relative Density, $\%G_{mm}$, of specimen at N_{ini}	86.8	86.7	86.8
*Relative Density, $\%G_{mm}$, of specimen at N_{des}	95.5	95.5	95.5
*Relative Density, $\%G_{mm}$, of specimen at N_{max}	96.6	96.7	96.7

$$*\text{Relative Density}, \%\, G_{mmx} = \frac{(G_{mb}) \times (h_{max})}{(G_{mm}) \times (h_x)} \times 100$$

Where: $\%G_{mmx}$ = Relative Density, $\%G_{mm}$, of specimen at N_{ini}, N_{des}, or N_{max}
G_{mb} = Bulk Specific Gravity of specimen at N_{max}
h_{max} = Height, in mm, of specimen at N_{max}
G_{mm} = Maximum Specific Gravity [from Rice Test]
h_x = Height of specimen, in mm, at N_{ini}, N_{des}, or N_{max}

Notes:

The individual specimen heights are reported to the nearest 0.1 mm.

The individual specimen masses are reported to the nearest 0.1 gram.

The indivdual bulk specific gravities are reported to the nearest 0.001.

The maximum specific gravity [from Rice Test] is reported to the nearest 0.001.

The individual relative densities are reported to the nearest 0.1 percent.

The average relative density for each set of specimens (at N_{ini}, N_{des}, and N_{max}) is calculated, and reported to the nearest 0.1 percent, using the corresponding individual relative densities which have been reported to the nearest 0.1 percent.

Three specimens are used when referee testing is performed.

Percent Air Voids = (100) – (Average Relative Density, % G_{mm}, at N_{des})
= (100) – (95.5) = 4.5%

EXAMPLE AIR VOIDS CALCULATION FOR GYRATORY LABORATORY COMPACTED SPECIMENS

FIGURE 2

CALCULATION OF AIR VOIDS FOR MARSHALL LABORATORY COMPACTED SPECIMENS OR FIELD COMPACTED SPECIMENS

Specimens Compacted by: Hand ☐ Mechanical ☐ 4 inch ☐ 6 inch ☐; Core ☐

Specimen I.D.				Average
Specimen Height				▨
Bulk Specific Gravity, Bulk Density, and Absorption (Arizona Test Method 415: Method A ☒, Method C ☐, or Vacuum Method ☐)				
A = Mass in grams of specimen in Air				▨
B = Mass in grams of SSD specimen in Air				▨
C = Mass in grams of specimen in Water				▨
G_{mb} = Bulk Specific Gravity = A/(B – C)				
% Absorption = [(B – A)/(B – C)] x 100				▨
Bulk Density = (G_{mb} x 62.3 lbs./cu. ft.)				▨
Range of Bulk Density values (lbs./cu. ft.)				▨
Average Bulk Density = (Average G_{mb} x 62.3 lbs./cu. ft)	▨	▨	▨	
Maximum Density (lbs./cu. ft.) [from Rice Test]				▨

Notes:

The individual specimen heights are reported to the nearest 0.001 inch.

The individual specimen masses are reported to the nearest 0.1 gram.

The indivdual bulk specific gravities are reported to the nearest 0.001.

The average bulk specific gravity is calculated, and reported to the nearest 0.001, using the individual bulk specific gravities which have been reported to the nearest 0.001.

The individual bulk densities are reported to the nearest 0.1 lb./cu. ft.

The average bulk density is reported to the nearest 0.1 lb./cu. ft.

The maximum density [from Rice Test] is reported to the nearest 0.1 lb./cu. ft.

$$\textbf{Percent Air Voids} = \left[1 - \frac{\textbf{Average Bulk Density}}{\textbf{Maximum Density from Rice Test}}\right] \times 100 = \left[1 - \frac{(\_\_\_\_)}{(\_\_\_\_)}\right] \times 100 = \_\_\_\%$$

FIGURE 3

CALCULATION OF AIR VOIDS FOR GYRATORY LABORATORY COMPACTED SPECIMENS

Specimen I.D.			Average
h_{ini} = Height, in mm, of specimen at N_{ini} (8 gyrations)			▨
h_{des} = Height, in mm, of specimen at N_{des} (100 gyrations)			▨
h_{max} = Height, in mm, of specimen at N_{max} (160 gyrations)			▨
Bulk Specific Gravity and Absorption (Arizona Test Method 415: Method A ☐, Method C ☐, or Vacuum Method ☐)			
A = Mass, in grams, of specimen at N_{max} in Air			▨
B = Mass, in grams, of SSD specimen at N_{max} in Air			▨
C = Mass, in grams, of specimen at N_{max} in Water			▨
G_{mb} = Bulk Specific Gravity of specimen at N_{max} $= \frac{A}{B - C}$			▨
% Absorption = [(B – A)/(B – C)] x 100			▨
G_{mm} = Maximum Specific Gravity [from Rice Test]			▨
*Relative Density, %G_{mm}, of specimen at N_{ini}			
*Relative Density, %G_{mm}, of specimen at N_{des}			
*Relative Density, %G_{mm}, of specimen at N_{max}			

$$^{*}\text{Relative Density, } \% G_{mmx} = \frac{(G_{mb}) \times (h_{max})}{(G_{mm}) \times (h_x)} \times 100$$

Where: $\%G_{mmx}$ = Relative Density, $\%G_{mm}$, of specimen at N_{ini}, N_{des}, or N_{max}
G_{mb} = Bulk Specific Gravity of specimen at N_{max}
h_{max} = Height, in mm, of specimen at N_{max}
G_{mm} = Maximum Specific Gravity [from Rice Test]
h_x = Height of specimen, in mm, at N_{ini}, N_{des}, or N_{max}

Notes:

The individual specimen heights are reported to the nearest 0.1 mm.

The individual specimen masses are reported to the nearest 0.1 gram.

The indivdual bulk specific gravities are reported to the nearest 0.001.

The maximum specific gravity [from Rice Test] is reported to the nearest 0.001.

The individual relative densities are reported to the nearest 0.1 percent.

The average relative density for each set of specimens (at N_{ini}, N_{des}, and N_{max}) is calculated, and reported to the nearest 0.1 percent, using the corresponding individual relative densities which have been reported to the nearest 0.1 percent.

Three specimens are used when referee testing is performed.

Percent Air Voids = (100) – (Average Relative Density, % G_{mm}, at N_{des})
= (100) – (________) = ______%

FIGURE 4

ADOT
Intermodal Transportation

ARIZ 427a
April 19, 2013
(15 Pages)

ASPHALT BINDER CONTENT OF ASPHALTIC CONCRETE MIXTURES BY THE IGNITION FURNACE METHOD

(A Modification of AASHTO T 308)

1. SCOPE

1.1 This procedure describes the method for determining the percent asphalt binder content of asphaltic concrete mixtures, by use of an ignition furnace. The aggregate remaining after ignition can be used for sieve analysis, as indicated in Section 6.

1.1.1 This procedure does not address the use of reclaimed asphalt pavement (RAP) in asphaltic concrete mixtures. **See Arizona Test Method 428 when testing is to be performed on asphaltic concrete mixtures containing RAP.**

1.2 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.

1.3 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.

1.4 A listing of subsequent Sections and Figures in this procedure is given below:

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

2.1.1 Ignition Furnace - a forced-air ignition furnace that heats the sample by the convection method. The furnace must be capable of heating to temperatures up to 538 °C (1000 °F), and able to maintain a given temperature at ± 5 °C (± 9 °F). The furnace shall have an internal weighing system thermally isolated from the furnace chamber and accurate to 0.1 gram. The balance shall be capable of weighing a 3500 gram sample in addition to the sample baskets. A data collection system shall also be included so that the sample mass loss can be automatically determined to an accuracy of 0.1 gram and displayed during a test. The furnace shall provide a printout that includes, as a minimum, the initial sample mass, sample mass loss, test time, and test temperature. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.01 percent of the total sample mass for three consecutive one minute intervals. A filter capable of reducing emissions to an acceptable level shall also be incorporated into the furnace. The furnace shall be vented into a hood or to the outside and be set up properly so that there are no noticeable odors escaping into the laboratory. The furnace shall have a fan with the capability to pull air through the furnace to expedite the test and to reduce escape of smoke into the laboratory. The furnace shall be equipped so that the door cannot be opened until testing is complete.

2.1.2 Stainless Steel Perforated Baskets - the baskets shall be an appropriate size that allow the samples to be a thickness which allows air to flow up through and around the sample particles. The sample shall be completely enclosed with screen mesh, perforated stainless steel plate, or other suitable material. Screen mesh or other suitable material with openings of No. 8 has been found to perform well.

2.1.3 Stainless Steel Catch Pan - of sufficient size to hold the sample baskets so that aggregate particles and melting asphalt binder falling through the screen mesh are caught.

2.1.4 Oven(s) - capable of heating to temperatures up to 350 °F, and able to maintain a given temperature at the tolerances specified herein.

2.1.5 Scale(s) or balance(s) - capable of measuring the maximum mass to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

2.1.6 Safety Equipment - safety glasses or face shield, high temperature gloves, and long sleeve jacket. Additionally, a heat resistant surface capable of withstanding 1200 °F and a protective cage capable of surrounding the sample baskets shall be provided.

2.1.7 Miscellaneous Equipment - a pan larger than the sample basket(s) for transferring samples after ignition, spatulas, bowls, spoons, and wire brushes.

2.1.8 Mixing apparatus - Mechanical mixing is recommended; 20 quart capacity mixer is required. (Hand mixing may be performed if desired.)

2.1.9 Thermometer - with a temperature range of 50 to 500 °F.

2.1.10 Hot plate - capable of heating to temperatures up to 350 °F, and able to maintain a given temperature at ± 5 °F.

2.1.11 For performing sieve analysis, apparatus as specified in Arizona Test Method 201.

3. SAMPLING

3.1 For preparing calibration samples, obtain representative samples of aggregates in accordance with Arizona Test Method 105. Samples shall be sufficiently large to provide enough material for calibration testing. The samples shall be adequately dried, if necessary, to a free-flowing condition in the portion passing the 4.75 mm (No. 4) sieve.

3.2 For testing field samples of asphaltic concrete, obtain a representative sample of the freshly produced mix in accordance with Arizona Test Method 104. Obtain representative test samples, in accordance with the appropriate sections of Arizona Test Method 416, for the determination of moisture content (if required) and asphalt binder content.

3.2.1 The size of the asphalt binder content test sample shall be within ± 150 grams of the sample size used for calibration and must also conform to the mass requirement shown in Table 1. When the mass of the test sample exceeds the capacity of the equipment used, the test sample shall be divided into suitable increments, tested, and the results appropriately combined.

TABLE 1 Size of Test Sample	
Nominal Maximum Aggregate Size (See Note)	**Mass of Sample, grams**
1-1/2 in.	4000 – 4500
1 in.	3000 – 3500
3/4 in.	2000 – 2500
1/2 in.	1500 – 2000
3/8 in.	1200 – 1700
No. 4	1200 – 1700
Note: The smallest sieve opening through which the entire amount of material, by specification, is permitted to pass.	

4. CALIBRATION

4.1 Asphalt binder content results may be affected by the type of aggregate and binder in the mixture. A calibration factor for the asphalt binder content must be established for each mix design. Certain aggregate types may result in an unusually high calibration factor and erroneous gradation results due to aggregate breakdown. Such mixes should be calibrated and tested at a lower temperature as described in Subsection 4.14.

4.2 Dry the aggregate samples to constant mass at 290 ± 10 °F. Allow the material to cool.

4.3 Screen the aggregate stockpile samples and separate into individual sizes for No. 8 and larger, and minus No. 8 material.

Note: In lieu of screening the aggregate sample for each individual stockpile, a bulk-batched sample may be used as described in Subsection 4.3.1.

4.3.1 Using the aggregate stockpile percentages shown in the mix design composite, the material from the individual stockpiles may be bulk-batched in a single sample of an adequate amount of material necessary to prepare the required calibration samples. Screen the bulk-batched material and separate into individual sizes for No. 8 and larger, and minus No. 8 material.

