FIELD TECHNICIAN CERTIFICATION

WORKBOOK

ARIZONA TECHNICAL TESTING INSTITUTE

Revised January 2020

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, materials 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.

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CERTIFICATION INFORMATION SECTION

INTRODUCTION

The ATTI Field Technician Certification program evaluates the competency of applicants performing sampling and testing of soils, aggregates, bituminous materials, and apathetic hot mix in the field. 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 Field Technician certification, administration of the certification process, and topics covered during the certification, administration of the certification process, and topics covered during the certification examinations. Brief coverage is given to safety issues, plan and profile, representative samples, record keeping, and properties of soils, aggregates, and asphaltic hot mix. Most importantly, the workbook contains copies of the applicable testing methods which a certified ATTI Field 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.

Instead of performing both Method A and Alternate Method D one point proctor tests, the examiner may ask the technician to verbally recite the differences between the two tests.

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.

If the technician has successfully attained an A TII Asphalt, Soils I Aggregate, or Field Technician Certification within the last 12 months you may receive credit for some of the test methods performed included in that certification.

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.

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.**

PLAN AND PROFILE

The plan and profile of a specific segment of a roadway are typically printed on a single sheet of the project plans with the plan view at the top of the sheet and the corresponding profile view at the bottom of the sheet. Plan and profiles are drawn such that profile stationing is directly below the plan stationing. See Figure 1.

The plan shows an aerial view of the roadway, as if the observer is looking directly down on the roadway. Roadway details such as horizontal alignment, roadway width, right-of-way, and structure locations are illustrated on the plan sheet relative to the roadway centerline. The profile shows a longitudinal cross-section view of the roadway elevation, taken through the centerline of the roadway. The profile illustrates details such as vertical alignment of the centerline, existing ground line elevation, culvert elevation, and structure elevations.

PLAN DETAILS

The **centerline**, denoted ℄ , is the surveyed center of the roadway. It may be an existing centerline or a newly established centerline. If both are illustrated, they should be clearly identified.

Station numbers are established along the centerline. Each station represents 100 feet; therefore, a distance of 700 feet is equivalent to 7 stations. Most projects will begin at station 0+00 and increase in stationing to the end of the project. For example, the location of a culvert is given as Station 21+76.8 which is equal to 2,176.8 feet from the beginning of the project. When a new centerline is established, and it is desired that the new stationing match the old, it is often necessary to add a correction equation.

Sampling of roadway materials is conducted randomly; consequently, very few samples are taken on the centerline. Specific sample locations are identified by station and **centerline offset** to the left of centerline or to the right of centerline. As an individual is facing in the direction of increasing stationing, the individual's left defines "left of centerline" and the individual's right defines "right of centerline."

PROFILE DETAILS

Elevations of various roadway centerline details are illustrated on the profile sheet. The elevations represent vertical distance above or below sea level.

The existing ground elevation along the **centerline** and the design finished roadway **centerline** are illustrated by lines drawn at the appropriate elevations.

The top elevation and depth of a sample is often drawn on the profile sheet.

TYPICAL SECTIONS

Typical sections illustrate the components and dimensional requirements of each pavement structure used on the project. The typical pavement sections are cross-sections taken transversely across the roadway. See Figure 2.

Pavement structural sections provide details on the material type and depth of each layer of the pavement structure. The pavement structure includes all pavement materials placed above the subgrade, including aggregate subbase, aggregate base, asphaltic concrete, Portland cement concrete, and asphaltic concrete friction course.

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 @ 4.0 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.

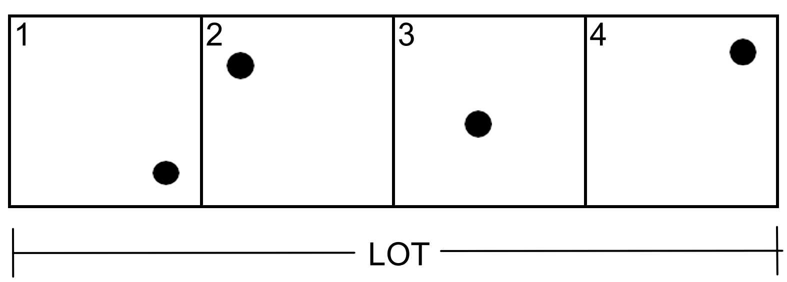


Figure 4. Sublots for stratified sampling.

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.

MATERIALS PROPERTIES

Specific strength, durability, water dispersion and other similar properties of soils, aggregates, and asphaltic concrete are the basic properties a highway construction material is designed to satisfy. The soils and aggregate properties of interest to the field testing technician are briefly discussed below. Compaction testing and sampling of mixtures for laboratory testing are the items of asphaltic concrete construction that are of primary interest to the field technician involved with sampling and testing.

ENGINEERING PROPERTIES OF SOILS

Selected characteristics of soils directly influence the design, construction, and performance of highway features. The properties of soils on a construction project determine the slope of a cut, the load bearing capacity of a subgrade and the sheer strength of embankments. Soils as well as aggregate base courses must have enough strength to support the applied loads of traffic, embankments, and structures under all climatic conditions. Two tests commonly used to determine the strength properties of a subgrade or embankment are the gradation and plasticity index test. These properties directly influence the soil support value of the subgrade under the pavement structure. The plasticity index is an indication of the cohesiveness, bonding, and moisture susceptibility of a soil.

For the purposes of this course, the engineering properties of three major soil types will be considered. Engineering properties for our use will refer to the properties of these soil types as they relate to highway design and construction.

These three main soil types consist of:

Granular soils-Sands and gravels
Fine-grained soils- silts and clays
Organic soils - organic clays and organic peat.

Granular soils, when free draining are not susceptible to frost and will settle quickly under a load. These characteristics make granular soils a good choice for use in foundations, embankments, and as wall backfill material. The drawback to the use of granular soils is that due to their high permeability it can be difficult to dewater them.

Cohesive soils are fine-grained soils. They sometimes possess low shear strength and are compressible and plastic. Wetting of these soils results in a further reduction of shear strength and also in expansion. The expansion will be followed by shrinkage as the material dries. Shear strength is also lost when a cohesive soil is disturbed. These soils can be subject to landslides. Cohesive soils are usually considered a poor choice for construction materials.

Organic refers to decayed animal and vegetable materials. Therefore an organic soil is any soil containing enough organic material to influence the properties and characteristics of the soil. In general, organic soils are not used in highway construction. All soils, which contain an organic component, should be reviewed carefully and with suspicion when used in highway construction. The presence of organic material in the soils results in an increase in compressibility and a reduction of load bearing capacity. Organic materials can also contain toxic gases, which are released when the soil is disturbed.

ENGINEERING PROPERTIES OF AGGREGATES

Particle size and shape, gradation, and cleanliness are three important properties of aggregates that are considered in highway construction. These three properties directly influence the capability of an aggregate mixture to compact, drain water, and adhere to binders.

Aggregate particles are sieved through screens to obtain portions of the same **particle size**. Percentages of the different sizes are then combined to create engineered base, bedding, backfill, and mineral aggregate composites. Particle shape also influences the compactibility and surface to surface contact of aggregates. Angular and irregular particles interlock and resist displacement much better than rounded particles.

Particle shape also influences the compactibility and surface to surface contact of aggregates. Angular and irregular particles interlock and resist displacement much better than rounded particles. Particle shapes of interest include irregular, angular, flaky, elongated and rounded. Elongated particles have a long dimension which is 1.8 times the average dimension and flaky particles are those whose shortest dimension is less than 0.6 times the average dimension. Each of these shapes is determined by test methods contained later in this manual.

Gradation defines the distribution of a variety of aggregate particle sizes and is often referred to as aggregate grading. The intended use for the aggregate will determine the percentage of each particle size to be used in the gradation or size distribution. Plant screening and crushing processes are used to control gradation. Sieve analyses (ARIZ 201) are performed on an aggregate mixture to determine the true percentage of each size in the mixture.

ENGINEERING PROPERTIES OF ASPHALTIC CONCRETE

Field sampling of asphaltic concrete mixes is performed to check the produced mix properties for compliance with mix design requirements. Asphaltic concrete mixture performance is affected by the mineral aggregate properties and liquid asphalt cement properties. Consequently, it is important that representative samples are taken. The common method for sampling asphaltic concrete mats is to place a 1’ x 4’ metal plate in front of the paver. As the paver travels across the plate, material is placed on the plate. When obtaining the asphaltic concrete sample from the surface of the plate, all slough material from the sides of the cut of the surface should not be collected.

Asphaltic concrete samples are typically tested for aggregate gradations, void properties, and asphalt cement content. These properties directly influence the mix's ability to resist deformation, cracking, and failure from the loads placed by the traffic and effects of weather.

Asphalt cements function as a binder, or glue, which hold the aggregate particles together and provide protection against the effects of water. Liquid asphalt cement samples are taken to check viscoelastic, temperature sensitivity and aging properties.

COMPACTION

Asphaltic concrete, soils and aggregate bases, backfills and beddings are typically compacted to a specified percentage of maximum density in the field by use of rollers or mechanical compactors. Maximum compaction is desirable to reduce settling and deformation, and increase load bearing capacity. The density of a layer of in-place soils/aggregate material is checked by the sand cone density test (ARIZ 230), nuclear density gauge (ARIZ 235), or one-point proctor test (ARIZ 232, ARIZ 246). Asphaltic concrete compaction is checked with the nuclear density gauge (ARIZ 412) or lab testing of cores taken from the compacted roadway. The in-place density of soils/aggregates is then compared to the maximum dry density determined in the lab by proctor testing to determine the degree of compaction. Similarly, the in-place density of a layer of compacted asphaltic concrete is compared to the maximum density determined by laboratory testing.

TEST METHODS

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.

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.

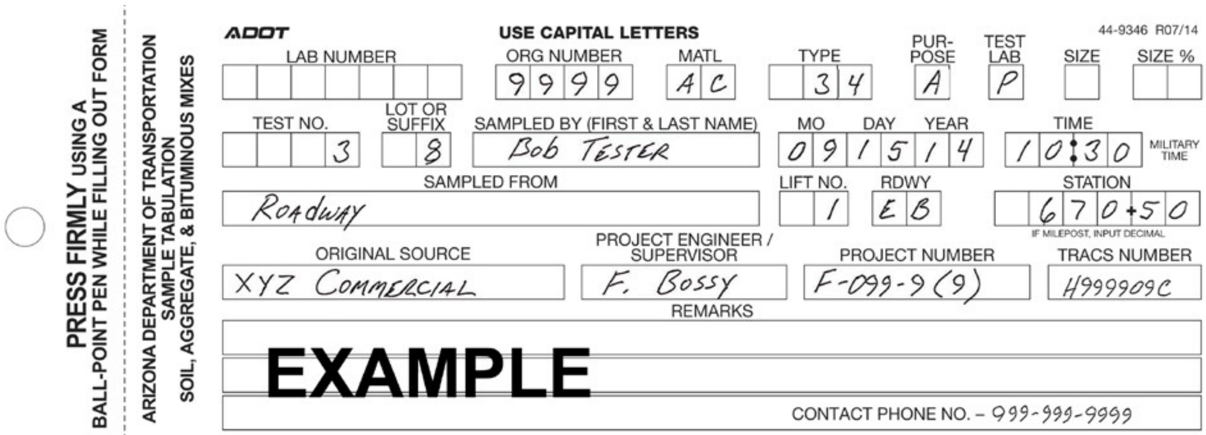
8. SAMPLE IDENTIFICATION

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: 9999 | MATL: AC | TYPE: 34 | PURPOSE: A | TEST LAB: P | SIZE: | SIZE %:

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

SAMPLED FROM: Roadway | LIFT NO.: 1 | RDWY: EB | STATION: 670+50 (IF MILEPOST, INPUT DECIMAL)

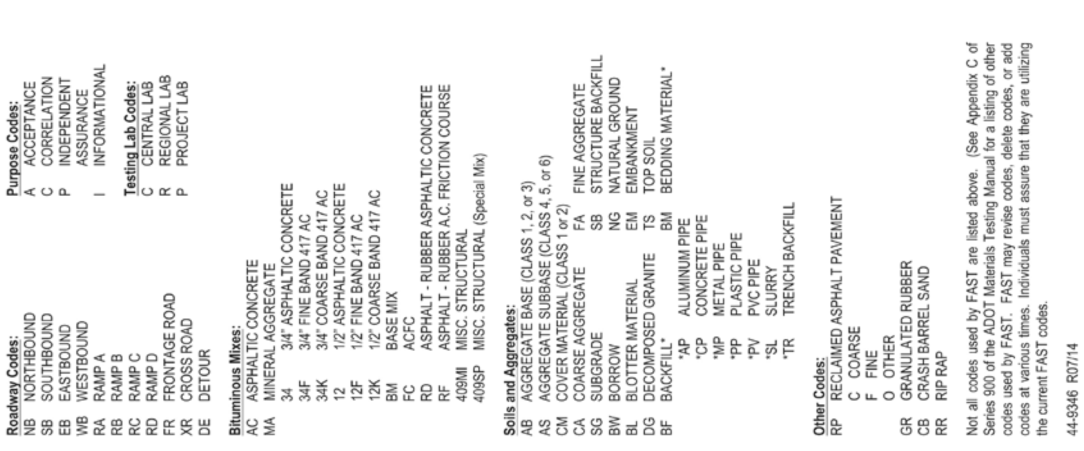
ORIGINAL SOURCE: XYZ COMMERCIAL | PROJECT ENGINEER / SUPERVISOR: F. Bossy | PROJECT NUMBER: F-099-9(9) | TRACS NUMBER: H999909C

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
SG SUBGRADE
BW BORROW
BL BLOTTER MATERIAL
DG DECOMPOSED GRANITE
BF BACKFILL*
FA FINE AGGREGATE
SB STRUCTURE BACKFILL
NG NATURAL GROUND
EM EMBANKMENT
TS TOP SOIL
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

SAMPLING SOILS AND AGGREGATES

(An Arizona Method)

1. SCOPE

1.1 This method describes the methods which are to be used when sampling soils and aggregates.

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

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

Table 1
Minimum Sample Sizes

Nominal Maximum Aggregate Size *	Sample Mass	
	lbs	kg
Fine Aggregate		
#8	22	10
#4	22	10
Coarse Aggregate		
3/8”	22	10
1/2”	35	15
3/4”	55	25
1”	110	50
1-1/2”	165	75
2”	220	100
2-1/2”	275	125
3”	330	150

* The smallest sieve opening through which the entire amount of material, by specification, is permitted to pass.