4.4 Using the individual sizes of aggregate for No. 8 and larger, and minus No. 8 material, as obtained either by screening the material from the individual aggregate stockpiles or by screening the the bulk-batched sample, weigh up four aggregate samples representative of the mix design gradation without mineral admixture. These samples will be used for a gradation check, two calibration samples, and a butter mix. The appropriate type and quantity of mineral admixture (by weight of aggregate) shall be added to the aggregate, and thoroughly blended. The weight of the gradation check sample shall conform to the requirements of Table 1. The weight of the two calibration samples and the butter mix shall be such that when the required amount of asphalt binder is added, they conform to the requirements of Table 1.

4.5 Using the aggregate and mineral admixture sample prepared for the gradation check, perform a gradation analysis according to Section 6 to determine the actual gradation. The gradation shall be representative of the mix design gradation with mineral admixture. If the gradation is not representative of the mix design, four new aggregate and mineral admixture samples shall be prepared.

4.6 Using the remaining three aggregate and mineral admixture samples, two calibration samples and a butter mix are prepared as described below at the design asphalt binder content. The asphalt binder grade and type shall be the same as will be used in the asphalt concrete mixture to be tested during production. Heat the samples to the laboratory mixing temperature prescribed in the mix design. (See Note following Subsection 4.7). Allow the samples to cool. Weigh and determine the mass of each sample to the nearest 0.1 gram. If mass is lost during the heating of the samples, do not add make-up material, as this will change the gradation of the samples. The percent asphalt binder content is based on the mass of total mix. For each sample, the weight of asphalt binder to be used is determined by the following:

$$\begin{bmatrix}\text{Weight of}\\ \text{Asphalt Binder}\end{bmatrix} = \frac{\begin{bmatrix}\text{Weight of Aggregate}\\ \text{and Mineral Admixture}\end{bmatrix}}{100 - \begin{bmatrix}\text{Percent of}\\ \text{Asphalt Binder}\end{bmatrix}} \times \begin{bmatrix}\text{Percent of}\\ \text{Asphalt Binder}\end{bmatrix}$$

4.7 All bowls, sample pans, and mixing tools shall be preheated to approximately the laboratory mixing temperature prescribed in the mix design. At the time mixing of the samples begins, the temperature of the asphalt binder, aggregate, and mineral admixture shall be in accordance with the prescribed laboratory mixing temperature ± 5 °F. Each individual sample shall be thoroughly mixed. All samples shall be mixed at the same mixing temperature ± 5 °F.

Note: If the mix design laboratory mixing temperature is not specified, a temperature of 300 ± 5 °F shall be used for mixes which do not use asphalt-rubber, and 325 ± 5 °F for asphalt-rubber mixes.

4.8 Preheat the ignition furnace to 538 ± 5 °C (1000 ± 9 °F), or as modified in Subsection 4.14. Do not preheat the sample basket.

4.9 Weigh and record the mass of the basket assembly to the nearest 0.1 gram.

4.10 The freshly mixed samples may be placed directly in the sample basket assembly. If the samples are allowed to cool, they must be reheated in a 290 ± 10 °F oven for 25 minutes.

4.11 Test samples in accordance with Subsections 5.6 through 5.14.

4.12 If the difference between the measured asphalt binder content of the two samples exceeds 0.07, repeat the test using two additional samples, and from the four results discard the high and the low values.

4.13 Subtract the actual asphalt binder content for each of the two samples from their respective measured asphalt binder content. The asphalt binder content calibration factor is the average of the two resultant values expressed in percent by mass of the asphalt mixture.

4.14 If the asphalt binder content calibration factor exceeds ± 1.0 percent, lower the test temperature to 482 ± 5 °C (900 ± 9 °F) and repeat the test to determine a new calibration factor. If the calibration factor continues to exceed ± 1.0 percent, lower the test temperature to 427 ± 5 °C (800 ± 9 °F) and repeat the test to determine a new calibration factor. Use the calibration factor obtained at 427 ± 5 °C (800 ± 9 °F) even if it exceeds ± 1.0 percent.

4.15 Perform a gradation analysis on the residual aggregate as indicated in Section 6. Subtract the actual percent passing the No. 200 sieve for each sample from the measured percent passing the No. 200 sieve (as determined in Subsection 4.5). Determine the average of the two values. If the resultant average value is greater than ± 0.50, an aggregate gradation correction factor (equal to the resultant average value) for the passing No. 200 material may be applied to the production field sample test results.

5. PROCEDURE

5.1 The moisture content of the asphaltic concrete shall be determined in accordance with Arizona Test Method 406. The moisture content sample shall be obtained at the same time and subjected to the same treatment prior to testing as the asphalt binder content test sample. As an alternate to performing the moisture determination, the test sample may be dried to a constant mass in an oven at 290 ± 10 °F.

5.2 Preheat the ignition furnace to 538 ± 5 °C (1000 ± 9 °F), or to the alternate temperature determined during the calibration (Subsection 4.14). Do not preheat the sample basket. Record the furnace temperature set point prior to the initiation of the test.

5.3 Record the asphalt binder content calibration factor, determined in accordance with Subsections 4.12 through 4.14, for the specific mix to be tested.

5.4 Weigh and record the mass of the basket assembly to the nearest 0.1 gram.

5.5 Obtain the asphalt binder content test sample in accordance with Subsection 3.2, ensuring that the size of the test sample is within ± 150 grams of the sample size used for calibration and that the test sample conforms to the requirements shown in Table 1.

5.6 Evenly distribute the test sample over the center of the sample basket(s) and level the material. Use a spatula or trowel to pull material approximately one inch away from the outside edge of basket(s).

5.7 Weigh and record the mass of the sample and basket assembly to the nearest 0.1 gram.

5.8 Calculate and record the initial mass of the sample to the nearest 0.1 gram.

5.9 Set the ignition furnace controller print mode to give a printout of the test data required in Subsection 2.1.1. Input the initial mass of the sample into the ignition furnace controller. Verify that the correct mass has been entered.

5.10 Open the furnace door and place the sample and basket assembly so that it is centered in the chamber. After assuring that the sample basket assembly is not in contact with any wall, close the door. Initiate the test by pressing the start button. This will lock the furnace door and start testing.

5.11 Allow the test to continue until the stable light and audible stable indicator indicates the test is complete. The test is deemed complete when the measured mass loss does not exceed 0.01 percent of the sample mass for three consecutive one minute intervals. If required, press the stop button. This will unlock the furnace door and cause the printer to print out the test results.

5.12 Open the furnace door and remove the sample and basket assembly. Allow the sample to cool 30 ± 5 minutes in the basket assembly. Weigh and record the mass of the sample and basket assembly after ignition to the nearest 0.1 gram.

5.13 Calculate and record the mass of sample after ignition to the nearest 0.1 gram.

5.14 Calculate and record the corrected asphalt binder content of the sample, to the nearest 0.01%, as follows:

$$\%AC = \left[\frac{W_i - W_A}{W_i} \times 100\right] - C_F - \%M$$

Where: $\%AC$ = measured (corrected) asphalt binder content in percent by mass of the sample
W_i = mass of the sample prior to ignition
W_A = mass of the sample after ignition
C_F = asphalt binder content calibration factor, percent by mass of the sample
$\%M$ = percent moisture in the sample

Note: During calibration, C_F and %M are zero.

5.14.1 If an ignition furnace correction (tank stab correction) is made, the %AC determined in Subsection 5.14 is adjusted by that correction.

5.15 Attach the original printed ticket to the back of the card.

5.16 Empty the contents of the baskets into a flat pan. Use a small wire sieve brush to ensure that any residual fines are removed from the baskets. Take care not to lose any material, as this will affect gradation results.

5.17 If needed, perform a gradation analysis of the residual aggregate according to Section 6.

6. SIEVE ANALYSIS OF AGGREGATE

6.1 If required, the aggregate shall be subjected to sieve analysis as described below. The coarse sieving shall be performed in accordance with Subsection 6.2, and the fine sieving in accordance with Subsection 6.3. The quantity of material on a given sieve at the completion of sieving shall not exceed the amount shown in Table 2.

TABLE 2

Sieve Size	**Maximum Mass Allowed (grams/sq. in.)**	**Maximum Mass Allowed (grams)**	
		8 inch Diameter Sieve	**12 inch Diameter Sieve**
1-1/2"	25	---	2827
1"	18	---	2036
3/4"	14	---	1583
1/2"	10	---	1131
3/8"	8	---	905
1/4"	6	---	679
No. 4	5	---	565
No. 8 and smaller	4	201	452

6.2 The coarse sieving of the aggregate shall be performed as follows:

6.2.1 Weigh and record the mass of the sample to be sieved to the nearest gram. Place sample on the top sieve of a nest of 12 inch sieves. The nest of sieves shall consist of sieves starting with the smallest size sieve that 100% of the material will pass, down through and including the No. 8 sieve and pan. Place lid on nested sieves and screen the material by either mechanical or hand shaking, until not more than 0.5 percent by mass of sample passes any sieve during one minute.

6.2.2 Weigh and record separately, to the nearest gram, the mass of the material retained on the individual sieves and in the pan. The material retained in the pan is recorded as the minus No. 8 material.

6.2.3 Do not discard any of the sieved material until the sum of the individual masses is compared to the mass of the sample prior to sieving. If the difference between the two masses is less than or equal to 1.0% of the mass of the sample prior to sieving, an adjustment in mass shall be made on the sieve which has the largest mass retained, except no adjustment shall be made on the minus No. 8 material. If the difference is greater than 1.0%, the sample shall be recombined, resieved, and carefully reweighed.

6.2.4 Determine the coarse sieve factor by dividing 100 by the total mass sieved. Record the factor to six decimal places.

6.2.5 The percent passing for each sieve in the coarse sieve analysis is determined by multiplying the mass retained on that sieve by the coarse sieve factor, and subtracting the result from the unrounded % passing for the next larger sieve. Values for "mass retained multiplied by the coarse sieve factor" and "percent passing each sieve" shall be determined and used in the calculations to six decimal places. The percent passing value for each sieve is recorded in the sieve analysis to the nearest percent.

6.2.6 As a check on the coarse sieve analysis, multiply the mass of minus No. 8 material by the coarse sieve factor. The result of this calculation, rounded to the nearest percent, should be the same as the value for percent passing the No. 8 sieve determined in Subsection 6.2.5 above.

6.2.7 The material passing the No. 8 sieve is split, if necessary, to obtain a minimum 500 gram sample for fine sieving; however, the sample size may be less than 500 grams if a minimum of 500 grams is not obtained from coarse sieving. If less than 800 grams passes the No. 8 sieve, the entire amount shall be subjected to fine sieving. The mass of the sample for fine sieving is recorded to the nearest gram as mass of pass No. 8 split.

6.3 The elutriation and fine sieving of the pass No. 8 material shall be performed as follows:

6.3.1 Subject sample to elutriation through a No. 200 screen either by hand or mechanical washing.

6.3.2 Dry sample to constant mass, allow to cool, then weigh and record the dry mass to the nearest gram.

6.3.3 Place sample on the top sieve of a nest of fine sieves. The nest of sieves shall consist of sieves starting with the No. 10 sieve, down through and including the No. 200 sieve and pan. Place lid on nested sieves and screen the material by either mechanical or hand shaking, until not more than 0.5 percent by mass of sample passes any sieve during one minute.

6.3.4 Weigh and record separately, to the nearest gram, the mass of material retained on the individual sieves and in the pan.

6.3.5 Do not discard any of the sieved material until the sum of the individual masses is compared to the mass of the sample prior to sieving. If the difference between the two masses is less than or equal to 1.0% of the mass of the sample prior to sieving, an adjustment in mass shall be made on the sieve which has the largest mass retained, except no adjustment shall be made on the minus No. 200 material. If the difference is greater than 1.0%, the sample shall be recombined, resieved, and carefully reweighed.

6.3.6 Determine and record elutriation to nearest gram by determining the difference between the dry mass and the mass of the pass No. 8 split.