2. SAMPLING FROM STOCKPILES

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

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

3. SAMPLING FROM BINS

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

4. SAMPLING FROM A CONVEYOR BELT

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

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

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

5. SAMPLING FROM A WINDROW

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

6. SAMPLING FROM THE ROADWAY

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

7. REDUCING FIELD SAMPLES TO TESTING SIZE

7.1 The reduction of samples to obtain the amount required for particular tests shall be performed in accordance with AASHTO R 76.

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 5. Commonly used codes for filling out the sample ticket are shown on the back side of the sample ticket (see Figure 6).

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

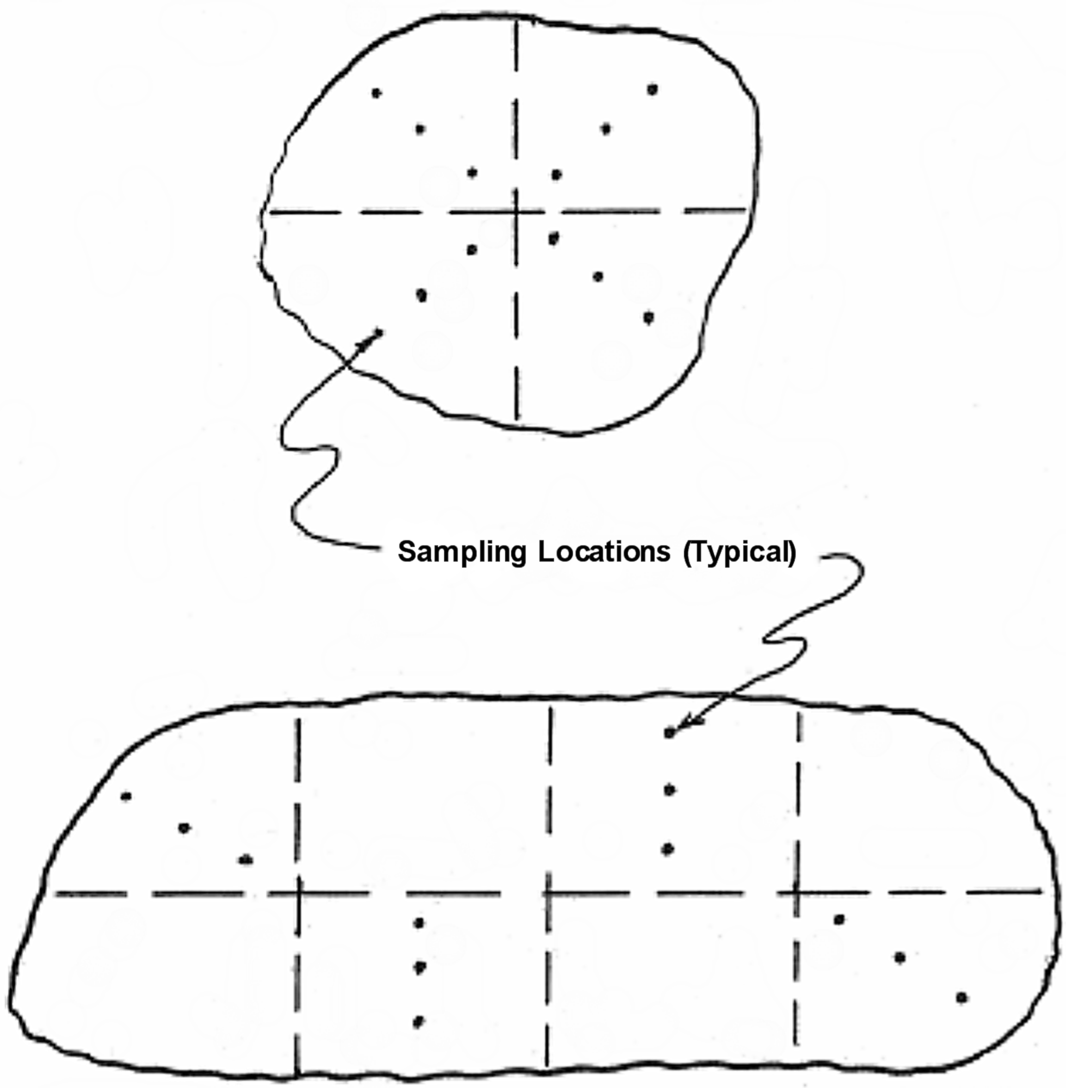
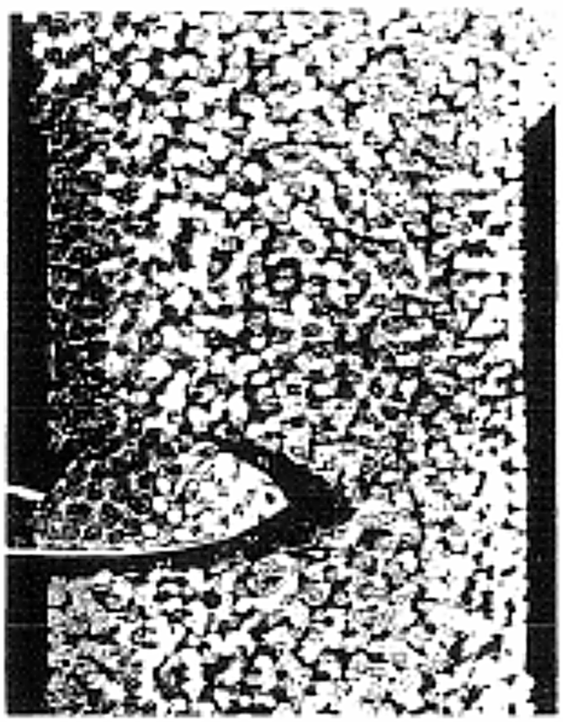


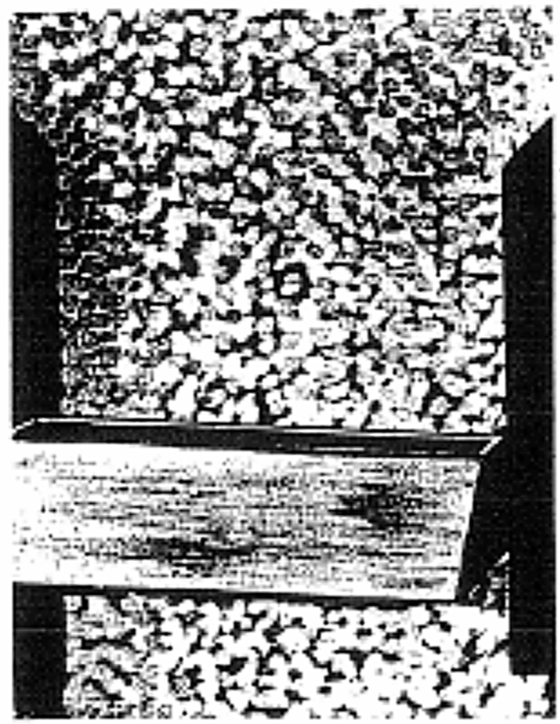
Illustration of Sampling Locations for Different Stockpile Types

FIGURE 1



WRONG

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

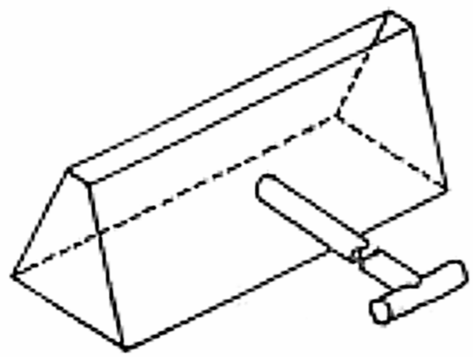


RIGHT

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

Illustration of Bin Sampling

FIGURE 2



Typical Bin Sampler

FIGURE 3

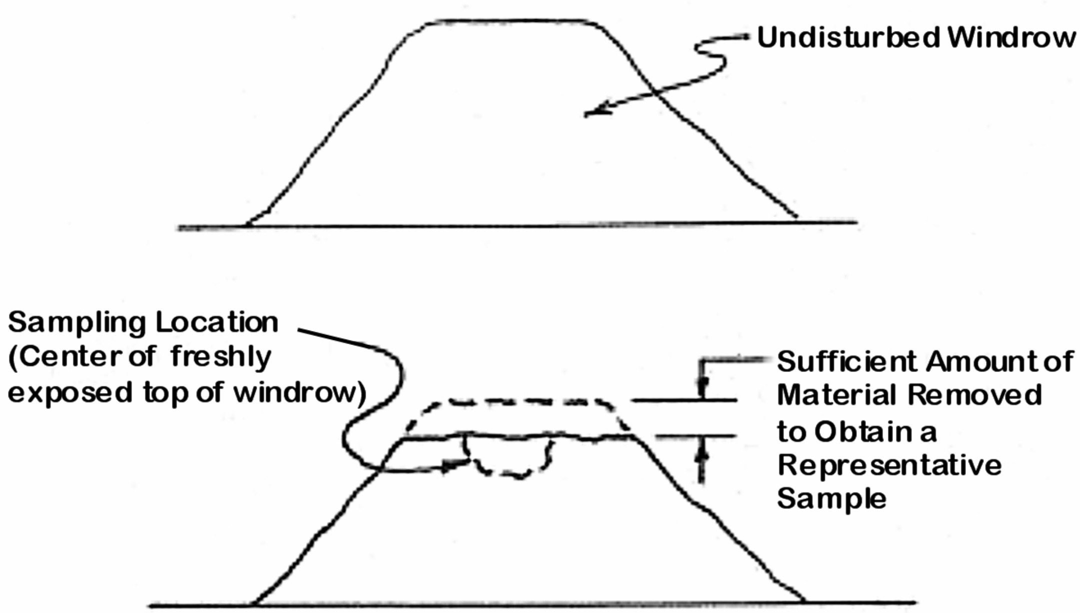
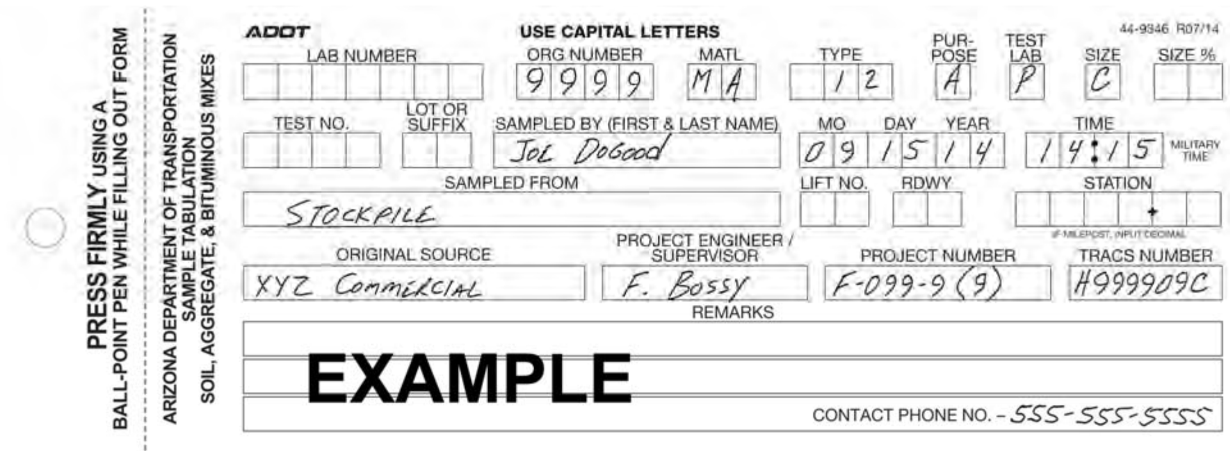


Illustration of Sampling From a Windrow

FIGURE 4



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: 9999 | MATL: MA | TYPE: 12 | PURPOSE: A | TEST LAB: P | SIZE: C | SIZE %

TEST NO. | LOT OR SUFFIX | SAMPLED BY (FIRST & LAST NAME): JOE DOGOOD | MO: 09 | DAY: 15 | YEAR: 14 | TIME: 14:15 (MILITARY TIME)

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

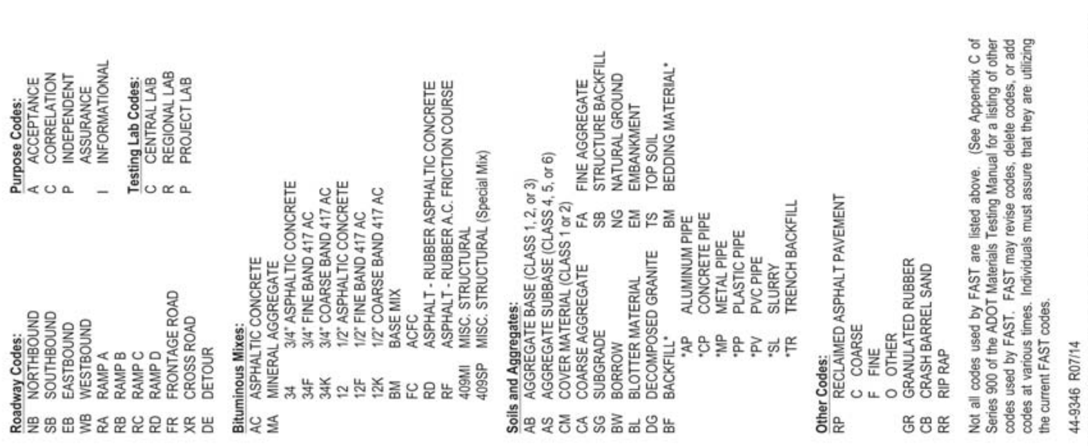
ORIGINAL SOURCE: XYZ COMMERCIAL | PROJECT ENGINEER / SUPERVISOR: F. BOSSY | PROJECT NUMBER: F-099-9 (9) | TRACS NUMBER: H999909C

REMARKS

EXAMPLE

CONTACT PHONE NO. – 555-555-5555

FIGURE 5



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
SG SUBGRADE
BW BORROW
BL BLOTTER MATERIAL
DG DECOMPOSED GRANITE
BF BACKFILL*
*AP ALUMINUM PIPE
*CP CONCRETE PIPE
*MP METAL PIPE
*PP PLASTIC PIPE
*PV PVC PIPE
*SL SLURRY
*TR TRENCH BACKFILL
FA FINE AGGREGATE
SB STRUCTURE BACKFILL
NG NATURAL GROUND
EM EMBANKMENT
TS TOP SOIL
BM BEDDING MATERIAL*

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 6

APPENDIX A

CALIBRATION OF PROCTOR MOLDS

1. CALIBRATION

1.1 Molds shall be calibrated at least once a year, or sooner if there is reason to question the accuracy of the calibration.