6.3.7 Determine a factor for calculating the fine sieve analysis by dividing the percent passing the No. 8 sieve (recorded to the nearest percent) by the mass of pass No. 8 split. Record the factor to six decimal places. If all the pass No. 8 material from coarse sieving was subjected to elutriation and fine sieving, a fine sieve factor is not determined. Rather, the coarse sieve factor is utilized and the calculation of the percent passing each sieve is continuous through the entire sieve analysis.

6.3.8 The percent passing for each sieve in the fine sieve analysis is determined by multiplying the mass retained on that sieve by the fine sieve factor, and subtracting the result from the unrounded % passing the next larger sieve, with the exception of the percent passing the No. 8 which has previously been recorded to the nearest percent. Values for "mass retained multiplied by the fine sieve factor" and "percent passing each sieve" shall be determined and used in the calculations to six decimal places. The percent passing value for each sieve is recorded in the sieve analysis to the nearest percent, except the percent passing the No. 200 sieve is recorded to the nearest 0.1 percent.

6.3.9 As a check on the fine sieve analysis, the mass of material passing the No. 200 sieve is added to the elutriation mass, and this total is multiplied by the fine sieve factor. The result of this calculation, rounded to the nearest 0.1 percent, should be the same as the value for the percent passing the No. 200 sieve determined in Subsection 6.3.8 above.

6.3.10 If an aggregate gradation correction factor is utilized, the percent passing the No. 200 sieve shall be adjusted by subtracting the correction factor determined in Subsection 4.15.

6.4 Other methods may be used that differ from that specified in Subsections 6.2 and 6.3 above to determine % passing each sieve, so long as the method utilized has been proven to give equivalent results. However, any procedure which includes recording percent retained values prior to completing the calculation of all percent passing values is not allowed.

7. REPORT AND EXAMPLE

7.1 Report test information on the Asphaltic Concrete Tabulation – Ignition Furnace laboratory card. An example for the testing performed on a field sample is shown in Figure 1. Only the portion of the laboratory card relevant to the ignition furnace test is used for the example. A blank Asphaltic Concrete Tabulation – Ignition Furnace laboratory card is shown in Figure 2.

7.1.1 Mass of basket assembly.

7.1.2 Mass of sample and basket assembly.

7.1.3 Calculated initial mass of the sample.

7.1.4 Mass of sample and basket assembly after ignition.

7.1.5 Calculated mass of sample after ignition.

7.1.6 Asphalt binder content calibration factor.

7.1.7 Percent moisture from moisture test, if one was performed.

7.1.8 Corrected percent asphalt binder content.

7.1.9 Elapsed time of test.

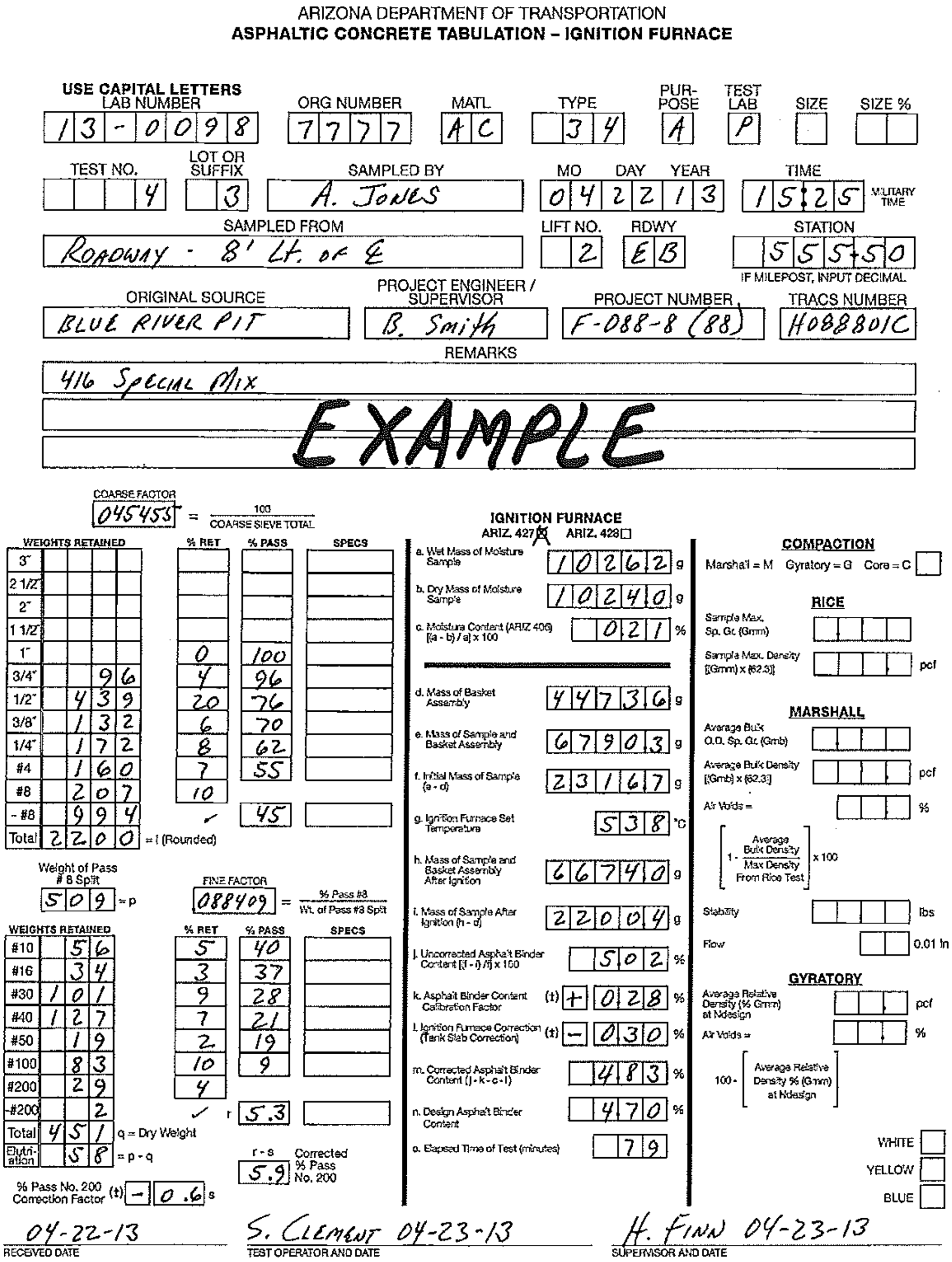
7.1.10 Name of the operator.

7.1.11 Sample test date.

7.1.12 Design percent asphalt binder content.

7.2.13 Ignition furnace set temperature.

7.2.14 If determined, the sieve analysis of the residual aggregate (corrected for passing the No. 200 sieve if applicable).



ARIZONA DEPARTMENT OF TRANSPORTATION
ASPHALTIC CONCRETE TABULATION – IGNITION FURNACE

USE CAPITAL LETTERS

LAB NUMBER: 13-0098
ORG NUMBER: 7777
MATL.: AC
TYPE: 34
PURPOSE: A
TEST LAB: P
SIZE:
SIZE %:

TEST NO.: 4
LOT OR SUFFIX: 3
SAMPLED BY: A. JONES
MO DAY YEAR: 04 22 13
TIME: 15:25 MILITARY TIME

SAMPLED FROM: ROADWAY - 8' LT. OF ℄
LIFT NO.: 2
RDWY: EB
STATION: 555+50
IF MILEPOST, INPUT DECIMAL

ORIGINAL SOURCE: BLUE RIVER PIT
PROJECT ENGINEER / SUPERVISOR: B. Smith
PROJECT NUMBER: F-088-8 (88)
TRACS NUMBER: H088801C

REMARKS: 416 SPECIAL MIX

EXAMPLE

COARSE FACTOR: 045455 = 100 / COARSE SIEVE TOTAL

WEIGHTS RETAINED		% RET	% PASS	SPECS
3"				
2 1/2"				
2"				
1 1/2"				
1"		0	100	
3/4"	96	4	96	
1/2"	439	20	76	
3/8"	132	6	70	
1/4"	172	8	62	
#4	160	7	55	
#8	207	10		
- #8	994	✓	45	
Total	2200 = t (Rounded)			

Weight of Pass # 8 Split: 509 = p

FINE FACTOR: 088409 = % Pass #8 / Wt. of Pass #8 Split

WEIGHTS RETAINED		% RET	% PASS	SPECS
#10	56	5	40	
#16	34	3	37	
#30	101	9	28	
#40	127	7	21	
#50	19	2	19	
#100	83	10	9	
#200	29	4		
-#200	2	✓	r 5.3	
Total	451 q = Dry Weight			
Elutriation	58 = p - q			

% Pass No. 200 Correction Factor (±) − 0.6 s

r - s: 5.9 Corrected % Pass No. 200

IGNITION FURNACE
ARIZ. 427☒ ARIZ. 428☐

a. Wet Mass of Moisture Sample: 1026.2 g
b. Dry Mass of Moisture Sample: 1024.0 g
c. Moisture Content (ARIZ 406) [(a - b) / a] x 100: 0.21 %
d. Mass of Basket Assembly: 4473.6 g
e. Mass of Sample and Basket Assembly: 6790.3 g
f. Initial Mass of Sample (e - d): 2316.7 g
g. Ignition Furnace Set Temperature: 538 °C
h. Mass of Sample and Basket Assembly After Ignition: 6674.0 g
i. Mass of Sample After Ignition (h - d): 2200.4 g
j. Uncorrected Asphalt Binder Content [(f - i) /f] x 100: 5.02 %
k. Asphalt Binder Content Calibration Factor (±) + 0.28 %
l. Ignition Furnace Correction (Tank Slab Correction) (±) − 0.30 %
m. Corrected Asphalt Binder Content (j - k - c - l): 4.83 %
n. Design Asphalt Binder Content: 4.70 %
o. Elapsed Time of Test (minutes): 79

COMPACTION
Marshall = M Gyratory = G Core = C ☐

RICE
Sample Max. Sp. Gr. (Gmm): ☐
Sample Max. Density [(Gmm) x (62.3)]: ☐ pcf

MARSHALL
Average Bulk O.D. Sp. Gr. (Gmb): ☐
Average Bulk Density [(Gmb) x (62.3)]: ☐ pcf
Air Voids = ☐ %

$$\left[1 - \frac{\text{Average Bulk Density}}{\text{Max Density From Rice Test}}\right] \times 100$$

Stability: ☐ lbs
Flow: ☐ 0.01 in

GYRATORY
Average Relative Density (% Gmm) at Ndesign: ☐ pcf
Air Voids = ☐ %

$$100 - \left[\text{Average Relative Density \% (Gmm) at Ndesign}\right]$$

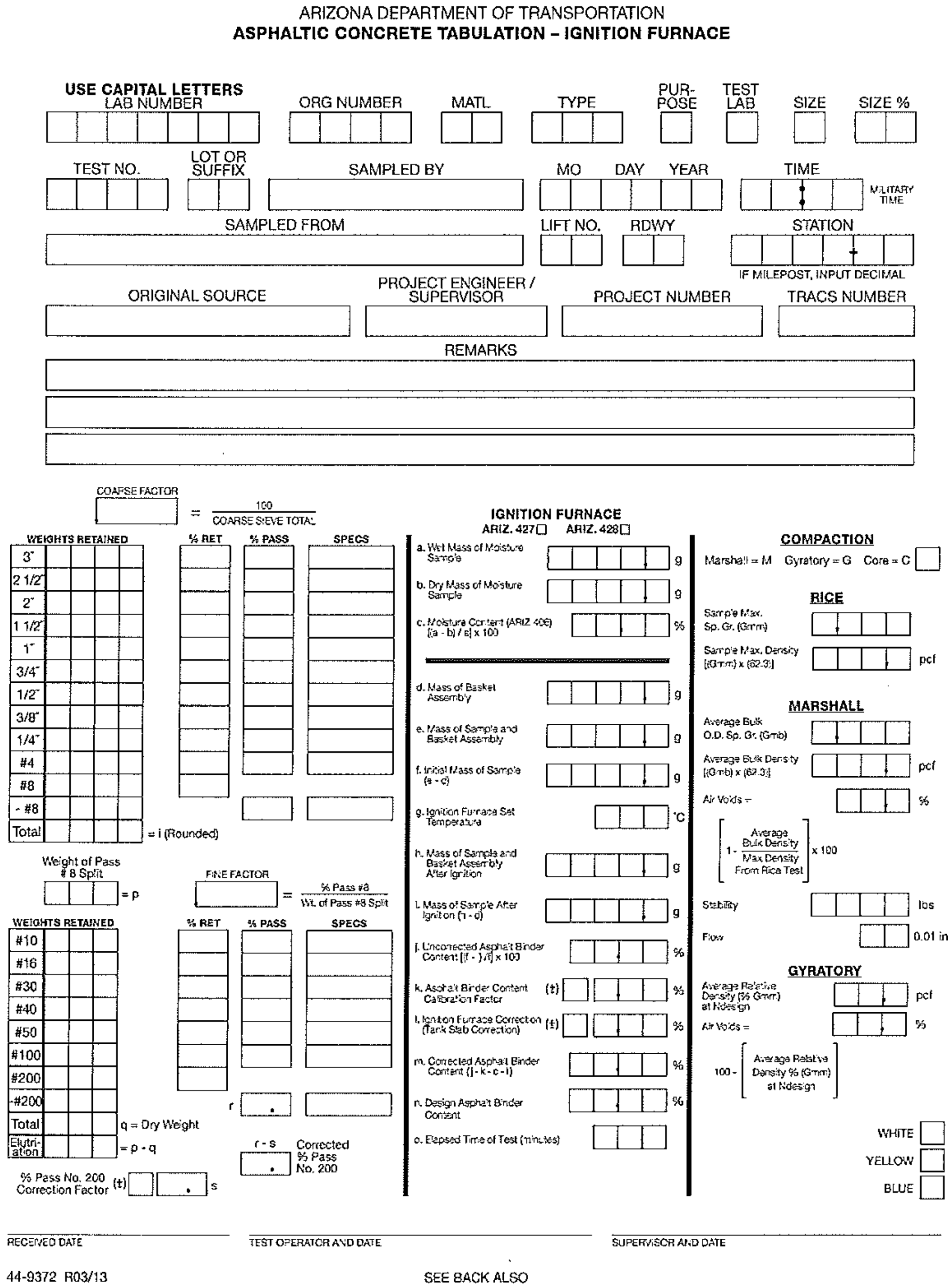
WHITE ☐
YELLOW ☐
BLUE ☐

RECEIVED DATE: 04-22-13
TEST OPERATOR AND DATE: S. CLEMENT 04-23-13
SUPERVISOR AND DATE: H. FINN 04-23-13

44-9372 R03/13

SEE BACK ALSO

FIGURE 1



ARIZONA DEPARTMENT OF TRANSPORTATION
ASPHALTIC CONCRETE TABULATION – IGNITION FURNACE

USE CAPITAL LETTERS

LAB NUMBER	ORG NUMBER	MATL	TYPE	PURPOSE	TEST LAB	SIZE	SIZE %

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO	DAY	YEAR	TIME (MILITARY TIME)

SAMPLED FROM	LIFT NO.	RDWY	STATION (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER

REMARKS

COARSE FACTOR ☐ = 100 / COARSE SIEVE TOTAL

WEIGHTS RETAINED		% RET	% PASS	SPECS
3"				
2 1/2"				
2"				
1 1/2"				
1"				
3/4"				
1/2"				
3/8"				
1/4"				
#4				
#8				
- #8				
Total	= i (Rounded)			

Weight of Pass # 8 Split ☐ = p

FINE FACTOR ☐ = % Pass #8 / Wt. of Pass #8 Split

WEIGHTS RETAINED		% RET	% PASS	SPECS
#10				
#16				
#30				
#40				
#50				
#100				
#200				
-#200			r .	
Total	q = Dry Weight			
Elutriation	= p - q			

r - s ☐ . Corrected % Pass No. 200

% Pass No. 200 Correction Factor (±) ☐ ☐ . s

IGNITION FURNACE
ARIZ. 427☐ ARIZ. 428☐

a. Wet Mass of Moisture Sample ☐ g
b. Dry Mass of Moisture Sample ☐ g
c. Moisture Content (ARIZ 406) [(a - b) / a] x 100 ☐ %

---

d. Mass of Basket Assembly ☐ g
e. Mass of Sample and Basket Assembly ☐ g
f. Initial Mass of Sample (e - d) ☐ g
g. Ignition Furnace Set Temperature ☐ °C
h. Mass of Sample and Basket Assembly After Ignition ☐ g
i. Mass of Sample After Ignition (h - d) ☐ g
j. Uncorrected Asphalt Binder Content [(f - i)/f] x 100 ☐ %
k. Asphalt Binder Content Calibration Factor (±) ☐ ☐ %
l. Ignition Furnace Correction (Tank Stab Correction) (±) ☐ ☐ %
m. Corrected Asphalt Binder Content (j - k - c - l) ☐ %
n. Design Asphalt Binder Content ☐ %
o. Elapsed Time of Test (minutes) ☐

COMPACTION

Marshall = M Gyratory = G Core = C ☐

RICE

Sample Max. Sp. Gr. (Gmm) ☐
Sample Max. Density [(Gmm) x (62.3)] ☐ pcf

MARSHALL

Average Bulk O.D. Sp. Gr. (Gmb) ☐
Average Bulk Density [(Gmb) x (62.3)] ☐ pcf
Air Voids = ☐ %

$$\left[1 - \frac{\text{Average Bulk Density}}{\text{Max Density From Rice Test}}\right] \times 100$$

Stability ☐ lbs
Flow ☐ 0.01 in

GYRATORY

Average Relative Density (% Gmm) at Ndesign ☐ pcf
Air Voids = ☐ %

$$100 - \left[\text{Average Relative Density \% (Gmm) at Ndesign}\right]$$

WHITE ☐
YELLOW ☐
BLUE ☐

RECEIVED DATE
TEST OPERATOR AND DATE
SUPERVISOR AND DATE

44-9372 R03/13

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FIGURE 2

APPENDIX A

DETERMINATION OF GRADATION, MOISTURE CONTENT, AND BINDER CONTENT OF THE RAP MATERIAL

A.1 Obtain a representative sample of the RAP material in accordance with Arizona Test Method 105. When multiple RAP stockpiles are used, a separate representative sample shall be obtained from each stockpile.

A.1.1 The sample shall be split to provide a sufficient amount of material for gradation testing, moisture content testing, and binder content testing.

A.2 The entire split sample of RAP material from each stockpile is dried at 140 °F and the percent moisture content determined as described below.

Note: A higher drying temperature is not appropriate because it will soften the binder causing the RAP material to break into smaller particles and adhere to the drying pan.

A.2.1 The weight of the RAP material from each stockpile is determined and recorded to the nearest 0.1 gram.

A.2.2 The material is dried to constant weight at 140 ± 10 °F.

Note: Drying to constant weight at 140 °F will typically take overnight.

A.2.3 After drying to constant weigtht at 140 ± 10 °F, cover the material and allow to cool 30 ± 10 minutes at room temperature. The weight of the RAP material is then determined and recorded to the nearest 0.1 gram.

A.2.4 The percent moisture content of the RAP material from each stockpile is determined and recorded to the nearest 0.01 percent by the following:

$$\begin{bmatrix}\text{Percent Moisture}\\ \text{Content}\end{bmatrix} = \left[\frac{\begin{pmatrix}\text{Weight of Material}\\ \text{Prior to Drying}\end{pmatrix} - \begin{pmatrix}\text{Weight of Material}\\ \text{After Drying}\end{pmatrix}}{\begin{pmatrix}\text{Weight of Material}\\ \text{After Drying}\end{pmatrix}}\right] \text{x } 100$$

A.3 After drying and determining the moisture content at 140 °F, the RAP material shall be tested for gradation, moisture content (at 290 °F), and binder content.

A.3.1 The gradation of the RAP material from each stockpile shall be determined as described below.

A.3.1.1 Split out a representative sample of the RAP material from each stockpile which conforms to the size specified in Table 3.

TABLE 3

Maximum Size of Particle (See Note)	**Minimum Weight of Sample, grams**
3/4 in. and larger	5000
1/2 in.	2000
3/8 in.	1000

Note: The smallest sieve opening through which the entire amount of material will pass.

A.3.1.2 Dry sieve the material in accordance with Arizona Test Method 240, with the exception that the No. 8 sieve shall be used as the smallest sieve. (Arizona Test Method 240 limits the time for shaking the sample to 5 minutes ± 15 seconds to control breakdown of the particles of RAP material into smaller size fractions.) The gradation of the RAP material from each stockpile is then determined in accordance with Arizona Test Method 248, Alternate #2.

A.3.2 The percent moisture content of the RAP material from each stockpile shall be determined by drying at 290 °F as described below.

Note: The sample for determining the moisture content at 290 °F shall be obtained at the same time and subjected to the same treatment prior to testing as the sample obtained for determining the RAP binder content.

A.3.2.1 Split out a representative 1000 ± 50 gram sample of the RAP material from each stockpile. The weight of each sample is determined and recorded to the nearest 0.1 gram.

A.3.2.2 Each sample is dried at 290 ± 10 °F to constant weight. Constant weight is defined as the weight at which further drying does not alter the weight more than 0.1 gram at intervals of a minimum of 30 minutes.

A.3.2.3 After drying to constant weight at 290 ± 10 °F, cover the sample and allow to cool 30 ± 10 minutes at room temperature. The weight of the sample is then determined and recorded to the nearest 0.1 gram.

A.3.2.4 The percent moisture content of the RAP material from each stockpile is determined and recorded to the nearest 0.01 percent by the following:

$$\begin{bmatrix}\text{Percent Moisture}\\ \text{Content}\end{bmatrix} = \left[\frac{\begin{pmatrix}\text{Weight of Material}\\ \text{Prior to Drying}\end{pmatrix} - \begin{pmatrix}\text{Weight of Material}\\ \text{After Drying}\end{pmatrix}}{\begin{pmatrix}\text{Weight of Material}\\ \text{Prior to Drying}\end{pmatrix}}\right] \times 100$$

A.3.3 The total percent moisture content of the RAP material from each stockpile is determined by adding the percent moisture content by drying at 140 °F (Subsection A.2) to the percent moisture content by drying at 290 °F (Subsection A.3.2).

A.3.4 The binder content of the RAP material from each stockpile shall be determined as described below.

A.3.4.1 Split out a representative sample of the RAP material from each stockpile which conforms to the size specified in Table 4.

TABLE 4

Nominal Maximum RAP Aggregate Size (See Notes)	Mass of Sample, grams
1 in.	2500 – 3000
3/4 in.	2000 – 2500
1/2 in.	1500 – 2000
3/8 in.	1200 – 1700
No. 4	1200 – 1700

Note: The nominal maximum RAP aggregate size is defined as: One size larger than the first sieve that retains more than 10 percent RAP aggregate.

Note: To determine the nominal maximum RAP aggregate size, the RAP aggregate gradation of each RAP stockpile, as shown in the mix design or as detemined from previous testing, may provide information.

A.3.4.2 Preheat the ignition furnace to 538 ± 5 °C (1000 ± 9 °F). Do not preheat the sample basket.

A.3.4.3 Weigh and record the mass of the basket assembly to the nearest 0.1 gram.

A.3.4.4 Perform ignition furnace testing on the RAP material from each stockpile in accordance with Subsections 5.6 through 5.13.

A.3.4.5 Calculate and record the binder content of the material from each RAP stockpile, to the nearest 0.01%, as follows:

$$\%AC = \left[\frac{W_i - W_A}{W_i} \times 100 \right] - \%M$$

Where:
$\%AC$ = measured RAP binder content in percent by mass of the sample
W_i = mass of the sample prior to ignition
W_A = mass of the sample after ignition
$\%M$ = percent moisture in the sample (determined by drying at 290 °F, per Subsection A.3.2)

A.3.4.5.1 Retain the original printed ticket and save with other test documentation.