1.2 Lightly coat the bottom of the mold with a waterproofing grease. (Dow Corning High Vacuum Grease, or similar, has proven satisfactory for this application.) For split molds, waterproofing grease is also necessary on the edges of the split mold halves which join together.

1.3 Fit mold into baseplate and secure snugly into place.

1.4 Wipe excess grease from the mold and the baseplate.

1.5 Record weight of baseplate, empty mold, and glass plate to at least the nearest 0.1 gram.

Note: An example which illustrates the recording of calibration data and calculations is shown in Figure 5. Figure 6 is a blank calibration form.

1.6 With the mold and baseplate assembly on a flat and level surface fill the mold with distilled water at room temperature 77 $\pm$ 9 °F.

1.7 Determine and record the temperature of the water to the nearest one degree Fahrenheit.

1.8 With a small rod, remove any air bubbles that may be clinging to the sides or bottom of the mold. Add additional water to completely fill the mold, using a glass plate in such a way to ensure accurate filling of the mold, eliminating air bubbles and excess water. Check bottom of mold to assure there is no leakage.

1.9 Dry the base plate, glass and outside of mold with a dry, absorbent cloth. Care must be taken to not lose water from inside of mold during drying. Record weight of baseplate, mold filled with water, and glass plate to at least the nearest 0.1 gram.

APPENDIX A - (Continued)

1.10 Determine the weight of water to fill mold by subtracting the weight of baseplate, empty mold, and glass plate from the weight of the baseplate, mold filled with water, and glass plate.

1.11 For the temperature of the water, determine its corresponding unit weight from the table below.

Temperature	**Unit Weight of Water**
Temp °F	**lbs/cu. Ft.**
68	62.315
69	62.308
70	62.301
71	62.293
72	62.285
73	62.277
74	62.269
75	62.261
76	62.252
77	62.243
78	62.234
79	62.225
80	62.216
81	62.206
82	62.196
83	62.186
84	62.176
85	62.166
86	62.155

1.12 Calculate the volume of the mold, in cu. ft., as shown on the calibration form in Figures 5 and 6, and record to the nearest four decimal places.

1.13 Thoroughly clean grease from the mold and base plate. On the mold, record the identification of the mold, the date of calibration, and the volume of the mold.

1.14 Documentation of the calibration data shall be kept on file.

2. REQUIRED DOCUMENTATION

2.1 Record of weights, temperatures, and calculations required in the calibration procedure.

2.2 Identification of mold.

2.3 Date of calibration.

2.4 Volume of the mold.

2.5 Operator performing calibration.

2.6 Supervisor check of calibration data.

2.7 Date of calibration expiration.

ARIZONA DEPARTMENT OF TRANSPORTATION

CALIBRATION OF PROCTOR MOLD
ARIZ 225 Appendix A

✓ Four Inch Mold ______ Six Inch Mold Mold I. D. #: 4A

Calibration Date: 08/15/15 Calibration Expiration Date: 08/15/16

Temperature of water used for Calibration: 73 ° F

Unit Weight of Water: 62.277 lb. /cu. ft.

Test Operator: Joe Tester Supervisor and Date: Joe Supervisor 08/17/15

Weight of Baseplate, Empty Mold, and Glass Plate (grams)	Weight of Baseplate, Mold Filled with Water, and Glass Plate (grams)	Weight of Water to Fill Mold (grams)
4458.7	5407.9	949.2

$$V = \left[\begin{array}{c}\textbf{Volume of}\\ \textbf{Mold}\\ \textbf{(cu. ft.)}\end{array}\right] = \frac{\textbf{Weight of Water to Fill Mold (grams)}}{\left[\begin{array}{c}\textbf{Unit Weight}\\ \textbf{of Water}\\ \textbf{(lb. / cu. ft.}\end{array}\right] \times [\textbf{453.6 (grams / lb.)}]}$$

$$V = \frac{(\quad 949.2 \quad)}{(\quad 62.277 \quad) \times (\quad 453.6 \quad)} = 0.0336 \text{ cu. ft.}$$

0.033601371

REMARKS: ______________________

Unit Weight of Water Table

Temp °F	lbs/cu. Ft.	Temp °F	lbs/cu. Ft.
68	62.315	77	62.243
69	62.308	78	62.234
70	62.301	79	62.225
71	62.293	80	62.216
72	62.285	81	62.206
73	62.277	82	62.196
74	62.269	83	62.186
75	62.261	84	62.176
76	62.252	85	62.166
		86	62.155

FIGURE 5

ADOT Intermodal Transportation

ARIZONA DEPARTMENT OF TRANSPORTATION

CALIBRATION OF PROCTOR MOLD
ARIZ 225 Appendix A

______ Four Inch Mold ______ Six Inch Mold Mold I. D. #: ____________

Calibration Date: ____________ Calibration Expiration Date: ____________

Temperature of water used for Calibration: __________ ° F

Unit Weight of Water: ______________ lb. /cu. ft.

Test Operator: ____________________ Supervisor and Date: ____________________

Weight of Baseplate, Empty Mold, and Glass Plate (grams)	Weight of Baseplate, Mold Filled with Water, and Glass Plate (grams)	Weight of Water to Fill Mold (grams)

$$V = \left[\begin{array}{c}\text{Volume of}\\ \text{Mold}\\ \text{(cu. ft.)}\end{array}\right] = \frac{\text{Weight of Water to Fill Mold (grams)}}{\left[\begin{array}{c}\text{Unit Weight}\\ \text{of Water}\\ \text{(lb. / cu. ft.}\end{array}\right] \times [453.6\ \text{(grams / lb.)}]}$$

$$V = \frac{(\qquad\qquad)}{(\qquad) \times (\qquad)} = \underline{\qquad\qquad} \text{ cu. ft.}$$

REMARKS: ____

Unit Weight of Water Table

Temp °F	lbs/cu. Ft.	Temp °F	lbs/cu. Ft.
68	62.315	77	62.243
69	62.308	78	62.234
70	62.301	79	62.225
71	62.293	80	62.216
72	62.285	81	62.206
73	62.277	82	62.196
74	62.269	83	62.186
75	62.261	84	62.176
76	62.252	85	62.166
		86	62.155

FIGURE 6

ROCK CORRECTION PROCEDURE FOR MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT DETERMINATION

(A Modification of AASHTO Designation T 99 - ANNEX)

1. SCOPE

1.1 This procedure is used to determine the corrected maximum dry density and optimum moisture content for a sample of material when coarse aggregate or rock particles are retained on the No. 4 sieve (for Method A proctor) or 3/4 inch sieve (for Alternate Method D proctor).

1.2 The rock correction procedure shall not be used when the material consists of volcanic cinders or light weight porous material on which the specific gravity cannot be determined with consistency or when the moisture absorption for the coarse aggregate is greater than 4.0%.

1.3 The rock correction procedure shall not be used when the percent rock retained on the No. 4 for Method A is less than 10% or greater than 50% (greater than 60% in the case of an aggregate base material); or when the percent rock retained on the 3/4 inch sieve for Alternate Method D is less than 10% or greater than 40%.

2. NECESSARY INFORMATION

2.1 Refer to, or determine the maximum dry density and optimum moisture content of the material by Method A (Arizona Test Method 225 or 232); or Alternate Method D (Arizona Test Method 245 or 246).

2.2 For Method A, the percentage of rock particles in the sample which are coarser than the No. 4 sieve is recorded as "PR4". For Alternate Method D, the percentage of rock particles in the sample which are coarser than the 3/4 inch sieve is recorded as "PR3/4".

2.3 If not known, determine the bulk oven-dry specific gravity of the coarse aggregate in accordance with AASHTO T 85.

Note: Once determined for a source, the specific gravity may usually be used for all rock corrections on material from that source. Any slight change in specific gravity should not change the maximum dry density to a large extent. (A change of ± 0.02 could result in a change of ± 0.6 lb. per cubic foot.) Similarly, the maximum dry density of the passing No. 4 or passing 3/4 inch material, having been determined by Method A or Alternate Method D for a source, may usually be used for that source providing the sieve analysis of the passing No. 4 or passing 3/4 inch material and the Plasticity Index remain reasonably uniform.

3. ROCK CORRECTED MAXIMUM DRY DENSITY

3.1 The corrected maximum dry density of the total sample for the amount of rock (plus No. 4 for Method A proctor or plus 3/4 inch for Alternate Method D proctor) shall be determined by the following equation:

$$CMD = \frac{\left[(100 - PR) \times (MD)\right] + \left[(56.2) \times (PR) \times (SG)\right]}{100}$$

Where: CMD = Corrected maximum dry density of the total sample containing "PR" percent coarse rock particles, lbs./cu. ft.

PR = "PR4", percent rock retained on the No. 4 sieve for Method A; or "PR3/4" percent rock retained on the 3/4 inch sieve for Alternate Method D.

MD = Maximum dry density (Method A for plus No. 4; or Alternate Method D for plus 3/4 inch), lbs./cu. ft.

SG = Bulk O.D. Specific Gravity of the coarse aggregate.

Example (For Method A):

PR = PR4 = 29% rock retained on the No. 4 sieve.
MD = 114.0 lbs./cu. ft.
SG = 2.499

$$CMD = \frac{\left[(100 - 29) \times (114.0)\right] + \left[(56.2) \times (29) \times (2.499)\right]}{100}$$

$$CMD = \frac{\left[(71) \times (114.0)\right] + \left[4072.9\right]}{100} = \frac{\left[8094.0\right] + \left[4072.9\right]}{100}$$

CMD = 121.7 lbs./cu. ft. [Corrected maximum dry density of the total sample containing 29% rock retained on the No. 4 sieve.]

Example (For Alternate Method D):

PR = PR3/4 = 32% rock retained on the 3/4 inch sieve.
MD = 112.6 lbs./cu. ft.
SG = 2.526

$$CMD = \frac{\left[(100 - 32) \times (112.6)\right] + \left[(56.2) \times (32) \times (2.526)\right]}{100}$$

$$CMD = \frac{\left[(68) \times (112.6)\right] + \left[4542.8\right]}{100} = \frac{\left[7656.8\right] + \left[4542.8\right]}{100}$$

CMD = 122.0 lbs./cu. ft. [Corrected maximum dry density of the total sample containing 32% rock retained on the 3/4 inch sieve.]

4. ROCK CORRECTED OPTIMUM MOISTURE CONTENT

4.1 The rock corrected optimum moisture content of the total sample shall be determined by the following equation:

$$COM = \frac{\left[(OM) \times (100 - PR)\right] + (PR)}{100}$$

Where: COM = Corrected optimum moisture content for the total sample.

OM = optimum moisture content for Pass No. 4 (Method A) or pass 3/4 inch material (Alternate Method D).

PR = "PR4", % rock retained on the No. 4 sieve for Method A; or "PR3/4", % rock retained on the 3/4 inch sieve for Alternate Method D.

Example (For Method A):

OM = 14.3%
PR = PR4 = 29% rock retained on the No. 4 sieve.

$$COM = \frac{\left[(14.3) \times (100 - 29)\right] + (29)}{100}$$

$$COM = \frac{\left[(14.3) \times (71)\right] + (29)}{100} = \frac{(1015.3) + (29)}{100}$$

COM = 10.4% [Corrected optimum moisture content of the total sample containing 29% rock retained on the No. 4 sieve.]

Example (For Alternate Method D):

OM = 15.2%
PR = PR3/4 = 32% rock retained on the 3/4 inch sieve.

$$COM = \frac{\left[(15.2) \times (100 - 32)\right] + (32)}{100}$$

$$COM = \frac{\left[(15.2) \times (68)\right] + (32)}{100} = \frac{(1033.6) + (32)}{100}$$

COM = 10.7% [Corrected optimum moisture content of the total sample containing 32% rock retained on the 3/4 inch sieve.]

5. **USE OF RESULTS**

5.1 The corrected maximum dry density obtained by this method is used, in comparison with the field density of the material, to determine the percentage of compaction.

5.2 The corrected optimum moisture content is used to determine the amount of moisture which should be added to the material to achieve maximum dry density.