A.3.4.6 Each measured binder content test result, as determined in Subsection A.3.4.5, is adjusted by the appropriate RAP binder content correction factor (See Appendix B). This adjustment is made by adding the RAP binder correction factor to each measured binder content. The corrected RAP binder content is recorded to the nearest 0.01%.

A.4 If needed, determine the RAP aggregate gradation by performing a sieve analysis of the residual aggregate in accordance with Section 6.

Note: Subsection 6.3.10 does not apply when determining the RAP aggregate gradation.

A.5 Report test information on the "RAP Material Tabulation - Ignition Furnace" laboratory card. An example is shown in Figure 6. A blank "RAP Material Tabulation - Ignition Furnace" laboratory card is shown in Figure 7.

Standard Method of Test for

Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

AASHTO Designation: T 312-19

AASHTO

Technical Subcommittee: 2d, Proportioning of Asphalt–Aggregate Mixtures

Release: Group 3 (July)

1. SCOPE

1.1. This standard covers the compaction of cylindrical specimens of asphalt mixtures using the Superpave gyratory compactor.

1.2. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 231, Weighing Devices Used in the Testing of Materials
- R 30, Mixture Conditioning of Hot Mix Asphalt (HMA)
- R 35, Superpave Volumetric Design for Asphalt Mixtures
- R 47, Reducing Samples of Asphalt Mixtures to Testing Size
- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
- T 168, Sampling Bituminous Paving Mixtures
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures
- T 275, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Paraffin-Coated Specimens
- T 316, Viscosity Determination of Asphalt Binder Using Rotational Viscometer
- T 344, Evaluation of Superpave Gyratory Compactor (SGC) Internal Angle of Gyration Using Simulated Loading

2.2. *Other Standards*:

- ANSI/ASME B89.1.6, Measurement of Qualified Plain Internal Diameters for Use as Master Rings and Ring Gages

- ANSI/ASME B89.4.19, Performance Evaluation of Laser-Based Spherical Coordinate Measurement Systems
- ASME B46.1, Surface Texture (Surface Roughness, Waviness, and Lay)

3. SIGNIFICANCE AND USE

3.1. This standard is used to prepare specimens for determining the mechanical and volumetric properties of asphalt mixtures. The specimens simulate the density, aggregate orientation, and structural characteristics obtained in the actual roadway when proper construction procedure is used in the placement of the paving mix.

3.2. This test method may be used to monitor the density of test specimens during their preparation. It may also be used for field control of an asphalt mixture production process.

4. APPARATUS

4.1. *Superpave Gyratory Compactor*—An electrohydraulic or electromechanical compactor with a ram and ram heads as described in Section 4.3. The axis of the ram shall be perpendicular to the platen of the compactor. The ram shall apply and maintain a pressure of 600 ± 18 kPa perpendicular to the cylindrical axis of the specimen during compaction (Note 1). The compactor shall tilt the specimen molds at an average internal angle of 20.2 ± 0.35 mrad (1.16 ± 0.02 degrees), determined in accordance with T 344. The compactor shall gyrate the specimen molds at a rate of 30.0 ± 0.5 gyrations per minute throughout compaction.

Note 1—This stress calculates to 10 600 ± 310 N total force for 150-mm specimens.

4.1.1. *Specimen Height Measurement and Recording Device*—When specimen density is to be monitored during compaction, a means shall be provided to continuously measure and record the height of the specimen to the nearest 0.1 mm during compaction once per gyration.

4.1.2. The system may include a connected printer capable of printing test information, such as specimen height per gyration. In addition to a printer, the system may include a computer and suitable software for data acquisition and reporting.

4.1.3. The loading system, ram, and pressure indicator shall be capable of providing and measuring a constant vertical pressure of 600 ± 60 kPa during the first five gyrations, and 600 ± 18 kPa during the remainder of the compaction period.

4.2. *Specimen Molds*—Specimen molds shall have steel walls that are at least 7.5 mm thick and are hardened to at least a Rockwell hardness of C48. The initial inside finish of the molds shall have a root mean square (rms) of 1.60 μm or smoother when measured in accordance with ASME B46.1 (see Note 2). New molds shall be manufactured to have an inside diameter of 149.90 to 150.00 mm. The inside diameter of in-service molds shall not exceed 150.2 mm. Molds shall be at least 250 mm in length. The inside diameter and length of the molds shall be measured in accordance with Annex A.

Note 2—One source of supply for a surface comparator, which is used to verify the rms value of 1.60 μm, is GAR Electroforming, Danbury, Connecticut.

4.3. *Ram Heads and End Plates*—Ram heads and end plates shall be fabricated from steel with a minimum Rockwell hardness of C48. The ram heads shall stay perpendicular to their axis. The platen side of each end plate shall be flat and parallel to its face. All ram and end plate faces (the sides presented to the specimen) shall be flat to meet the smoothness requirement in Section 4.2 and shall have a diameter of 149.50 to 149.75 mm.

4.4. *Thermometers*—Armored, glass, or dial-type thermometers with metal stems for determining the temperature of aggregates, binder, and HMA between 10 and 232°C.

4.5. *Balance*—A balance meeting the requirements of M 231, Class G 5, for determining the mass of aggregates, binder, and asphalt mixtures.

4.6. *Oven*—An oven, thermostatically controlled to ±3°C, for heating aggregates, binder, asphalt mixtures, and equipment as required. The oven shall be capable of maintaining the temperature required for mixture conditioning in accordance with R 30.

4.7. *Miscellaneous*—Flat-bottom metal pans for heating aggregates, scoop for batching aggregates, containers (grill-type tins, beakers, containers for heating asphalt), large mixing spoon or small trowel, large spatula, gloves for handling hot equipment, paper disks, mechanical mixer (optional), lubricating materials recommended by the compactor manufacturer.

4.8. *Maintenance*—In addition to routine maintenance recommended by the manufacturer, check the Superpave gyratory compactor's mechanical components for wear, and perform repair, as recommended by the manufacturer.

5. HAZARDS

5.1. Use standard safety precautions and protective clothing when handling hot materials and preparing test specimens.

6. STANDARDIZATION

6.1. Items requiring periodic verification of calibration include the ram pressure, angle of gyration, gyration frequency, LVDT (or other means used to continuously record the specimen height), and oven temperature. Verification of the mold and platen dimensions and the inside finish of the mold are also required. When the computer and software options are used, periodically verify the data-processing system output using a procedure designed for such purposes. Verification of calibration, system standardization, and quality checks may be performed by the manufacturer, other agencies providing such services, or in-house personnel. Frequency of verification shall follow the manufacturer's recommendations.

6.2. The angle of gyration refers to the internal angle (the tilt of the mold with respect to the end plate surface within the gyratory mold). The calibration of the internal angle of gyration shall be verified in accordance with T 344.

7. PREPARATION OF APPARATUS

7.1. Immediately prior to the time when the asphalt mixture is ready for placement in the mold, turn on the main power for the compactor for the manufacturer's required warm-up period.

7.2. Verify the machine settings are correct for angle, pressure, and number of gyrations.

7.3. Lubricate any bearing surfaces as needed per the manufacturer's instructions.

7.4. When specimen height is to be monitored, the following additional item of preparation is required. Immediately prior to the time when the asphalt mixture is ready for placement in the mold, turn on the device for measuring and recording the height of the specimen, and verify the readout is in the proper units, mm, and the recording device is ready. Prepare the computer, if used, to record the height data, and enter the header information for the specimen.

8. HMA MIXTURE PREPARATION

8.1. *Laboratory Prepared*:

8.1.1. Weigh the appropriate aggregate fractions into a separate pan, and combine them to the desired batch weight. The batch weight will vary based on the ultimate disposition of the test specimens. If a target air void level is desired, as would be the case for Superpave mix analysis and performance specimens, batch weights will be adjusted to create a given density in a known volume. If the specimens are to be used for the determination of volumetric properties, the batch weights will be adjusted to result in a compacted specimen having dimensions of 150 mm in diameter and 115 ± 5 mm in height at the desired number of gyrations.

Note 3—It may be necessary to produce a trial specimen to achieve this height requirement. Generally, 4500 to 4700 g of aggregate are required to achieve this height for aggregates with combined bulk specific gravities of 2.550 to 2.700, respectively.

8.1.2. Place the aggregate and binder container in the oven, and heat them to the required mixing temperature.

8.1.2.1. The mixing temperature range is defined as the range of temperatures where the unaged binder has a viscosity of 0.17 ± 0.02 Pa·s when measured in accordance with T 316.

Note 4—Modified asphalts may not adhere to the equiviscosity requirements noted, and the manufacturer's recommendations should be used to determine mixing and compaction temperatures.

8.1.3. Charge the mixing bowl with the heated aggregate from one pan and dry-mix thoroughly. Form a crater in the dry-blended aggregate, and weigh the required amount of binder into the mix. Immediately initiate mixing.

8.1.4. Mix the aggregate and binder as quickly and thoroughly as possible to yield an asphalt mixture having a uniform distribution of binder. As an option, mechanical mixing may be used.

8.1.5. After completing the mixture preparation, perform the required mixture conditioning in accordance with R 30.

8.1.6. Place the compaction mold(s) in an oven at the required compaction temperature for a minimum of 30 min prior to the estimated beginning of compaction (during the time the mixture is being conditioned in accordance with R 30). Place any additional compaction surfaces, such as base plates and upper plates, into the oven with and for the same time frame as the molds, according to the manufacturer's instructions.

8.1.7. Following the mixture conditioning period specified in R 30, if the mixture is at the compaction temperature, proceed immediately with the compaction procedure as outlined in Section 9. If the compaction temperature is different from the mixture conditioning temperature used in accordance with R 30, place the mix in another oven at the compaction temperature for a brief time (maximum of 30 min) to achieve the required temperature.

8.1.7.1. The compaction temperature is the midpoint of the range of temperatures where the unaged binder has a viscosity of 0.28 ± 0.03 Pa·s when measured in accordance with T 316. (See Note 4.)

8.2. *Plant Produced*:

8.2.1. Place the compaction mold(s) in an oven at the required compaction temperature (see Section 8.1.7.1). Place any additional compaction surfaces, such as base plates and upper plates, into the oven with and for the same time frame as the molds, according to the manufacturer's instructions.

8.2.2. Obtain the sample in accordance with T 168.

8.2.3. Reduce the sample in accordance with R 47.

8.2.4. Place the sample into a pan to a uniform thickness.

8.2.5. Bring the HMA to the compaction temperature range by careful, uniform heating in an oven immediately prior to molding.

9. COMPACTION PROCEDURE

9.1. When the compaction temperature is achieved, remove the heated mold and any compaction surfaces from Section 8.1.6 or 8.2.1 from the oven. Place the base plate and a paper disk in the bottom of the mold.

9.2. Place the mixture into the mold in one lift. Care should be taken to avoid segregation in the mold. After all the mix is in the mold, level the mix, and place another paper disk on top of the leveled material. Complete any remaining mold assembly, load the mold into the compactor, and center the loading ram according to the manufacturer's instructions.

9.3. Apply a pressure of 600 ± 18 kPa on the specimen.

9.4. Apply a 20.2 ± 0.35 mrad (1.16 ± 0.02 degrees) average internal angle to the mold assembly and begin the gyratory compaction.

9.5. Allow the compaction to proceed until the desired number of gyrations specified in R 35 is reached and the gyratory mechanism shuts off.

9.6. Remove the angle from the mold assembly, remove the ram pressure, and retract the loading ram in the order specified by the SGC manufacturer (the preceding steps may be done automatically by the compactor on some models of SGCs). Remove the mold from the compactor (if required) and extrude the specimen from the mold.

Note 5—No additional gyrations with the angle removed are required unless specifically called for in another standard referencing T 312. The extruded specimen may not be a right-angle cylinder. Specimen ends may need to be sawed to conform to the requirements of specific performance tests.

Note 6—The specimens can be extruded from the mold immediately after compaction for most asphalt mixtures. However, a cooling period of 5 to 10 min in front of a fan may be necessary before extruding some specimens to ensure the specimens are not damaged.

9.7. Remove the paper disks from the top and bottom of the specimens.

Note 7—Before reusing the mold, place it in an oven for at least 5 min. The use of multiple molds will speed up the compaction process.

10. DENSITY PROCEDURE

10.1. Determine the maximum specific gravity (G_{mm}) of the loose mix in accordance with T 209 using a companion sample. The companion sample shall be conditioned to the same extent as the compaction sample.

10.2. Determine the bulk specific gravity (G_{mb}) of the specimen in accordance with T 166 or T 275 as appropriate.

10.3. When the specimen height is to be monitored, record the specimen height to the nearest 0.1 mm after each revolution.

11. DENSITY CALCULATIONS

11.1. Calculate the uncorrected relative density ($\%G_{mmux}$) at any point in the compaction process using the following equation:

$$\%G_{mmux} = \frac{W_m}{V_{mx} G_{mm} G_m} \times 100 \qquad (1)$$

where:

$\%G_{mmux}$ = uncorrected relative density at any point during compaction expressed as a percent of the maximum theoretical specific gravity;
W_m = mass of the specimen, g;
G_{mm} = theoretical maximum specific gravity of the mix;
G_m = unit weight of water, 1 g/cm^3;
x = number of gyrations; and
V_{mx} = volume of the specimen, in cm^3, at any point based on the diameter (d) and height (h_x) of the specimen at that point (use "mm" for height and diameter measurements).

It can be expressed as:

$$V_{mx} = \frac{\pi d^2 h_x}{4 \times 1000} \qquad (2)$$

Note 8—This formula gives the volume in cm^3 to allow a direct comparison with the specific gravity.

11.2. At the completion of the bulk specific gravity test (G_{mb}), determine the relative density ($\%G_{mmx}$) at any point in the compaction process as follows:

$$\%G_{mmx} = \frac{G_{mb} h_m}{G_{mm} h_x} \times 100 \qquad (3)$$

where:

$\%G_{mmx}$ = corrected relative density expressed as a percent of the maximum theoretical specific gravity;
G_{mb} = bulk specific gravity of the extruded specimen;
h_m = height in millimeters of the extruded specimen; and
h_x = height in millimeters of the specimen after x gyrations.

12. REPORT

12.1. *Report the following information in the compaction report, if applicable:*

12.1.1. Project name;

12.1.2. Date of the test;

12.1.3. Start time of the test;

12.1.4. Specimen identification;

12.1.5. Percent binder in specimen, nearest 0.1 percent;

12.1.6. Average diameter of the mold used (d), nearest 1.0 mm;

12.1.7. Mass of the specimen (W_m), nearest 0.1 g;

12.1.8. Maximum specific gravity (G_{mm}) of the specimen by T 209, nearest 0.001;

12.1.9. Bulk specific gravity (G_{mb}) of the specimen by T 166 or T 275, nearest 0.001;

12.1.10. Height of the specimen after each gyration (h_x), nearest 0.1 mm;

12.1.11. Relative density ($\%G_{mm}$) expressed as a percent of the theoretical maximum specific gravity (G_{mm}), nearest 0.1 percent; and

12.1.12. Gyration angle, nearest 0.2 mrad (0.01 degrees), and the method used to determine or verify the gyration angle.

13. PRECISION AND BIAS

13.1. *Precision:*

13.2. *Single-Operator Precision*—The single operator standard deviations (1s limits) for relative densities at N_{ini} and N_{des} for mixtures containing aggregate with an absorption of less than 1.5 percent are shown in Table 1. The results of two properly conducted tests on the same material, by the same operator, using the same equipment, should be considered suspect if they differ by more than the d2s single operator limits shown in Table 1.

13.3. *Multi-Laboratory Precision*—The multi-laboratory standard deviations (1s limits) for relative densities at N_{ini} and N_{des} for mixtures containing aggregate with an absorption of less than 1.5 percent are shown in Table 1. The results of two properly conducted tests on the same material, by different operators, using different equipment, should be considered suspect if they differ by more than the d2s multi-laboratory limits shown in Table 1.

Table 1—Precision Estimates[a]

	1s limit Relative Density, %	d2s limit Relative Density, %
Single-operator precision:		
12.5-mm nominal max agg.	0.3	0.9
19.0-mm nominal max agg.	0.5	1.4
Multi-laboratory precision:		
12.5-mm nominal max agg.	0.6	1.7
19.0-mm nominal max agg.	0.6	1.7

[a] Based on an interlaboratory study described in NCHRP Research Report 9-26 involving 150-mm diameter specimens with 4 to 5 percent air voids, 26 laboratories, two materials (a 12.5-mm mixture and a 19.0-mm mixture), and three replicates. Specimens were prepared in accordance with T 312-04. The angle of gyration was verified using Method A, external angle.

13.4. *Bias*—No information can be presented on the bias of the procedure because no material having an accepted reference value is available.

14. KEYWORDS

14.1. Compaction; density; gyratory.

ANNEX A—EVALUATING SUPERPAVE GYRATORY COMPACTOR (SGC) MOLDS

(Mandatory Information)

A1. SCOPE

A1.1. This Annex covers the evaluation of the molds as a check for compliance with the requirements outlined in Sections 4.2 and 4.3. Measurements of the mold inside diameter and end-plate diameters as well as visual inspection of critical surface conditions are included.

Minimum frequency of this evaluation is 12 months or 80 hours of operation.

The inside diameter of the molds may be measured using a three-point bore gauge or a Coordinate Measuring Machine (CMM). See Annexes A4 and A5 for additional procedures for using these devices.

Note A1—Because CMMs are typically limited to manufacturers, it is considered best practice for a lab to also use the three-point bore method as a check before putting a mold into service.

A2. APPARATUS

A2.1. *Three-Point Internal Bore Gauge*—Minimum resolution shall be 0.0025 mm (0.0001 in.). This equipment is applicable only if measuring the inside diameter of molds according to Annex A4.

A2.2. *Calibrated Master Ring*—A calibrated master ring of the same nominal size as the mold diameter shall be used to set the measuring instrument reference for each series of measurements. A 150-mm ANSI/ASME B89.1.6 Class Z (0.00635 mm/0.00025 in.) standard is acceptable for 150-mm sized molds. The master ring shall be calibrated at a frequency no less than every 36 months, measured to a minimum resolution of 0.001 mm (0.00004 in.). This equipment is applicable only if measuring the inside diameter of molds according to Annex A4.

A2.3. *Length Measurement Instrument (Outside Calipers or Micrometer)*—With appropriate range and a minimum resolution of 0.025 mm (0.001 in.). The length measurement instrument shall be standardized annually.

A2.4. *Coordinate Measuring Machine (CMM)*—Capable of performing the three-point diametral measurement at the vertical locations specified in Figure A4.2 with a minimum resolution of 0.0025 mm (0.0001 in.). The CMM shall be calibrated annually per ASME B89.4.19 (or equivalent for CMM type). This equipment is applicable only if measuring the inside diameter of molds according to Annex A5 or measuring the outside diameter of the mold end plates according to Annex A6.

A3. PROCEDURE FOR VISUALLY INSPECTING THE CONDITION OF THE MOLD

A3.1. *Perform a visual inspection of the mold:*

A3.1.1. Confirm that the molds are thoroughly cleaned and identified with a unique serial number or other unique identifier. Allow the molds to achieve a temperature of 18 to 28°C (64 to 82°F).

Note A2—This temperature range can be confirmed with an infrared thermometer.

A3.1.2. The mold bore shall be free of residue and deep gouges. Mold bores without gouges typically have an acceptable surface finish. Identify any wear area that may be visible in the mold.

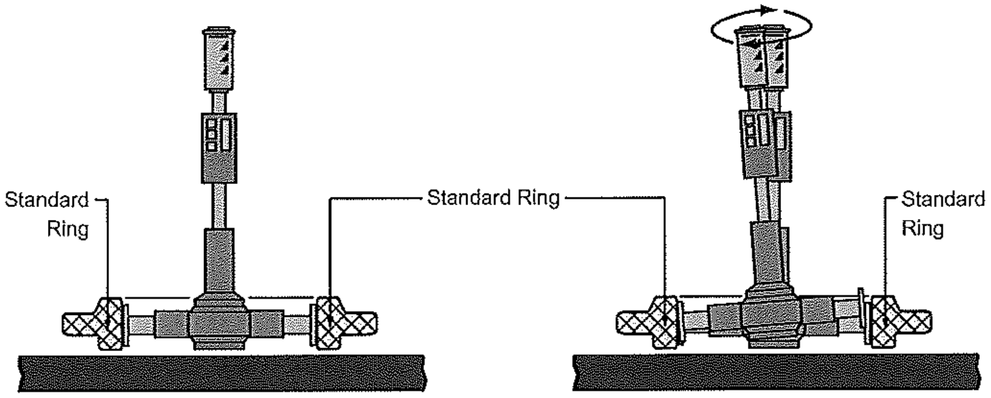
Note A3—Do not attempt to clean an SGC mold in an ignition oven. Extreme heat may cause the mold to soften or become "out of round" and unrepairable.

A4. PROCEDURE FOR MEASURING THE INSIDE DIAMETER OF SUPERPAVE GYRATORY MOLDS WITH A THREE-POINT BORE GAUGE

A4.1. *Standardize the Bore Gauge*—The three-point bore gauge shall be standardized with the master ring prior to each use.

A4.1.1. Allow the gauge and calibrated master ring to achieve a temperature of 18 to 28°C (64 to 82°F) (Note A2).

A4.1.2. Place the master ring on a flat surface. Position the gauge inside the ring without contacting the surface. Engage the contact points with the ring internal diameter. On some gauges, this operation requires turning an adjuster knob to extend the contact points; other gauge types may have alternate engagement operation. (See Figure A4.1.) While extending the gauge contacts, use a small circular motion at the top of the gauge to align the contact tips with the master ring bore. As the bore gauge contacts engage the master ring, the circular movement will reduce until the contacts seat against the ring bore. This engagement should be firm but not overly tight.



Hold the micrometer inside the ring and off the table surface and centered vertically in the ring while tightening.

Move the top of the micrometer in a circular motion while extending the contact points.

Figure A4.1—Techniques for Using the Three-Point Bore Gauge with the Calibrated Master Ring

Note A4—The circular motion depicted in Figure A4.1, applied to the top of the gauge while tightening the contact tips against the bore surface, is necessary to eliminate errors from misalignment.

A4.1.3. Reset (zero) the bore gauge. On mechanical gauges without an electronic reset, confirm the gauge reads within 0.0025 mm (0.0001 in.) of the master ring. Release the gauge from the ring by retracting the contact points.

If the mechanical bore gauge does not read correctly, measurements taken with the gauge require the addition of an offset to compensate for the bias (amount of error from the standard), or the gauge can be recalibrated.

A4.2. Identify the rotational orientation of the measurements. Position the mold on a flat surface with the bore vertical. Place a mark on the top of the mold to identify the rotational orientation of the measurements to be taken.

A4.3. *Measurements*—The inside diameter of the mold shall be measured at three locations (elevations) along its axis. Designate these elevations as 1, 2, and 3. The first measurement location (elevation) shall be approximately 50 mm from the top of the mold. The second measurement shall be in the visible wear area approximately 100 mm from an end of the mold (top or bottom) as determined by the wear area. The third elevation shall be approximately 50 mm from the end opposite the first measurement.

The diameter shall be measured three times at each elevation, resulting in a total of nine individual diameter measurements. Each measurement is identified by a number (1, 2, or 3) corresponding to the elevation and a letter (A, B, or C) corresponding to the angular orientation of the gauge. At each elevation, measurements designated as "A" shall have one of the three contacts aligned with the mark made in Section A4.2, measurements designated as "B" shall have the contact rotated 90 degrees from the mark, and measurements designated as "C" shall have the contact oriented 180 degrees from the mark.

For best accuracy and consistency, each bore measurement should use the same firmness and technique applied in Section A4.1.2 for gauge standardization.

Record each measurement to at least the nearest 0.0025 mm (0.0001 in.). Record the value to the nearest 0.001 mm (0.00004 in.) if the gauge resolution permits.

A4.3.1. Position the bore gauge at the first measurement elevation with one of the contact points aligned with the mark made in Section A4.2. Obtain the measurement, and record this reading as "1A."