6. **REPORT**

6.1 Report the corrected maximum dry density to the nearest 0.1 lb./cu. ft.

6.2 Report the corrected optimum moisture content to the nearest 0.1 percent.

CALIBRATION OF STANDARD SAND AND SAND CONE APPARATUS

(A Modification of AASHTO Designation T 191)

1. SCOPE

1.1 This method of test is to determine a weight per cubic foot of sand to be used in soil density determinations, and the volume of the sand to fill the funnel and baseplate on the sand cone apparatus.

1.2 This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever 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 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 Sand Cone Density Apparatus with Base Plate - A 1 gallon jar and a detachable appliance consisting of a cylindrical valve with an orifice 1/2 inch in diameter and having a small funnel connecting to a standard G mason jar cap on one end and a large funnel on the other end. The valve shall have stops to prevent rotating the valve past the completely open or closed positions. The plate shall have a flanged center hole to receive the large funnel. The apparatus shall conform to the requirements of AASHTO T 191.

2.3 Sand to be standardized, clean, dry, free flowing and uncemented

2.4 Calibrated 1/13.33 (0.0750) cubic foot mold

2.5 Straightedge

2.6 Balance, 20 kg capacity, accurate to 1.0 g, or 35 lb capacity, accurate to 0.01 lb.

3. PROCEDURE

3.1 For determining the density of the sand, the weight of sand to fill the mold is determined as follows:

3.1.1 Fill the jar with the sand to be used and attach the funnel.

3.1.2 Weigh the empty 0.0750 cubic foot mold and baseplate.

3.1.3 Set the mold and baseplate in a flat square pan large enough to catch any excess sand.

3.1.4 Invert the apparatus and set the funnel directly over the mold.

3.1.5 Open the valve and let the sand flow freely into the mold being careful not to jar the apparatus, until the sand ceases to move in the jar. Ensure there are no vibrations in the immediate vicinity.

3.1.6 Close the valve and carefully re-move the apparatus from the mold.

3.1.7 Using the straightedge, strike off the excess sand, being careful not to jar the mold. Work the straightedge in the least number of strokes possible until sand is level with the mold. Tap the side of the mold. Using a brush, clean off excess sand from mold and baseplate, and weigh and record.

3.1.8 Repeat steps 3.1.1 through 3.1.7 twice more.

3.2 For determining the volume of funnel and base plate, the weight of sand to fill the funnel and base plate is determined as follows:

3.2.1 The jar shall now be refilled with the sand, the funnel attached, and the apparatus weighed and recorded.

3.2.2 Place the base plate in the bottom of a level, smooth pan. Ensure that there is not a gap between the baseplate and the bottom of the pan.

3.2.3 Invert the apparatus and place on the base plate in the same manner as the apparatus would be placed over a field density hole.

3.2.4 Open the valve all the way and allow the sand to flow freely, being careful not to jar the apparatus, until the sand ceases to move. Ensure there are no vibrations in the immediate vicinity.

3.2.5 Close the valve and carefully remove the jar and record the weight.

3.2.6 Repeat steps 3.2.1 through 3.2.5 twice more.

4. CALCULATION

4.1 The calculations are as follows. See Figures 2 and 3 for example forms.

4.1.1 Density of Standard Sand (D_s), pcf:

$$D_s = \frac{\text{Average of 3 Weights (grams)}}{\text{(453.6 g/lb) x (volume of mold)}}$$

Example:

Trial No.	Wt. of Baseplate and Mold Filled with Sand (grams)	Wt. of Baseplate and Empty Mold (grams)	Wt. of Sand to Fill Mold (grams)
1	9,436	6,649	2,787
2	9,430	6,649	2,781
3	9,429	6,649	2,780
		Total	8,348

The Average of 3 Weights, determined in accordance with Subsections 3.1.1 through 3.1.8, is:

$$\text{Average of 3 Weights} = \frac{8{,}348}{3} = 2{,}783$$

Using the equation for D_s (shown above this example), the Density of Standard Sand in this example is:

$$D_s = \frac{2{,}783}{(453.6) \times (0.0750)} \quad 81.8 \text{ pcf}$$

4.1.2 Volume of Funnel and Base Plate, cu.ft.:

$$\text{Volume of Funnel and Base Plate (cu.ft.)} = \frac{\text{Average of 3 Weights (grams)}}{(453.6) \times (D_S)}$$

Example:

Trial No.	Initial Wt. of Apparatus (grams)	Final Wt. of Apparatus (grams)	Wt. of Sand to Fill Funnel and Baseplate (grams)
1	6,348	4,870	1,478
2	6,347	4,871	1,476
3	6,345	4,874	1,471
		Total	4,425

The Average of 3 Weights, determined in accordance with Subsections 3.2.1 through 3.2.6, is:

$$\text{Average of 3 Weights} = \frac{4{,}425}{3} = 1{,}475$$

Using the equation for the Volume of Funnel and Base Plate (shown above this example), the Volume of Funnel and Base Plate in this example is:

$$\text{Volume of Funnel and Base Plate (cu.ft.)} = \frac{1{,}475}{(453.6) \times (81.8)} \quad 0.0398 \text{ cu.ft.}$$

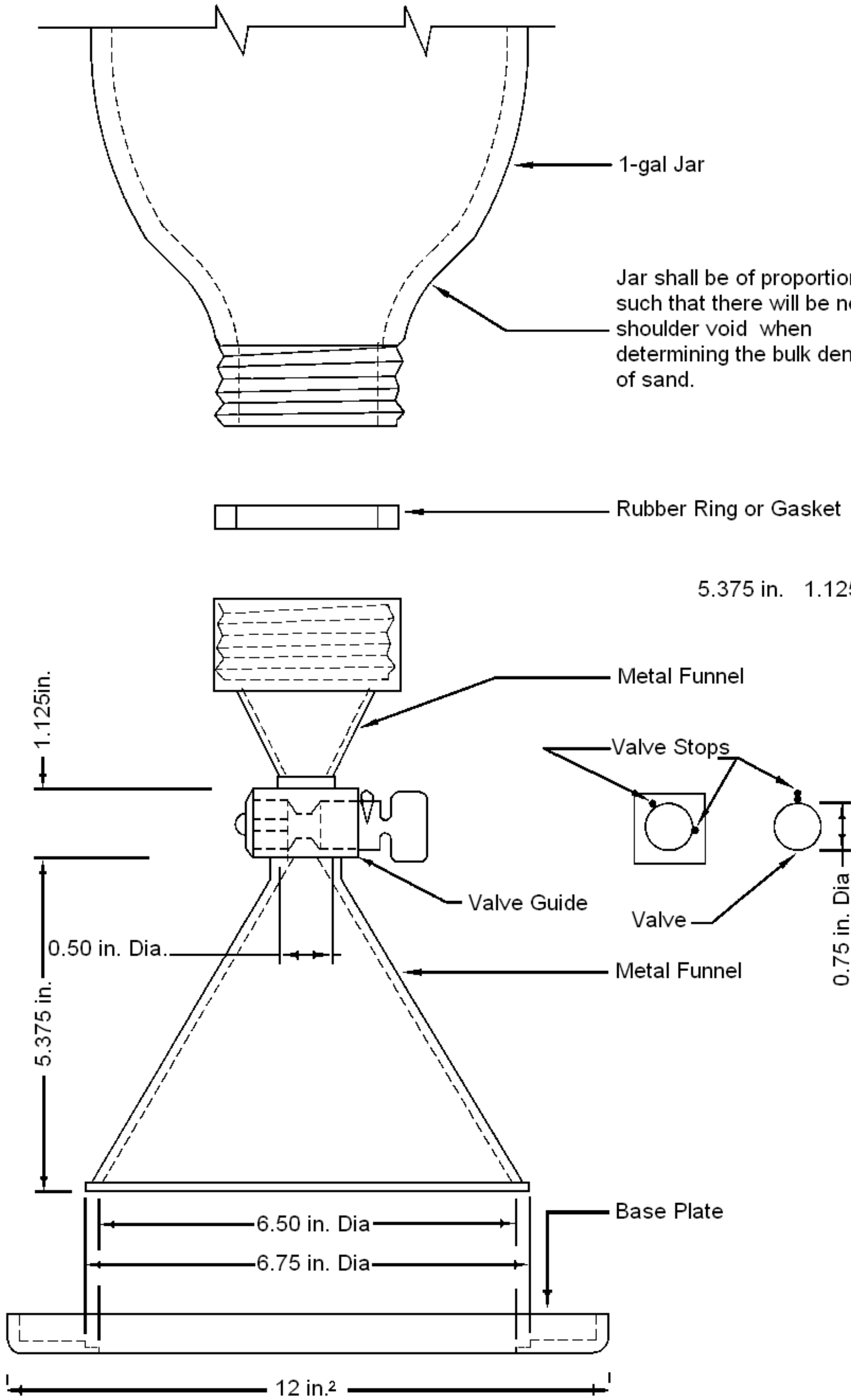

1-gal Jar
Jar shall be of proportions such that there will be no shoulder void when determining the bulk density of sand.
Rubber Ring or Gasket
5.375 in. 1.125in.
Metal Funnel
1.125in.
Valve Stops
Valve Guide
Valve
0.50 in. Dia.
Metal Funnel
0.75 in. Dia
5.375 in.
Base Plate
6.50 in. Dia
6.75 in. Dia
12 in.2

FIGURE 1

CALIBRATION OF DENSITY SAND AND SAND CONE APPARATUS
ARIZ 229
(A Modification of AASHTO T191)

Date of Calibration: ______________ Test Operator: ______________

I. D. No. of Mold used in calibration: ______________

Volume of Mold used in calibration: ______________

Identification of Sand: ______________

Identification of Sand Cone Apparatus: ______________

Trial No.	Wt. of Baseplate and Mold Filled with Sand (grams)	Wt. of Baseplate and Empty Mold (grams)	Wt. of Sand to Fill Mold (grams)
1			
2			
3			

Average Weight of Sand to Fill Mold = ______________ grams

$$\text{Density of Sand, } D_s = \frac{\text{Average Weight of Sand to Fill Mold}}{(453.6 \text{ grams / lb.}) \times (\text{Volume of Mold})}$$

$$D_s = \frac{\qquad\qquad}{(\ 453.6\ ) \times (\qquad\qquad)} = \text{\_\_\_\_\_\_\_\_ lb. /cu. ft.}$$

Trial No.	Initial Wt. of Apparatus (grams)	Final Wt. of Apparatus (grams)	Wt. of Sand to Fill Funnel and Baseplate (grams)
1			
2			
3			

Average Weight of Sand to Fill Funnel and Baseplate = ______________ grams

$$\text{Volume of Funnel and Baseplate, } V_{fb} = \frac{\text{Average Weight of Sand to Fill Funnel and Baseplate}}{(453.6 \text{ grams / lb.}) \times (\text{Density of Sand})}$$

$$V_{fb} = \frac{\qquad\qquad}{(\ 453.6\ ) \times (\qquad\qquad)} = \text{\_\_\_\_\_\_\_\_ cu. ft.}$$

Remarks: ______________

Supervisor and Date: ______________

Calibration Expiration Date: ______________

FIGURE 2

CALIBRATION OF DENSITY SAND AND SAND CONE APPARATUS
ARIZ 229
(A Modification of AASHTO T191)

Date of Calibration: ______________ Test Operator: ______________

I. D. No. of Mold used in calibration: **26**

Volume of Mold used in calibration: **0.0751**

Identification of Sand: ______________

Identification of Sand Cone Apparatus: ______________

Trial No.	Wt. of Baseplate and Mold Filled with Sand (grams)	Wt. of Baseplate and Empty Mold (grams)	Wt. of Sand to Fill Mold (grams)
1	9436	6649	2787
2	9430	6649	2781
3	9429	6649	2780

Average Weight of Sand to Fill Mold = 2783 grams

$$\text{Density of Sand, } D_s = \frac{\text{Average Weight of Sand to Fill Mold}}{(453.6 \text{ grams / lb.}) \times (\text{Volume of Mold})}$$

$$D_s = \frac{2783}{(453.6) \times (\mathit{0.0751})} = 81.7 \text{ lb. /cu. ft.}$$

Trial No.	Initial Wt. of Apparatus (grams)	Final Wt. of Apparatus (grams)	Wt. of Sand to Fill Funnel and Baseplate (grams)
1	6348	4870	1478
2	6347	4871	1476
3	6345	4874	1471

Average Weight of Sand to Fill Funnel and Baseplate = 1475 grams

$$\text{Volume of Funnel and Baseplate, } V_{fb} = \frac{\text{Average Weight of Sand to Fill Funnel and Baseplate}}{(453.6 \text{ grams / lb.}) \times (\text{Density of Sand})}$$

$$V_{fb} = \frac{1475}{(453.6) \times (81.7)} = 0.0398 \text{ cu. ft.}$$

Remarks: ______________

Supervisor and Date: ______________

Calibration Expiration Date: ______________

FIGURE 3

FIELD DENSITY BY THE SAND CONE METHOD

(A Modification of AASHTO Designation T 191)

SCOPE

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

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

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

APPARATUS

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

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

(a) Miscellaneous digging tools.

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

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

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

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

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

PREPARATION OF TEST SITE

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

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

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

PROCEDURE

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

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

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

Where:

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

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

Table 1

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

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

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

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

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

REFERENCE TO METHOD 'A' PROCTOR

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

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

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

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

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

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

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

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

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

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

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

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

CALCULATIONS

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

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

Where:

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

Example:

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

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

$$= 9.36 \text{ lbs}$$

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

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

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

Example:

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

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

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

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

Where:

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

Example:

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

$$= 11.4\ \%$$

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

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

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

Example:

w = 11.4 %
R = 29 %

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

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

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

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

Where:

W_t = weight of total sample, lb.