A4.3.2. Release the gauge; rotate it 90 degrees and obtain the measurement in this orientation. Record this measurement as "1B."

A4.3.3. Rotate the bore gauge an additional 90 degrees (180 degrees from "1A") to obtain a third reading at the same elevation. Record this reading as "1C."

Note A5—Figure A4.2 shows the gauge in the mold positioned for each measurement. The wear zone is represented in this figure at the top of the mold. Take care not to position the bore gauge probe at the sloped edge of the wear zone.

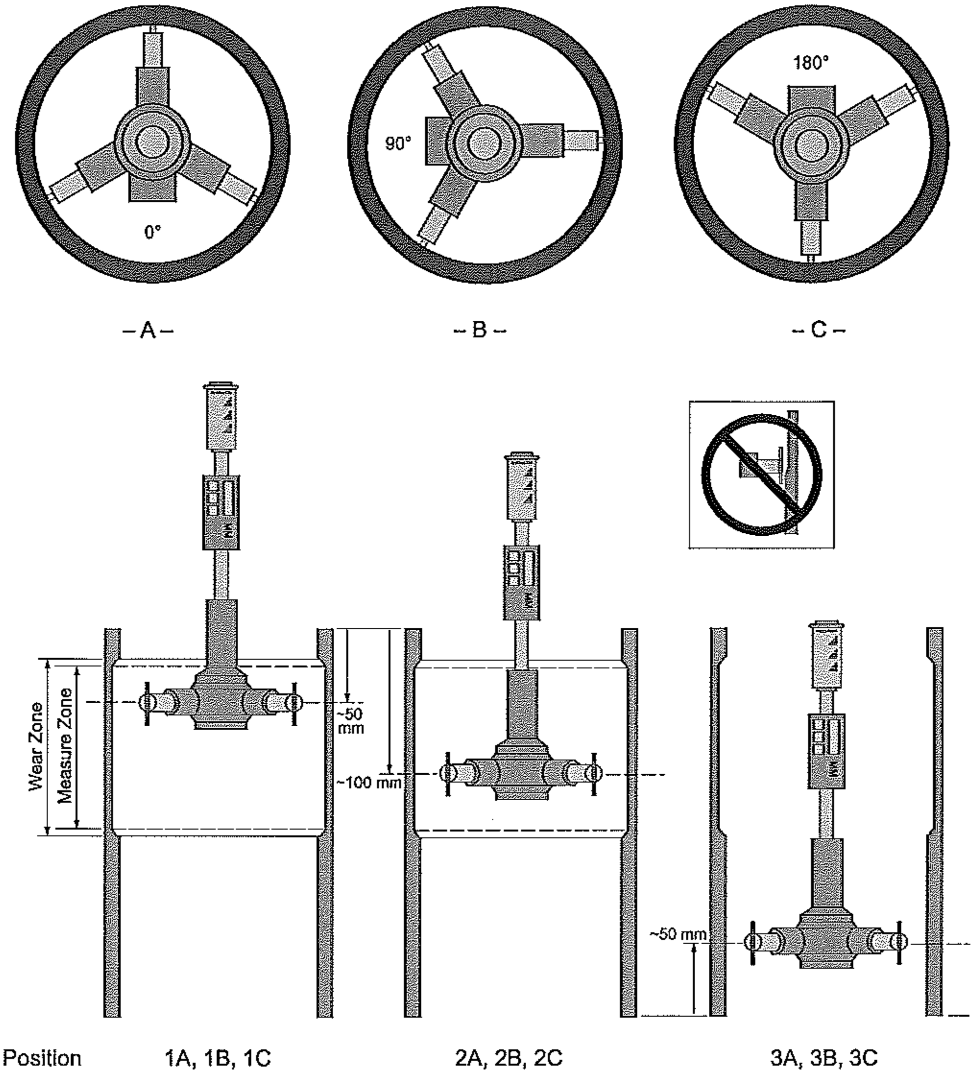


Figure A4.2—Bore Gauge Measurement Positions within the Mold Bore

A4.3.4. Release the bore gauge, and position it for the measurements at the second elevation. Repeat Sections A4.3 through A4.3.3 for elevations 2 and 3. Record the readings, and designate them as "2A," "2B," and "2C" and "3A," "3B," and "3C," respectively.

A4.3.5. Each individual bore measurement shall be compared to the specified range and given a pass/fail rating. If any of the individual bore measurements are assigned a "fail" rating, the mold is considered to be out of conformance and shall not be used.

A4.4. *Calculations*:

A4.4.1. For instruments that indicate the measured value directly, no calculation is required.

A4.4.2. For instruments for which the diameter measurement is an increment from the master ring size, calculate the mold diameter for each measurement by the following equation:

$$\text{measurement} = M + D \quad (A4.1)$$

where:

M = master ring diameter, mm; and
D = instrument reading, mm (retain the positive or negative sign).

Note A6—A negative reading for "D" indicates that the mold diameter is smaller than the master ring, and a positive reading indicates that the mold diameter is larger than the master ring.

A4.4.3. Measurements taken with instruments measuring in inches shall be converted and reported as millimeters (mm) using the following equation:

$$\text{mm} = \text{in.} \times 25.40 \quad (A4.2)$$

A5. PROCEDURE FOR MEASURING THE INSIDE DIAMETER OF SUPERPAVE GYRATORY MOLDS WITH A COORDINATE MEASUREMENT MACHINE (CMM)

A5.1. Take measurements in accordance with the operating instructions provided by the equipment manufacturer. Measurements shall be obtained at the vertical locations specified in Figure A4.2.

A5.1.1. Report information in accordance with the requirements in Section A7 of this Annex.

A6. PROCEDURE FOR MEASURING THE OUTSIDE DIAMETER OF SUPERPAVE GYRATORY COMPACTOR MOLD END PLATES

A6.1. *Perform a visual inspection of the mold end plates*:

A6.1.1. Confirm that the end plates are thoroughly cleaned and properly identified. Allow the end plates and outside measuring instrument (caliper, micrometer, or CMM) to achieve a temperature of 18 to 28°C (64 to 82°F) (Note A2).

A6.1.2. The plates shall be free of residue and deep gouges. Surfaces in contact with the asphalt mixture shall be flat. Minor abrasion marks from aggregates are acceptable. Surfaces in contact with the SGC frame or compaction ram shall be free of raised burrs that may cause the plate to wobble during gyration. Small recesses on the side of the plate interfacing the SGC (opposite the asphalt mixture) can reduce rocking and are acceptable.

A6.2. Determine the maximum diameter of the end plate by measuring it at several locations. Place a removable mark at this position. Record the maximum plate diameter to the nearest 0.025 mm (0.001 in.). Designate this measurement as "A."

A6.2.1. Measure the diameter at a 90-degree orientation to the maximum diameter. Record this diameter as "B."

A6.2.2. Each individual diameter measurement shall be compared to the specified range and given a pass/fail rating. If any of the individual bore measurements are assigned a "fail" rating, the mold is considered to be out of conformance and shall not be used.

A7. INSPECTION REPORT

A7.1. *Record and report the following information*:

A7.1.1. Name of evaluator;

A7.1.2. Date;

A7.1.3. Mold owner;

A7.1.4. Location of evaluation;

A7.1.5. Superpave gyratory compactor model;

A7.1.6. Measurement system for the inside diameter measurements;

A7.1.6.1. Bore gauge information, if used (manufacturer and model);

A7.1.6.2. Master ring information, if using three-point bore gauge (diameter to the nearest 0.001 mm (0.00004 in.), calibration certificate number, and calibration date);

A7.1.6.3. CMM information, if used (manufacturer, model, last calibration date);

A7.1.7. Length-measuring instrument information (model, serial number, range, and calibration date);

A7.1.8. *Mold and End Plate Identification*—Mold identification (serial number or other identifying mark) and end plate identification(s) (serial number or other identifying mark);

A7.1.9. Individual inside diameter measurements of the mold to the nearest 0.0025 mm (0.0001 in.) and the corresponding pass/fail rating;

A7.1.10. Individual outside diameter measurements of the end plate to the nearest 0.025 mm (0.001 in.) and the corresponding pass/fail rating; and

A7.1.11. Length measurement of the mold to the nearest 0.1 mm (0.004 in.).

APPENDIX A1
December 4, 2015
(2 Pages)

ROUNDING PROCEDURE

The following describes the rounding procedure which is to be used for rounding numbers to the required degree of accuracy:

1. Except as specified in Section 2 below, the following procedure will apply. This procedure correlates with the "built-in" rounding method normally utilized by calculators and computers.

1.1 When the figure next beyond the last figure or place to be retained is less than 5, the figure in the last place retained is left unchanged.

Examples:
Rounding 2.6324 to the nearest thousandth is 2.632
Rounding 7843.343 to the nearest hundredth is 7843.34
Rounding 4928.22 to the nearest tenth is 4928.2
Rounding 7293.1 to the nearest whole number is 7293
Rounding 2042 to the nearest units of 10 is 2040
Rounding 3548 to the nearest units of 100 is 3500
Rounding 8436 to the nearest units of 1000 is 8000

1.2 When the figure next beyond the last figure or place to be retained is 5 or larger, the figure in the last place retained is increased by 1.

Examples:
Rounding 4839.4575 to the nearest thousandth is 4839.458
Rounding 9347.215 to the nearest hundredth is 9347.22
Rounding 8420.35 to the nearest tenth is 8420.4
Rounding 1728.5 to the nearest whole number is 1729
Rounding 3685 to the nearest units of 10 is 3690
Rounding 6650 to the nearest units of 100 is 6700
Rounding 2500 to the nearest units of 1000 is 3000

Rounding 2.6326 to the nearest thousandth is 2.633
Rounding 7843.347 to the nearest hundredth is 7843.35
Rounding 4928.28 to the nearest tenth is 4928.3
Rounding 7293.9 to the nearest whole number is 7294
Rounding 2046 to the nearest units of 10 is 2050
Rounding 3572 to the nearest units of 100 is 3600
Rounding 8634 to the nearest units of 1000 is 9000

1.3 No result shall be rounded more than once.

Example: 3024.5 rounded to the nearest units of 10 will be 3020;

<u>not</u>

3024.5 rounded to 3025, and then rounded again to 3030.

2. The rounding procedure specified in Section 1 above shall be used for all calculations and recording of data in performing materials testing, except when a specific test method cites a method of rounding which differs from this procedure, for example, the sand equivalent test (AASHTO T 176 or Arizona Test Method 242).

3. Compliance will be based upon interpreting the reported results as though they are rounded to the terms (whole numbers, decimals, or fractions reduced to decimals) of the specifications. For example, a value reported as 8.4% shall be considered as having no deviation from specifications that require 4 – 8%. It would however be a deviation for specifications requiring 4.0 – 8.0%.

4. Computers and most electronic calculators automatically carry several decimal places beyond the point of desired accuracy. At times, results of calculations utilizing these values are different than that achieved when calculations are performed utilizing values that have been rounded to the desired degree of accuracy by the above rules. The user is cautioned that the use of a computer or electronic calculator without re-entry of values after rounding, and discarding any figures beyond those needed, may cause unacceptable variations in final results.

APPENDIXA2
July 15, 2005
(8 Pages)

METRIC GUIDE

The following information is provided as a guide for utilizing the International System of Units (SI), generally referenced as "metric units". Related information can be found in AASHTO R1 "Metric Practice Guide", and ASTM E380, "Use of the International System of Units (Sl)(The Modernized Metric System)".

Included herein are commonly used equivalents and conversions for U.S. Customary Units and Metric Units. It is not the intention of this guide to provide a detailed compilation of such equivalents and conversions. Such lists are available in many publications, including those referenced above.

One common conversion, which is found in many test procedures, is to determine an equivalent temperature in units of either degrees Celsius or degrees Fahrenheit.