Example:

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

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

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

Example:

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

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

Example:

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

Percent rock = 29 %

Corrected Maximum Dry Density = 122.0 lb/ cu ft

Note: Compaction shall be reported to the nearest whole percent

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

$$= 99\ \%$$

REFERENCE TO ALTERNATE METHOD ‘D’ PROCTOR

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

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

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

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

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

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

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

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

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

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

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

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

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

CALCULATIONS

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

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

(An Arizona Method)

SCOPE

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

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

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

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

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

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

APPARATUS

2. The apparatus shall consist of the following:

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

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

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

CALIBRATION OF MOLD

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

SAMPLE

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

PROCEDURE

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

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

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

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

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

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

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

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

(e) Remove the material from the mold and slice vertically through the center. Take a representative minimum 300 gram sample from the full length and width of one of the cut faces. Record the weight of wet soil to the nearest 0.1 gram as “WW”. Dry the sample to constant weight at approximately 230° F. and record weight of dry soil to the nearest 0.1 gram as “DW”. The percent moisture shall be recorded to the nearest 0.1 percent. The equation below is used when the percent moisture is determined by drying the sample. For testing performed in the field, the Speedy Moisture Tester (AASHTO T 217), may be used. For the Speedy Moisture Tester, a representative sample of the pass No. 4 material shall be utilized and tested in accordance with the instructional manual for that apparatus.

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

MAXIMUM DENSITY DETERMINATION

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

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

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

EXAMPLE

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

For:

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

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

By interpolation:

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

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

Therefore:

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

Optimum Moisture = 20.3 + 0.7 = 21.0%

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

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

REPORT

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

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

TABLE 1

ONE POINT PROCTOR DENSITY

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

Wet Density Determination

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

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

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

Percent Moisture Determination

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

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

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

For Method A, when Speedie Moisture Tester is used:

% Moisture = ____________________ %

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

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

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

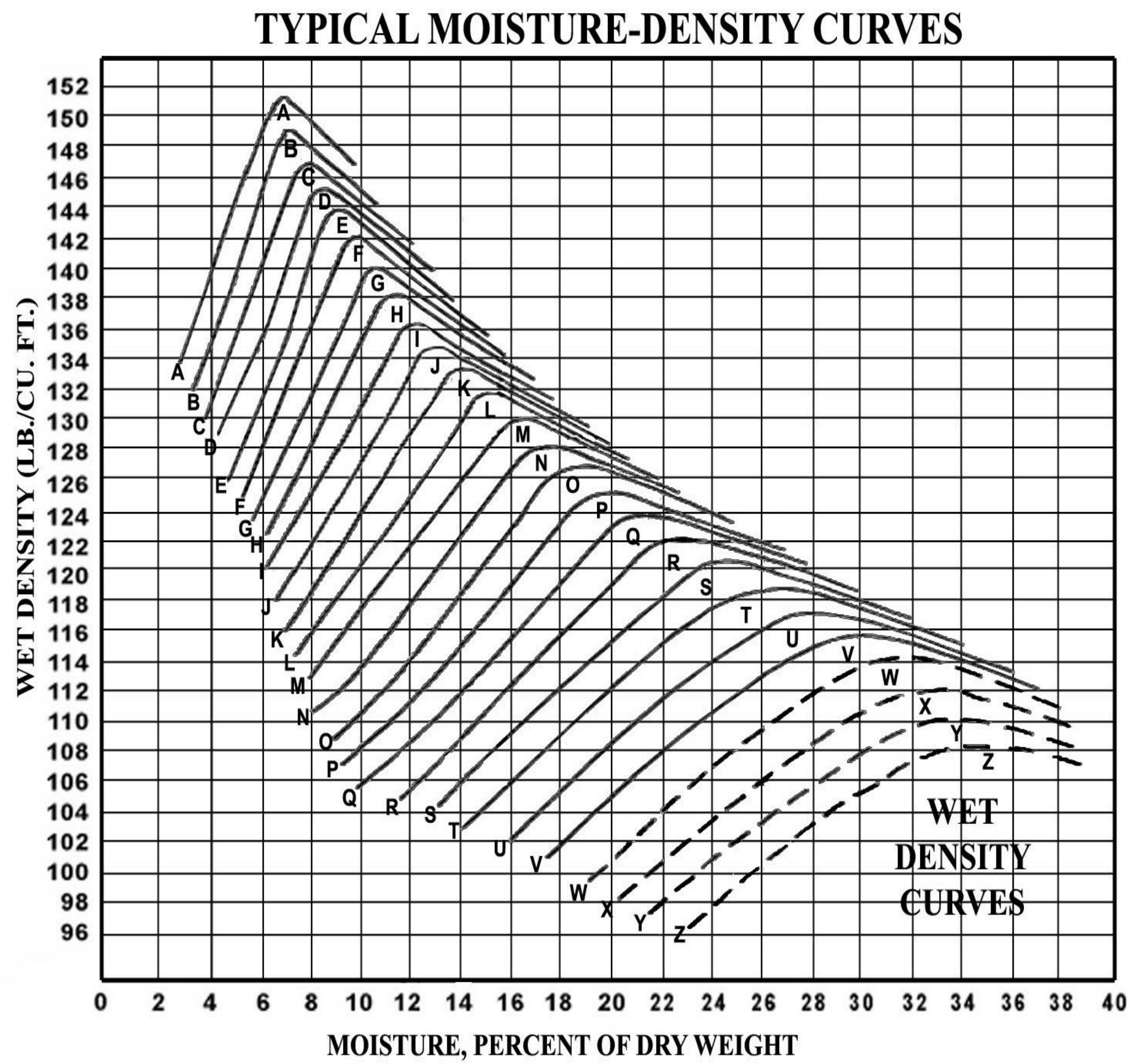
$$\text{Total \% Moisture} = TW = \frac{W(100 - PR4) + PR4}{100} = \_\_\_\_\_\_\_\_\_\_\ \%$$

From Typical Moisture-Density Curves:

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

REMARKS: ____________________

FIGURE 1



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

FIGURE 2

ONE POINT PROCTOR DENSITY

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

Wet Density Determination

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

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

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

Percent Moisture Determination

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

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

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

For Method A, when Speedie Moisture Tester is used:

% Moisture =__________%

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

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

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

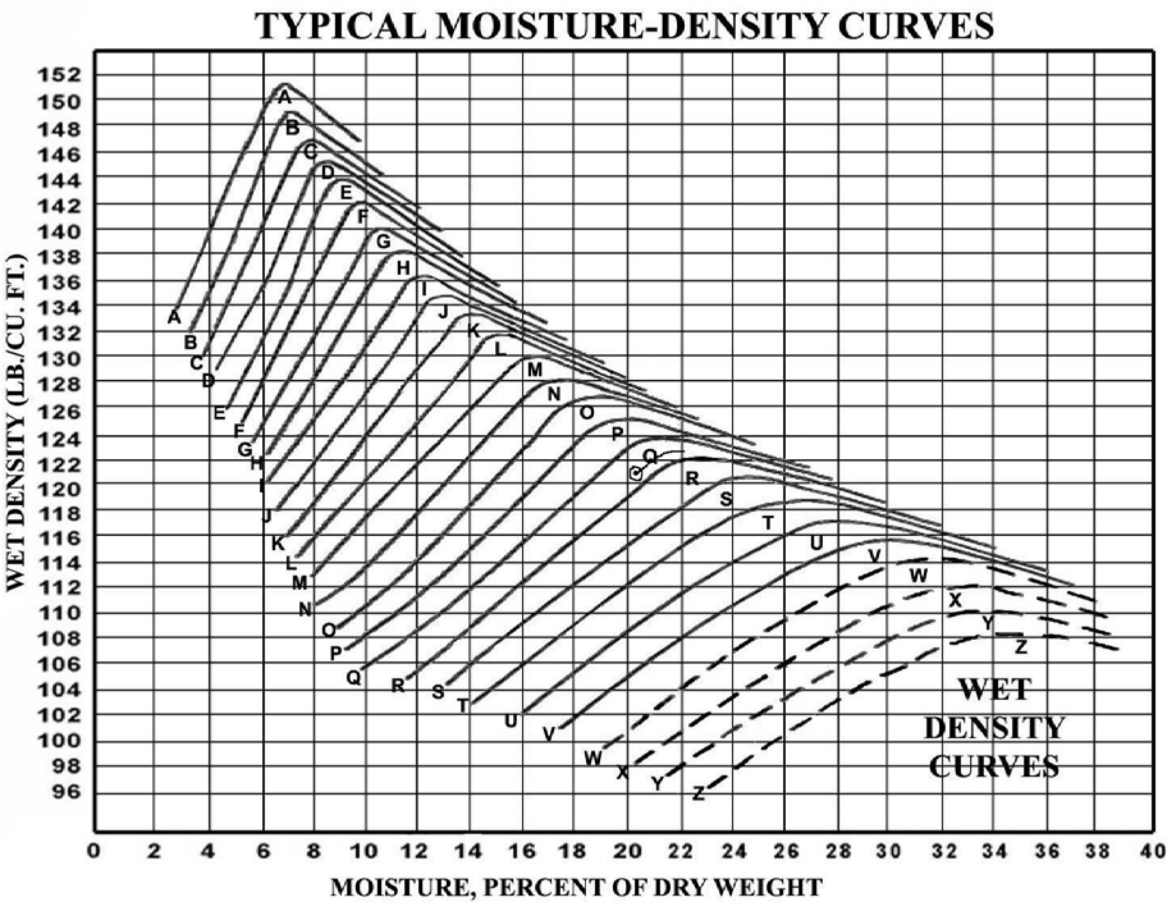
$$\text{Total \% Moisture} = TW = \frac{W(l00 — PR4) + PR4}{100} = \_\_\_\_\_\_ \%$$

From Typical Moisture-Density Curves:

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

REMARKS: __________

FIGURE 3



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

Approx. 60% Below Curve Q

Interpolated Max. Dry Density: 102.4 (Curve Q)
− 99.9 (Curve R)
2.5 X 0.60 = 1.5 lb./cu. ft. 102.4 − 1.5 = **100.9 lb. / cu. ft.**

Interpolated % Optimum Moisture: 21.5 (Curve R)
− 20.3 (Curve Q)
1.2 X 0.60 = 0.7% 20.3 + 0.7 = **21.0%**

FIGURE 4

FIELD DENSITY AND MOISTURE CONTENT OF SOIL AND SOIL-AGGREGATE MIXTURES BY THE NUCLEAR METHOD

(An Arizona Method)

SCOPE

1. (a) This method is used to determine the in-place density and moisture content of compacted soil and soil-aggregate mixtures to a depth of 12 inches with a nuclear gauge. This test method is especially suited for soils of a specified gradation such as aggregate base course, or fine soils of a consistent · nature. Rock correction of the Proctor maximum density requires excavation of the soils at the test site to determine rock content, which increases the time required for the test and decreases test efficiency. This method is acceptable for normal soil and aggregate density testing, including pumping and heaving soils, but should not be used for open-graded aggregate.

(b) An example is provided in Figure 1 for the calculations and determinations referenced herein.

SAFETY

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

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

APPARATUS

3. The apparatus shall consist of the following:

(a) Moisture/Density Nuclear gauge capable of determining densities by the direct transmission method. Calibration of the gauge shall be performed in accordance with AASHTO T238, Subsection 3.1., on an annual basis. Adjustment of the calibration curve for field soil conditions shall be done as needed in accordance with **AASHTO T238,** Subsection **3.3.**

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

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

(d) Charging cord, if applicable.

(e) Scraper plate and drill rod guide.

(f) Drill rod.

(g) Hammer for driving the drill rod to make the hole for the direct transmission probe.

(h) A #10 sieve or a supply of dry, fine-sieved sand to be used as a sand blanket for surface irregularities at the test site and a fine brush for sand removal.

(i) A #4 and 3/4 inch sieve for use in removing plus #4 or plus 3/4 inch material for rock correction, depending upon the proctor method.

(j) A 3 inch sieve for determining the presence of oversize rock material.

(k) Safety goggles for eye protection, steel-toed footwear, and the radiation exposure badge.

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

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

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

3) Applicable documentation necessary to meet requirements of **ARRA** for gauge safety.

4) Blank test forms for use on the applicable nuclear gauge (See Figure 2).

(m) Calculator for necessary computations.

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

GAUGE STABILITY CHECK

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

(a) Place the reference standard block on any asphalt, concrete, compacted aggregate or similar surface which is dry and level. The reference standard block should be at least 24 inches away from any vertical projection, at least 15 feet away from any large object, or vehicle, and at least 50 feet away from another nuclear gauge.

(b) Seat the nuclear gauge on the reference block in accordance with the gaugf3 operation manual. It is very important that the gauge is seated properly on the standard reference block.

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

(d) Turn the gauge on (in standby power condition) and allow it to warm-up, if neccessary, for the recommended time as given in the gauge operation manual, normally 15 minutes.

(e) After the warm-up period, take a standard moisture count and a standard density count.

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

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

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

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

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

SITE PREPARATION

5. (a) Select a location for the field density test at random where the gauge will be at least 24 inches from any vertical projection such as a trench wall, retaining wall or pipe, at least 15 feet away from any vehicle, and at least 50 feet away from another nuclear gauge. If within 24 inches of a vertical projection, refer to section 8, Trench Correction.

(b) Remove an loose, disturbed, and excess material as necessary to reach the top of the compacted lift to be tested. Prepare a horizontal area sufficient in size to accommodate the gauge using the scraper plate supplied with the gauge. Plane the area to a smooth condition removing loose stones to obtain maximum contact between the gauge and the soil or aggregate being tested. Make sure the gauge sits solidly on the test site without rocking.

(c) Use native fines which pass a #-10 sieve, or fine dry sand to fill voids only, and level the excess with the scraper plate. The total area of voids filled with fines or sand should be minimized as much as possible.

OBTAINING NUCLEAR MOISTURE AND DENSITY COUNTS

6. (a) Nuclear Density Counts and Moisture Counts shall be obtained by inserting the probe into the soil at the test site. (Refer to the gauge operation manual.) Prior to density count determination, select the mode of testing as follows based on the lift thickness of the soil or aggregate being tested:

LIFT THICKNESS "T" INCHES	TRANSMISSION MODE
T< 2	Backscatter
2<=T< 4	Direct - 2 inch
4<=T< 6	Direct - 4 inch
6<=T< 8	Direct - 6 inch
8<=T<=12	Direct - 8 inch
12< T	See 6(b) Below

(b) Tests which require the density for a lift greater than 12 inches in thickness require an initial surface test to determine the density of the upper portion of the lift. Then the soil must be excavated downward to allow another test or tests to determine the density of the lower portion of the lift.

(c) To prepare the gauge for direct transmission testing, place the scraper plate drill rod guide on the test site so that the access hole for the probe will be at the desired location.

(d) Securely hold the scraper plate in place while driving the drill rod into the material. The hole should be at least 2 inches deeper than the depth to be tested. Safety goggles and steel-toed footwear should be worn while driving the drill rod. Note the depth marks on the drill rod. It would be desirable to turn the drill rod slightly after every other blow to allow easier removal.

(e) Remove the drill rod by pulling straight up in order to avoid disturbing the access hole.

(f) Remove the scraper plate and clear away all loose surface material. Using fine material as stated previously, fill any voids caused by driving the drill rod.

(g) Carefully place the gauge over the access hole and extend the probe into the hole to the desired direct transmission mode depth according to the lift thickness as outlined previously. <u>Do not</u> force the probe into the hole. If the probe will not extend into the hole, pull the probe back up. Lift up the gauge and check for a probe imprint. This will help determine if a slight change in the position of the gauge is necessary to allow the probe to enter the hole. Once the probe is in the hole, gently push it down. Some minor shifting of the gauge may be required to extend the probe in gravelly soils. However, if an obstruction is encountered, it may be necessary to use the drill rod again to open up the hole.

(h) Once the probe is fully extended to the direct transmission depth, pull the gauge firmly, toward the scaler or readout end of the gauge, so that the probe is in firm contact with the soil or aggregate on the scaler side of the hole.

(i) Take density and moisture counts for a minimum one minute time period by pressing the proper button on the gauge. Both counts normally will occur simultaneously during the count period (Refer to the gauge operation manual).

(j) After the count period, press the proper button to obtain the moisture count. Record the moisture count on the data sheet, as "MC". Also, in a similar manner, obtain the density count. Record the density count on the data sheet, as "DC". It is also possible to get a wet density and moisture content readout in lbs./cu.ft. at this time for gauges capable of storing the standard counts and calculating these values (Refer to the gauge operation manual). If so, obtain these values and record on the test data sheet as "WD" and "M" respectively. The gauge may also be capable of calculating the moisture content in %, "%M", and the dry density in lbs./cu.ft., "DD". If so, these values may be recorded on the test data .sheet. However, the gauge internal calculations may require some additional corrections as required by the test location or soil type. Refer to Sections 8 and 9 for further information on the trench and moisture corrections.

(k) In those instances when the soil or soil-aggregate mixture being tested in-place is not homogeneous and/or contains substantial variations in the rock content, it may be necessary to rotate the gauge 90 degrees at each test site and obtain an additional moisture and wet density reading at that position. If the new moisture and wet density readings differ by 5% or less from the original readings, the two readings may be averaged for use in later calculations. If they differ from the original readings by more than 5%, the gauge should be moved to a new test site.

PROCTOR DENSITY ROCK CORRECTION

7. (a) For determining the percent compaction based on the maximum proctor densities determined by Method A (Arizona Test Method 225 or 232) or Alternate Method D (Arizona Test Method 245 or 246), a rock correction may be

required for the amount of plus No. 4 (Method A) or plus 3/4 inch (Alternate Method D) rock or coarse aggregate in the material tested by the nuclear gauge.

(b) If it appears that 10% of the material will be retained on the No. 4 sieve (Method A) or 3/4 inch sieve (Alternate Method D), excavate the area occupied by the base of the gauge at the testing location to the depth of the test, which is normally the lift thickness. If an average rock correction is to be utilized, refer to 7(f).

(c) Obtain a minimum 3000 gram (7 pound) sample of excavated material and weigh to the nearest gram. Record the weight of this sample as **"A".** Sieve this material first over a 3 inch sieve to determine the presence of any oversize rock material. If any oversize rock is encountered, proceed to 7(d). If not, sieve the material over a No. 4 sieve (Method A) or 3/4 inch sieve (Alternate Method D), and record the weight of retained material as "B". Proceed to 7(e).

(d) If any rock is retained on the 3 inch sieve, this shall be reported with a note stating that the density is not determinable due to rock being retained on the 3 inch sieve. Additional attempts should be made to locate an area where the test can be accomplished.

(e) Calculate the percent of coarse particles, "PR" according to the following equation:

$$PR = \frac{B}{A} \times 100$$

Where: PR = Percent of coarse aggregate or rock particles retained on either the No. 4 sieve for Method A or the 3/4 inch for Alternate Method D.

B = Weight of coarse aggregate or rock particles retained on the No. 4 sieve (Method A) or 3/4 inch sieve (Alternate Method D).

A = . Weight total of sample which is sieved.

(f) If the material has from 10 to 50 percent (10 to 60 percent in the case of an Aggregate Base) retained on the No. 4 sieve (Method A) or 10 to 40 percent retained on the 3/4 inch sieve (Alternate Method D), the maximum proctor density will require a rock correction. Record the data at the appropriate locations on the data sheet.

(g) If the percent retained on the No. 4 sieve or 3/4 inch exceeds the maximum values listed above (50 or 60 percent), report the percent rock with a note stating that the density is not determinable due to excess rock. Additional attempts should be made to locate an area where a test can be accomplished. Also, if the proctor is a Method A proctor, an Alternate Method D proctor may be considered for this material.

Note: When conditions prevent the determination of density at a specific location, due to the presence of excesssive rock or rock retained on the 3 inch sieve, the compactive effort in those areas should be the same as that performed in surrounding locations where the required density was found through testing to be satisfactory.

(h) If, from the results of a minimum of five samples, it is indicated that no rock is retained on the 3 inch sieve and the percent rock retained on the No. 4 or 3/4 inch sieve is within a 12% range (plus or minus 6% from the average), then an average percent of rock based on the five samples may be utilized. However, if a failing density test results from utilization of this average percent of rock, then the test site must be excavated and the actual percent of rock must be determined in accordance with 7(c) and 7(d) above. If there is a visible change in the material including the percent of rock, then a new proctor is required and a new average percent of rock must be determined.

TRENCH CORRECTION

8. (a) Moisture and dry density test results may be affected when a gauge is operated within 24 inches of a vertical projection such as a trench wall, pipe or retaining wall which contains moisture. The density counts, determined in the direct transmission mode, should not be affected, but moisture counts will possibly be affected. Without a trench correction, the moisture content determined could be higher than the actual moisture content which would cause the dry density determined to be too low. If the density test passes without a trench correction, then a trench correction would not be necessary.

(b) When a trench correction is necessary, refer to the gauge operation manual for the proper procedure in making a trench correction. Usually it is necessary that a moisture count be taken on the standard block in the trench at the same position and orientation that the moisture count for the density test is taken.

(c) Based on the original standard moisture count and the moisture count taken on the standard block in the trench, a trench correction may be made internally in most gauges by a calculation process or by an external manual moisture count shift. Refer to gauge operation manual for the proper input of the trench correction. Be sure to delete this correction after each test since each test location would have a different correction.

MOISTURE CORRECTION

9. (a) Moisture and dry density test results may be affected by hydrogen in the soil unrelated to actual moisture. Only the moisture reading is affected. The wet density reading is not affected.

(b) The moisture correction is obtained by determining the difference between the average oven dry moisture contents and the average nuclear gauge moisture contents for five or more samples obtained per paragraph 7(c). The oven-dry moisture content in percent, "TW", will be determined for each representative sample according to AASHTO T265. The sample shall include all plus No. 4 or 3/4 inch material, since the nuclear gauge measures total moisture. If the moisture is determined by the Speedy Moisture Tester and the sample contains material retained on the No. 4 sieve, the "Speedy" results must be adjusted in accordance with the following formula to obtain the percent moisture of the total sample.

$$TW = \frac{[W(100 - PR)] + PR}{100}$$

Where: TW = % moisture content in total sample
W = % moisture in Pass No. 4 material
PR = % rock retained on the No. 4 sieve

(c) A moisture correction is needed if the difference calculated indicates that the gauge moisture results are more than 1% higher or lower than the oven dry or Speedy results. Moisture corrections of 1 % or less may be disregarded.

(d) Most gauges have the capability for correction of the moisture content in % by an internal calculation or an external moisture count shift. Simply apply the moisture correction up or down as applicable in the gauge according to the procedures in the gauge operation manual. Future density calculations within the gauge will apply this moisture count shift until it is deleted by the operator.

MOISTURE-DENSITY CALCULATIONS

1O. Calculations shall be performed as follows:

(a) Record the standard counts for moisture and density on the data sheet in the spaces for "MS" and "DS" respectively.

(b) Most current gauges have the internal capability to calculate the moisture content in lbs./cu.ft. and %, the wet density in lbs./cu.ft., and the dry density in lbs./cu.ft. If so, record "M", "%M", "WD" and "DD" at the appropriate locations on the test data form. Also, list any corrections which have been input into the gauge and apply to these calculations. If it is necessary to use count ratios and calibration tables to determine the moisture content, wet density, and dry density, this should be done in accordance with the procedures in the gauge operation manual. Any data calculated in this manner should also be recorded on the test data sheet at the proper location.

(c) Determine from the correction data obtained in Section 7 whether a rock correction is necessary. If so, determine the rock corrected maximum density using the maximum proctor dry density and percent rock according to the Rock Correction Method, **ARIZ 227.**

(d) The percent of compaction, based on the maximum dry density (corrected, if necessary) is determined and reported to the nearest whole percent.

$$\%\ \text{compaction} = \frac{\textbf{DD x 100}}{\textbf{MD or CMD}}$$

Where: MD = Maximum Proctor Dry Density (if no rock correction)
CMD = Corrected Maximum Density (if rock correction is necessary).

NOTE: If a rock correction is not necessary, many current nuclear gauges have the capability to perform all of the other density and moisture calculations internally, with results shown in the display or output to an external printer or computer. Refer to the gauge operation manual to take advantage of all possible gauge options.

REPORT

10. Record the pertinent moisture and density data on the test form along with the test number, location and other information required. An example is given in Figure **1**. A blank test form is provided in Figure 2.

ARIZONA DEPARTMENT OF TRANSPORTATION
FIELD DENSITY/MOISTURE OF SOILS BY THE NUCLEAR METHOD
ARIZONA TEST METHOD 235

TRACS Number : H099901C
Project Code 88...,B;.JiB:...-
Project Number F-099-9(11)
Contractor 8u/,P M. 6110.D. /11Jc,
Date Jan. 13, 1993
Badge Number 19
Tested By Joe Dogood :;;
Gauge Type 5001
Material Type - Embankment
Gauge Number 1146. -.- -----
Test Number ...:::.22..,.,.-,-------
Proctor Type Method A
Proctor Number _ EM #1
Lift---7----------
Material Source - Inplace
Test Location - SR 51, Sta 97+00, 60' Lt. cl =--------------

STANt>ARD COtllffS

Density Standard (DS) 3239.4
Moisture standard (MS) 415.1

FIELD COOH'1'S

Density Count (DC) 1645.8
Moisture Count (MCj 93.3
Wet Density (WO) 126.7 PCF
Moisture Content (M) 2.7 PCF
Dry Density (DD) 124.0 PCF
Moisture Content (M%) 2.2 I

ROCK CORRECTION [IF NECESSARY] (ARIZ 227)

wet wt. of Material (A) 24.72 lb..
Percent Rock (PR)
Wet Wt. Retained (B) 6.07 lb.
PR • (B/A) x 100 • 25

TRENCH CORRECTION [IF' NBCESSARY]

Trench Moist. stand. (TMS) ____
Trench Correction (TC)
Trench Moist. Count (TMC) -----
TC = TMC - TMS = --------

HOISTtJRE CORRECTION [IF' NBCESSARY

Moisture Correction ____,
Input into gauge [YES/NO] ____

PROCTOR DATA (ARIZ 225 or 245)

Max. Dry Density (MD) 121.0 PCF
Optimum **Moisture** 11.5 %
Coarse Agg. Sp. Gr. (SG) 2.609
Proctor t Rock Retained 43 %
Corrected Maximum Dry Density (CMD) (For Rock correction]:

$$CMD \bullet \frac{[(100 - PR) \times (MD)] + ((S6.2) \times (PR) \times (SG)]}{100} = 127.4 \text{ PCF}$$

ONE POINT PROCTOR DATA (ARIZ 232 or 246)

Wt. of Mold and soil (Ml) ____ lb
Wt. of Mold (M2) ____ lb
Mold Volume (VM) ·- ____ CF
Wet Density (Ml-M2)/VM ____ PCF
Moisture Content ____ t
Density eurve I.D. ____ ~~PCF~~
Max. Dry Density (MD) ____ PCF
corr. Max. Dry Dens. (CMD)

COHPACTXOB COJOLilUJCB CALCm.ATXOB

Required Compaction 95" I
Percent Compaction •
Pass y Fail ------
(DD X 100)/MD or CMD - 97

Remarks:--------------------------------

Lab Supervisor Ted Hedman
.....: Date 1-13-93

ARIZONA DEPARTHEN'l' OP TR.AllSPORTATIOH
FIELD DENSITY/MOISTtJRE OP SOILS BY TI:IE NOCLEAR METHOD
ARIZONA TEST KETI:100 235