Convert degrees Fahrenheit to degrees Celsius by:

$$^{\circ}\square C = \frac{}{9} \text{ x } (^{\circ}F - 32)$$

Convert degrees Celsius to degrees Fahrenheit by:

$$^{\circ}F = \left[\frac{9}{5} \times {^{\circ}C}\right] + 32$$

Under the SI (Metric) system, the base unit for mass is the "kilogram". (Although not technically correct, "weight" is often used in common practice to mean "mass".) The base unit for length is the "meter". The base unit for time is the "second". Primary metric units for area and volume are the "square meter" and the "cubic meter", respectively.

In addition to expressing values in the base or primary metric units, other associated metric units are identified and determined by varying the magnitude of the base metric unit by powers of 10. Metric values are commonly shown in scientific notation form, (for example, $1 \text{ x } 10^4 = 10{,}000$;1 x 10-4 = 0.0001).

Table 1 below gives a listing of prefixes used in the metric system, with their associated powers of ten, and their symbol.

TABLE 1

Prefix	Power of ten	Symbol
*deci	10^{-1}	d
*centi	10^{-2}	c
milli	10^{-3}	m
micro	10^{-5}	µ
nano	10^{-9}	n
pico	10-12	p
femto	10-15	f
atto	10-18	a
*deka	10^{1}	da
*hecto	10^{2}	h
kilo	10^{3}	k
mega	10^{6}	M
giga	10^{9}	G
tera	1012	T
peta	1015	p
exa	1018	E

* Use is to be avoided where practical. When expressing a quantity by a numerical value and a unit, a prefix should preferably be chosen so that the numerical value lies between 0.1 and 1000. In expressing area and volume, the prefixes hecto, deka, deci, and centi may be required, for example, square hectometer, cubic centimeter.

Table 2 below gives the symbols commonly used for various metric units.

TABLE2

kg = kilogram
g = gram
mg = milligram
m = meter
km= kilometer
cm = centimeter
mm = millimeter
µm = micrometer (micron)
s = second
m^2 = square meter
cm^2 = square centimeter
mm^2 = square millimeter
m3 = cubic meter
cm^3 or cc= cubic centimeter
mm^3 = cubic millimeter
L = liter
ml = milliliter
Pa= pascal
N = newton
kPa = kilopascal
MPa = megapascal

Table 3 below includes common conversions from the base and primary metric units (kilogram, meter, square meter, and cubic meter) to other associated metric units. Also listed are some common derived metric units.

TABLE 3

1 gram= 0.001 kilogram
1 milligram = 1 x 10-6 kilogram
1 milligram = 0.001 gram
1 kilogram = 1000 grams
1 metric ton = 1000 kilograms
1 kilometer = 1000 meters
1 centimeter= 0.01 meter
1 millimeter = 0.001 meter
1 micron (micrometer) = 1 x 10^{-6} meter
1 square kilometer = 1 x 10^{6} square meters
1 square centimeter= 1 x 10^{-4} square meter
1 square millimeter = 1 x 10^{-6} square meter
1 cubic centimeter= 1 x 10^{-6} cubic meter
1 cubic millimeter = 1 x 10^{-9} cubic meter
1 liter= 0.001 cubic meter
1 milliliter = 1 x 10^{-6} cubic meter
1 milliliter= 1 cubic centimeter
1 newton= 1 kg·m/s^2
1 pascal= 1 N/m^2
1 kilopascal = 1000 pascals
1 megapascal = 1 x 10^{6} pascals
1 poise (absolute viscosity)= 0.10 Pa·s
1 centistoke (kinematic viscosity) = 1 mm^2/s or 1 x 10^{-6} m^2/s

Some common U.S Customary units, with their corresponding base and primary metric unit equivalents, are given below in Table 4.

TABLE 4

1 pound (avoirdupois)= 0.453 5924 kilogram
1 ton (2000 lbs.) = 907.1847 kilograms
* 1 inch= 0.0254 meter
* 1 foot= 0.3048 meter
* 1 yard = 0.9144 meter
* 1 mile (5280 feet)= 1609.344 meters
* 1 square inch = 6.4516 x 10^{-4} square meter
* 1 square foot = 0.092 903 04 square meter
1 square yard= 0.836 1274 square meter
1 cubic inch = 1.638 706 x 10^{-5} cubic meter
1 cubic foot= 0.028 316 85 cubic meter
1 cubic yard = 0.764 5549 cubic meter
1 pint (U.S. liquid)= 4.731 765 x 10^{4} cubic meter
1 quart (U.S. liquid)= 9.463 529 x 10^{-4} cubic meter
1 gallon (U.S. liquid) = 0.003 785 412 cubic meter

(Exact equivalents are noted with an asterisk.)

Table 5 below lists commonly used conversions for U.S. Customary Units and metric units. Values are shown to the degree of accuracy which generally may be used to achieve satisfactory results. If more accuracy is desired, the values may be derived by using Tables 3 and 4.

TABLE 5

1 kilogram = 2.205 pounds
1 pound = 453.6 grams
1 ounce (avoirdupois)= 28.35 grams
1 ton (2000 lbs)= 0.9072 metric ton
1 meter= 39.37 inches or 3.281 feet
1 kilometer= 0.62 miles
* 1 mil = 0.0254 millimeters or 25.4 micrometers
* 1 inch = 2.54 centimeters or 25.4 millimeters
* 1 foot = 0.3048 meters
* 1 yard = 0.9144 meters
1 mile= 1.61 kilometers
1 square inch = 6.452 cm^2 or 645.16 mm^2
1 square foot= 0.0929 square meters
1 square yard = 0.836 square meters
1 cubic inch = 16.39 cm^3 or 16386 mm3
1 cubic foot= 0.028 m^3 or 28317 cm^3
1 cubic yard = 0.765 cubic meters
1 liter= 1.06 quarts (U.S. liquid)
1 ounce (U.S. fluid)= 29.574 milliliter
1 pint (U.S. liquid)= 0.47 liter
1 quart (U.S. liquid)= 0.95 liter
1 gallon (U.S. liquid)= 3.79 liters
1 lb/ft^3 = 16.02 kg/m3
1 kilometer/hour = 0.62 mile/hour
1 mile/hour= 1.61 km/hour
1 pound/square inch= 6.895 kPa
1 pound force = 4.448 newton
1 gallon/square yard = 4.527 liters/m^2
1 gallon/ton (2000 lbs.)= 4.173 liters/metric ton
1 gallon/cubic yard = 4.951 liters/m^3
1 pound/square yard = 0.542 kg/m2
1 pound/cubic yard = 0.593 kg/m^3
1 pound/gallon = 0.120 kg/liter
1 cubic yard/square yard= 0.914 m^3/m^2
1 inch/mile = 0.0158 meter/kilometer

(Exact equivalents are noted with an asterisk.)

Table 6 below is from information contained in AASHTO M92 and ASTM E11 "Wire-Cloth Sieves for Testing Purposes", and shows Standard (Metric) and Alternative (U.S. Customary) sieve size designations. As shown, metric size designations are given in mm or µm. (1,000 µm = 1 millimeter)

8 inch diameter sieve= 203.2 mm diameter sieve
12 inch diameter sieve = 304.8 mm diameter sieve

TABLE 6

Sieve Designation	
Standard	Alternate
125 mm	5 in.
106 mm	4.24 in.
100 mm	4 in.
90mm	3-1/2 in.
75 mm	3 in.
63mm	2-1/2 in.
53mm	2.12 in.
50mm	2 in.
45mm	1-3/4 in.
37.5 mm	1-1/2 in.
31.5 mm	1-1/4 in.
26.5 mm	1.06 in.
25.0 mm	1 in.
22.4 mm	7/8 in.
19.0 mm	3/4 in.
16.0 mm	5/8 in.
13.2 mm	0.530 in.
12.5 mm	1/2 in.
11.2 mm	7/16in.
9.5 mm	3/8 in.
8.0mm	5/16 in.
6.7mm	0.265 in.
6.3 mm	1/4 in.
5.6mm	No. 3-1/2
4.75 mm	No. 4
4.00 mm	No. 5
3.35 mm	No. 6
2.80 mm	No. 7
2.36 mm	No. 8
2.00 mm	No. 10
1.70 mm	No. 12
1.40 mm	No. 14
1.18 mm	No. 16
1.00 mm	No. 18
850 µm	No. 20
710 µm	No. 25
600 µm	No. 30
500 µm	No. 35
425 µm	No. 40
355 µm	No. 45
300 µm	No. 50
250 µm	No.60
212 µm	No. 70
180 µm	No. 80
150 µm	No. 100
125 µm	No. 120
106 µm	No. 140
90µm	No. 170
75µm	No.200
63 µm	No.230
53µm	No. 270
45µm	No. 325
38 µm	No. 400
32 µm	No.450
25 µm	No.500
20 µm	No. 635

TABLE 7

SI* (METRIC) CONVERSION FACTORS

{A��oximateeguivalents1 exce�t as noted**)

CONVERSIONS TO SI UNITS					CONVERSIONS FROM SI UNITS				
″ %	& ! o $	u! lyb % %	A v y	h%	h%	dS % ! o $	u! % %	y	# %
LENGTH					**LENGTH**				
_f.	_fO]V{	17)3	e_bb_eV|Vr{	ee	m	e_bb_eV|Vr{	+&+2<2:	_fQV{	_f.
[&	XVV|	+.2+3;**	eV|Vr{	e	e	eV|Vr{	2.1;	XVV|	X|&
~U"	□Jx{	+ <.33**	eV|Vv{	e	e	eV|Vr{	.&+<	□JrU{	□U.
e_.	e_bV{	..9.	a_bgeV|Vr{	ae	ae	a_bgeV|Vr{	+.91.	e_bV{	e_.
AREA					**AREA**				
{h! _f. gr _f◊	{p}JrV _fO]V{	937"1	{K}JrV e_bb_eW|Vr{	ee"	ee"'	{p}JrV e_bb_eV|Vr{	+#++.9	{p}JrV _fO]V{	{i& `f& gr _f,!
{p. Y|& gr ['	{p}JrV XVV|	+(+<2	{p}JsV eV|Vy	e□	e..	{i}JrV eV|Vr{	.+$:93	{i}JrV XVV|	{h. X|& gr X|2
{h% □U% gr □U"	{h}JrV ~JrU{	+=;29	{i}JrV eV|Vw{	e2	e□	{K}JrW eV|Vr{	.#.<	{h}JrV†JrU{	{i!†U& gr†U.:
	JOrV{	+&3+7	^VO|JrV{	]J	]J	]VO|JrV{	1.3:	JOrV{	
{p& e_& gr e_L	{p}JrV e_bV{	1&7<	{p}JrV a_bgeV|Vr{	ae.c	ae,!	{i}JrV a_bgeV|Vr{	+ 2;9	{i}JrV e_bV{	{i. e_$ gr e_2
VOLUME					**VOLUME**				
Xd# gS!	Xb}_U g}fOV{	1<.7:	e_bb_b_|Vr{	ec	ec	e_bb_eV|Vr{	0.034	Xd}_U g}fOV{	Xb& Dl*
LJb&	LJbbgf{ ‹b_q}_U)	2.:;85	b_|Vr{ *	c	c	b_|Vr{***	+ 194	jJbbgf{(b`K}_U)	\Jb!
O}& X|& gr Z|Œ	O}N_O XVV|	+.+1;	O}N_O eV|Vr{		e□	O}N_O eV|Vr{	27!2.7	P}N_O XVV|	P}& [' gr X|“
O}.†U. gr†U□	O}N_O†JrU{	+.:97	O}N_O eW|Vy	e□	e‘	O}N_O eV|Vv{	. 2.	O}N_O,JvU{	T& ~U gr ~U”
MASS					**MASS**				
gS%	g}fOV{	1;.27	LuJe{	L	a	LrJe{	+(+27	g}fOV{	kS&
bN!	og}fU{	+(383	a_bgMvJe{	kg	kg	a_bnrJe{	1(1+7	mg}fU{	bN.
F	{]gr| |gf{(1+++ bN	+.<+:	eV|w`O |gf{****	.	|	eV|v`O |gf{**	..+1	{]gz|gf{(1+++/N	G
F	{]gr| |gf{(1-++ bN	+.<+:	eVLJLrJe{****	Mg	CL	eVMJRrJe{•***	...+1	{]gr| |gf{(1+,+/N)	G

***

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