TRACS Number ___ __ ____ ___
Project Number ________________________
Contractor _________________
Date __________________________
Badge Number _________________
Tested By ____________________________
Gauge Type _________________
Gauge Number _______
Test Number ____________________
Material Type
Proctor Type _____________
Proctor Number __________________________
Lift ------------------
Material Source ------------------------------------
Test Location ------------------------------------

STANI>ARO COtnrl'S

Density Standard (OS) _________________
Moisture standard (MS) _______________

FIELD COtnrl'S

Density Count (DC) _________________ PCF
Moisture count (MC) _____________ PCF
Wet Density (WD) _________________ PCF
Moisture content (M) _____________ %
Dry Density (DD) PCF
Moisture Content (M%)

ROCK COMECTIOH [IP' HECESSARY] (ARIZ 227)

Wet Wt. of Material **(A)** _____________
Percent Rock (PR)
Wet Wt. Retained (B) _____________
PR • (B/A) x 100 • _____________

TRENCJI COMECTIOH [IJ' NECESSARY]

Trench Moist. stand. (TMS) ___________
Trench Correction (TC)
Trench Moist. Count (TMC) ___________
TC •TMC - TMS• ___________

HOISTtJRE COMECTIOH [IJ' HECESSARY]

Moisture correction _________________ % Input into gauge [YES/NO] ___________

PROCTOR DATA (ARIZ 225 or 245)

Max. Dry Density (MD) _________.PCF Optimum Moisture %
coarse Agg. Sp. Gr. (SG) ------ Proctor t Rock Retained _____________ %
Corrected Maximum Dry Density (CMD) (For Rock Correction]:

[(100 - **PR) X** (MD)]+ **[(56.2) X (PR) X (SG)]**
CMD• ------------------------ = ___________ PCF
100

on POINT PROCTOR DATA (Alt.II 232 or 24G)

Wt. of Mold and Soil (Ml) __________ 11:>.
Wt. of Mold (M2) lb
Mold Volume (VM) __________ CF
Wet Density (Ml-M2)/VM ____________, PCF
Moisture Content __________ %
Density eurve I.D. ______________
Max•. Dry Density (MD) _________.PCF
corr. Max. Dry Dens. (CMD) ____ .PCF

COHPACTIOH COHPLIAHCB CALCUUTIOH

Required Compaction _____________,
Percent Compaction•
Pass _______________ Fail _______________
(DD x 100)/MD or CMD• ____ _

Remarks: ____
____
____

Lab supervisor ____ Date ______________

"-1001 10'82

FIGURE 2

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

(An Arizona Method)

1. SCOPE

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

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

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

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

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

1.6 This test method may involve hazardous materials, 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 who ever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPARATUS

2.1 The apparatus shall consist of the following:

2.1.1 The apparatus utilized for this test method shall conform to the apparatus requirements of Arizona Test Method 245.

2.1.1.1 Instead of the 230 ± 9 °F oven, a hot plate or stove capable of maintaining a temperature of approximately 230 °F may be used. A Speedy Moisture Tester with a conversion table or calibration curve may also be used for moisture determinations made in the field. Finally, a microwave oven may be used in accordance with Arizona Test Method 719.

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

3. CALIBRATION OF MOLD

3.1 Molds shall be calibrated in accordance with APPENDIX A of Arizona Test Method 225.

4. SAMPLE

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

5. PROCEDURE

5.1 If the Speedy Moisture Tester is <u>not</u> to be used in making the moisture content determination, proceed to Subsection 5.4.

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

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

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

5.3 Recombine and thoroughly blend the plus No. 4 material with the passing No. 4 material.

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

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

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

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

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

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

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

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

5.8 The moisture content of the sample is determined either by drying (See Subsection 5.9); or, when testing is performed in the field, the Speedy Moisture Tester may be used (See Subsection 5.10).

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

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

Where: WW = Wet weight of moisture sample.
DW = Dry weight of moisture sample.

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

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

Where: TW = % moisture in pass 3/4 material.
W = % moisture in pass No. 4 material (determined by Speedy).
PR4 = % rock retained on the No. 4 sieve (determined in Subsection 5.2).

6. MAXIMUM DENSITY DETERMINATION

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

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

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

7. EXAMPLE

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

For:

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

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

By interpolation:

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

Moisture: 20.3- 19.2 = 1.1
0.20 X 1.1 = 0.2% difference

Therefore:

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

Optimum Moisture = 19.2 + 0.2 = 19.4%

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

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

8. REPORT

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

TYPICAL MOISTURE-DENSITY TABLE

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

TABLE 1

ONE POINT PROCTOR DENSITY

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

Wet Density Determination

Volume of Mold = VM = __________ cu. ft.
Weight of Mold = M2 = __________ grams __________ pounds
Weight of Sample and Mold = M1 = __________ grams __________ pounds

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

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

Percent Moisture Determination

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

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

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

For Method A, when Speedie Moisture Tester is used:

% Moisture = __________ %

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

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

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

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

From Typical Moisture-Density Curves:

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

REMARKS: __________

FIGURE 1

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

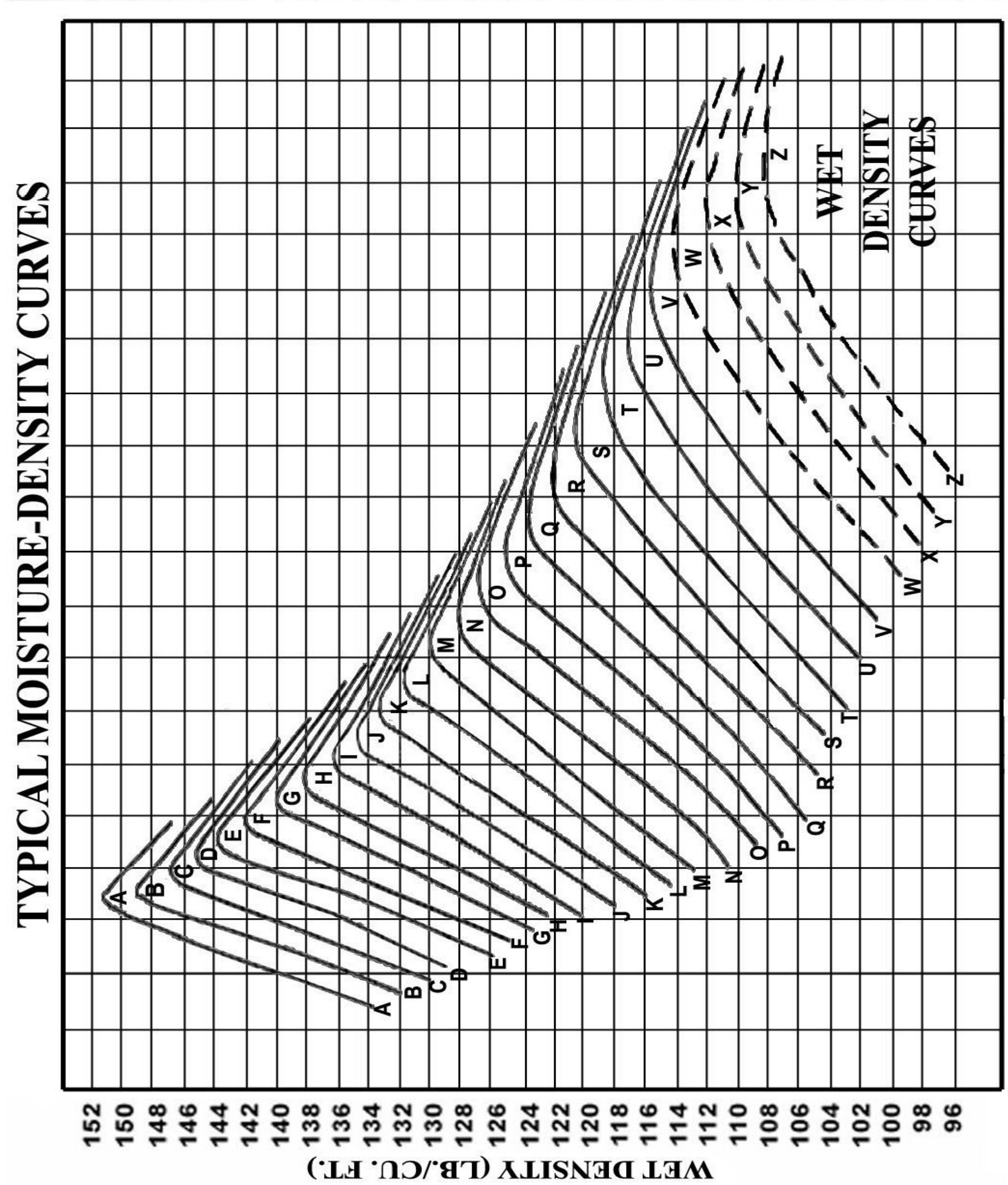


FIGURE 2

ONE POINT PROCTOR DENSITY

Lab. No:__________ Org No.:__________ Date:__________

Project No.__________ TRACS No. __________

Original Source:__________ Type of Material:__________

Coarse Agg. % Absorp.:__________ Coarse Agg. Bulk O.D. Sp. Gr.: __________

Proctor Method Used: Method A__________ Alternate Method D **X**

Test Operator:__________ Date:__________

Supervisor:__________ Date: __________

Wet Density Determination

Volume of Mold = VM = **0.0758** cu. ft.

Weight of Mold = M2 = **6608** grams__________pounds

Weight of Sample and Mold = M1 = **10820** grams__________pounds

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

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

Percent Moisture Determination

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

Wet Weight of Moisture Sample = WW =__________grams

Dry Weight of Moisture Sample = DW =__________grams

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

For Method A, when Speedie Moisture Tester is used:

% Moisture =__________%

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

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

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

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

From Typical Moisture-Density Curves:

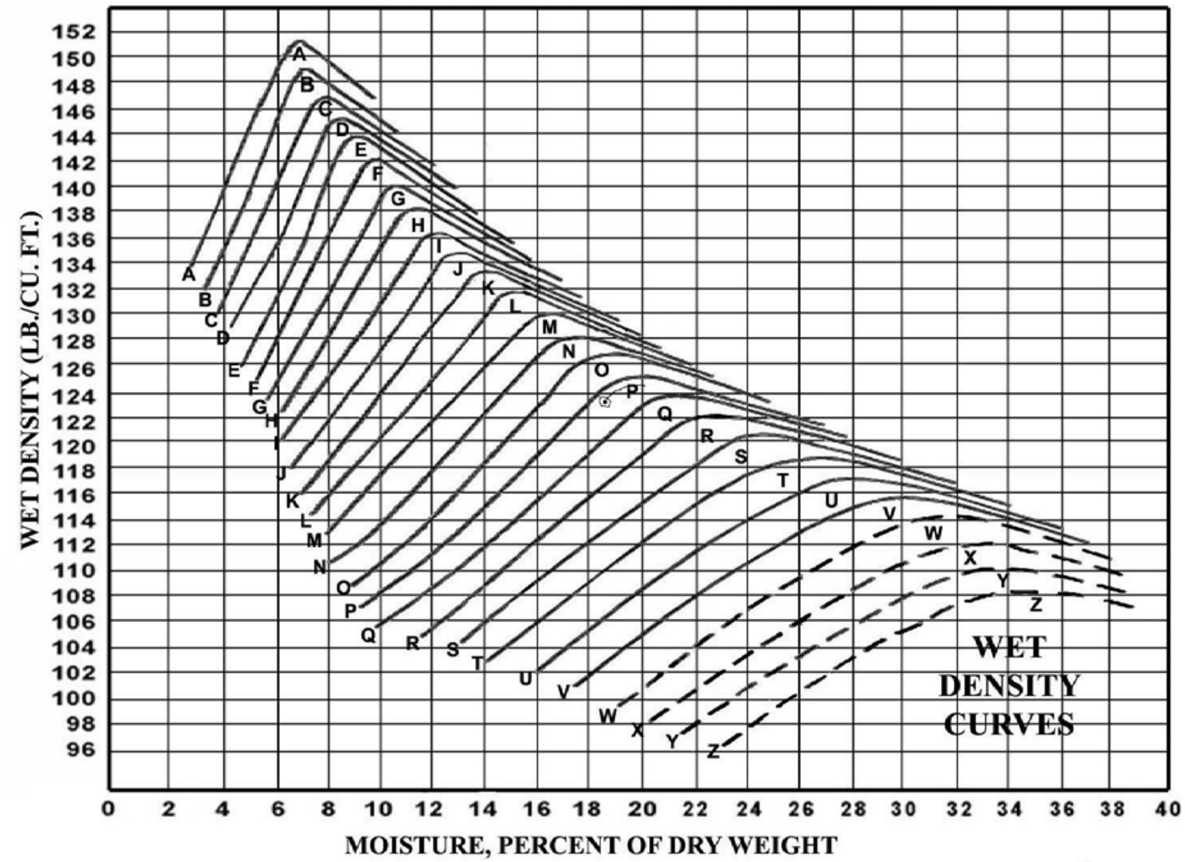
Maximum Dry Density = MD = **104.2** lb./cu. ft.

Percent Optimum Moisture = OM = **19.4** %

REMARKS: __________

FIGURE 3

TYPICAL MOISTURE-DENSITY CURVES



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

Approx. 20% Below Curve P

Interpolated Max. Dry Density: 104.7 (Curve P)
- 102.4 (Curve Q)
2.3 X 0.20 = 0.5 lb./cu. ft.   *104.7 - 0.5 = 104.2 lb. / cu. ft.*

Interpolated % Optimum Moisture: 20.3 (Curve Q)
- 19.2 (Curve P)
1.1 X 0.20 = 0.2%   *19.2 + 0.2 = 19.4%*

FIGURE 4

ARIZ 412b
November 14, 2008
(4 Pages)

DENSITY OF COMPACTED BITUMINOUS MIXTURES - NUCLEAR METHOD

(An Arizona Method)

SCOPE

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

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

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

APPARATUS

2. The apparatus shall consist of the following:

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

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

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

(d) Charging cord, if applicable.

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

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

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

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

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

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

(k) Calculator for necessary computations.

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

GAUGE STABILITY CHECK

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

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

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

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

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

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

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

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

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

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

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

PROCEDURE

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

(b) Normally the preparation of the surface for taking readings at each location shall not include the removal of any material for the purpose of making it more smooth, except that particles which are completely unattached and merely lying loose on top of the compacted and bound mixture shall be brushed away. Not more than one pound of dry fine sand (minus #10 material) shall be spread over each location and then scraped away with a straightedge so that the mixture is visible over the majority of the surface.

PRECAUTIONS

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

Standard Practice for

Reducing Samples of Aggregate to Testing Size

AASHTO Designation: R 76-16[1, 2]
Release: Group 3 (August 2016)
ASTM Designation: C702/C702M-11

AASHTO

1. SCOPE

1.1. These methods cover the reduction of large samples of aggregate to the appropriate size for testing, employing techniques that are intended to minimize variations in measured characteristics between the test samples so selected and the large sample.

1.2. The values stated in SI units are to be regarded as the standard.

1.3. *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 procedure to establish appropriate safety and health practices and to determine the applicability of regulat01y limitations prior to its use.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards:*
- T 2, Sampling of Aggregates
- T 84, Specific Gravity and Absorption ofPine Aggregate

2.2. *ASTMStandard:*
- Cl25, Standard Terminology Relating to Concrete and Concrete Aggregates

3. TERMINOLOGY

3.1. *Definitions_the* terms used in this standard are defined in ASTM Cl 25.

4. SIGNIFICANCE AND USE

4.1. Specifications for aggregates require sampling pmiions of the material for testing. Other factors being equal, larger samples will tend to be more representative of the total supply. The methods described in this standard provide for reducing the large sample obtained in the field or produced in the laboratory to a convenient size for conducting a number of tests to describe the material and measure its quality. These methods are conducted in such a manner that the smaller test sample portion will be representative of the larger sample and, thus, of the total supply. The individual test methods provide for minimum masses of material to be tested.

4.2. Under certain circumstances, reduction in size of the large sample prior to testing is not recommended. Substantial differences between the selected test samples sometimes cannot be avoided, as, for example, in the case ofan aggregate having relatively few large-sized patiicles in the sample. The laws ofchance dictate thatthese few particles may be unequally distributed among the reduced-size test samples. Similarly, ifthe test sample is being examined for cetiain contaminants occurring as a few discrete fragments in only small percentages, caution should be used in interpreting results from the reduced-size test sample. Chance inclusion or exclusion of only one ortwo patiicles in the selected test sample may impotiantly influence interpretation ofthe characteristics ofthe original sample. In these cases, the entire original sample should be tested.

4.3. Failure to carefully follow the procedures in these methods could result in providing a nonrepresentative sample to be used in subsequent testing.

5. SELECTION OF METHOD

5.1. *Fine* Aggregate-Samples of fine aggregate that are drier than the saturated surface-dry condition (Note I) shall be reduced in size by a mechanical splitter according to Method A. Samples having free moisture on the particle surfaces may be reduced in size by quartering according to Method B, or by treating as a miniature stockpile as described in Method C.

5.1.1. If the use ofMethod B orMethod C is desired, and the sample does not have free moisture on the particle surfaces, the sample may be moistened to achieve this condition, thoroughly mixed, and then the sample reduction perfo1med.

Note 1 The method ofdetermining the saturated surface-dry condition is described inT 84. As a quick approximation, ifthe fine aggregate will retain its shape when molded in the hand, it may be considered to be wetter than saturated surface-dry.

5.1.2. Ifuse ofMethod A is desired and the sample has free moisture on the patiicle surfaces, the entire sample may be dried to at least the surface-dry condition, using temperatures that do not exceed those specified for any ofthe tests contemplated, and then the sample reduction performed. Alternatively, if the moist sample is very large, a preliminary split may be made using a mechanical splitter having wide chute openings 38 mm (1 $^1/_2$ in.) or more to reduce the sample to not less than 5000 g. The pmiion so obtained is then dried, and reduction to test sample size is completed using Method A.

5.2. *Coarse Aggregates Reduce* the sample using a mechanical splitter in accordance with Method A (preferred method) or by quartering in accordance with Method B. The miniature stockpile Method C is not permitted for coarse aggregates or mixtures ofcoarse and fine aggregates.

5.3. *Combined Coarse andFine* Aggregate-Samples that are in a dry condition may be reduced in size by either Method A or Method B. Samples having free moisture on the patiicle surfaces may be reduced in size by quartering according to Method B. When Method A is desired and the sample is damp or shows free water, dry the sample until it appears dry or until clumps can be easily broken by hand (Note 2). Dry the entire sample to this condition, using temperatures that do not exceed those specified for any ofthe tests contemplated, and then reduce the sample. The miniature stockpile Method C is not permitted for combined aggregates.

Note 2-The dryness ofthe sample can be tested by tightly squeezing a small portion ofthe sample in the palm ofthe hand. Ifthe cast crumbles readily, the correct moisture range has been obtained.

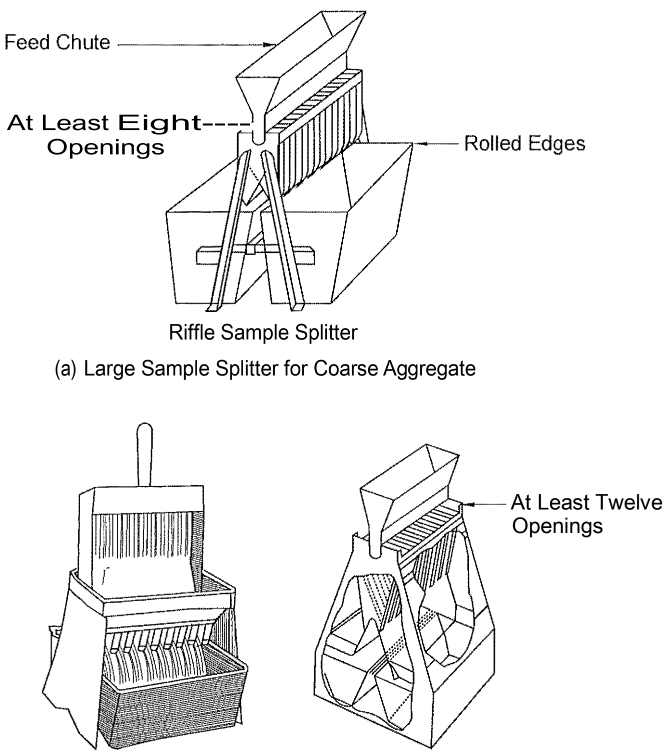
6. SAMPLING

6.1. The samples ofaggregate obtained in the field shall be taken in accordance withT 2, or as required by individual test methods. When tests for sieve analysis only are contemplated, the size of field sample listed in T2 is usually adequate. When additional tests are to be conducted, the user shall determine that the initial size of the field sample is adequate to accomplish all intended tests. Similar procedures shall be used for aggregate produced in the laboratory.

METHOD A-MECHANICAL SPLITTER

7. APPARATUS

7.1. *Sample Splitter-Sample* splitters shall have an even number of equal-width chutes, but not less than a total of eight for coarse aggregate, or twelve for fine aggregate, which discharge alternatively to each side of the splitter. For coarse aggregate and mixed aggregate, the minimum width of the individual chutes shall be approximately 50 percent larger than the largest particles in the sample to be split (Note 3). For dry fine aggregate in which the entire sample will pass the 9.5-mm ($^3 1_8$-in.) sieve, the minimum width of the individual chutes shall be at least 50 percent larger than the largest paiiicles in the sample and the maximum width shall be 19 mm ($^3/_4$ in.). The splitter shall be equipped with two receptacles to hold the two halves of the sample following splitting. It shall also be equipped with a hopper or straightedged pan, which has a width equal to or slightly less than the overall width of the assembly of chutes, by which the sample may be fed at a controlled rate to the chutes. The splitter and accessory equipment shall be so designed that the sample will flow smoothly without restriction or loss of material (see Figure I).



(a) Large Sample Splitter for Coarse Aggregate

(b) Small Sample Splitters for Fine Aggregate

Note: (a) may be constructed as either closed or open type. Closed type is prefen-ed.

Figure 1-Sample Splitters (Riffles)

Note 3-Mechanical splitters are commonly available in sizes adequate for coarse aggregate having the largest particle not over 37.5 mm (1 $^1/_2$ in.).

8. PROCEDURE

8.1. Place the original sample in the hopper or pan and uniformly distribute it from edge to edge, so that when it is introduced into the chutes, approximately equal amounts will flow through each chute. The rate at which the sample is introduced shall be such as to allow free flowing through the chutes into the receptacles below.

8.2. Reintroduce the portion of the sample in one of the receptacles into the splitter as many times as necessary to reduce the sample to the size specified for the intended test. The po1iion of the material collected in the other receptacle may be reserved for reduction in size for other tests.

METHOD 8-QUARTERING

9. APPARATUS

9.1. Apparatus shall consist of a straightedge; straightedged scoop, shovel or trowel; a broom or brush; and a canvas blanket or tear-resistant tarp approximately 2 by 2.5 m (6 by 8 ft).

10. PROCEDURE

10.1. Use either the procedure described in Section 10.1.1 or 10.1.2, or a combination of both.

10.1.1. Place the original sample on a hard, clean, level surface where there will be neither loss of material nor the accidental addition of foreign material. Mix the material by turning the entire sample over at least three times until the material is thoroughly mixed. With the last turning, form the entire sample into a conical pile by depositing individual lifts on top of the preceding lift. Carefully flatten the conical pile to a uniform thickness and diameter by pressing down the apex with a shovel or trowel so that each quarter sector of the resulting pile will contain the material originally in it. The diameter should be approximately four to eight times the thickness. Divide the flattened mass into four equal quarters with a shovel or trowel and remove two diagonally opposite quarters, including all fine material, and brush the cleared spaces clean. The two unused quarters may be set aside for later use or testing, if desired. Successively mix and quarter the remaining material until the sample is reduced to the desired size (see Figure 2).

10.1.2. As an alternative to the procedure in Section 10.1.1 or when the floor surface is uneven, the field sample may be placed on a canvas blanket or tear-resistant tarp and mixed with a shovel or trowel as described in Section 10.1.1, leaving the sample in a conical pile. As an alternative to mixing with the shovel or trowel, lift each corner of the blanket or tarp and pull it over the sample toward the diagonally opposite corner, causing the material to be rolled. After the material has been rolled a sufficient number of times (a minimum of four times), so that it is thoroughly mixed, pull each corner of the blanket or tarp toward the center of the pile so the material will be left in a conical pile. Flatten the pile as described in Section 10.1.1. Divide the sample as described in Section 10.1.1, or insert a stick or pipe beneath the blanket or tarp and under the center of the pile, then lift both ends of the stick, dividing the sample into two equal parts. Remove the stick, leaving a fold of the blanket between the divided portions. Insert the stick under the center of the pile at right angles to the first division and again lift both ends of the stick, dividing the sample into four equal parts. Remove two diagonally opposite quarters, being careful to clean the fines from the blanket or tarp. The two unused quarters may be set aside for later use or testing, if desired. Successively mix and quarter the remaining material until the sample is reduced to the desired size (see Figure 3).

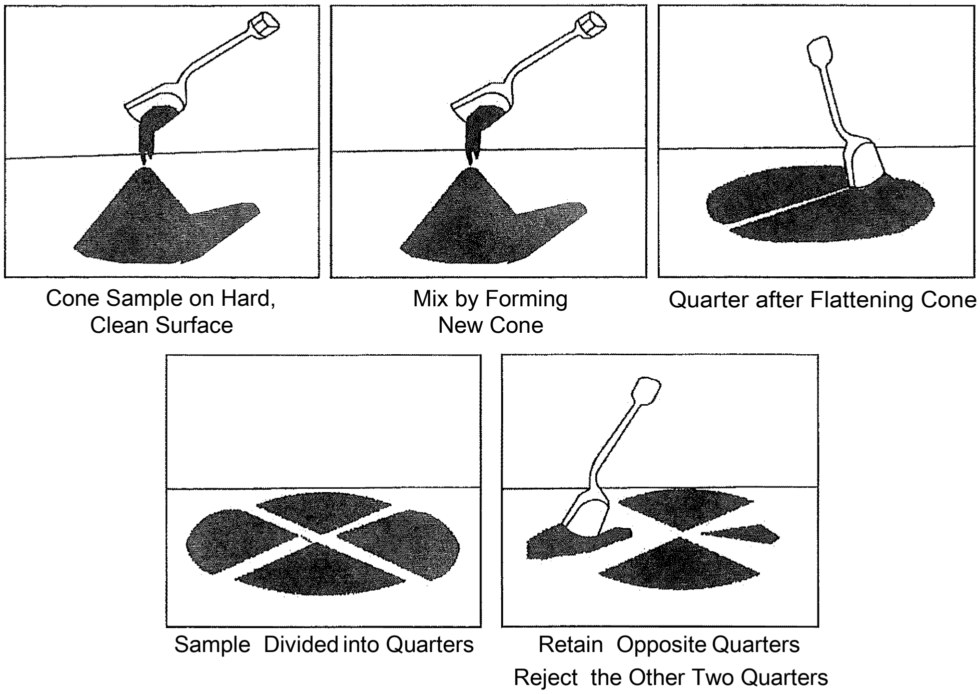


Figure 2-Quartering on a Hard, Clean, Level Surface

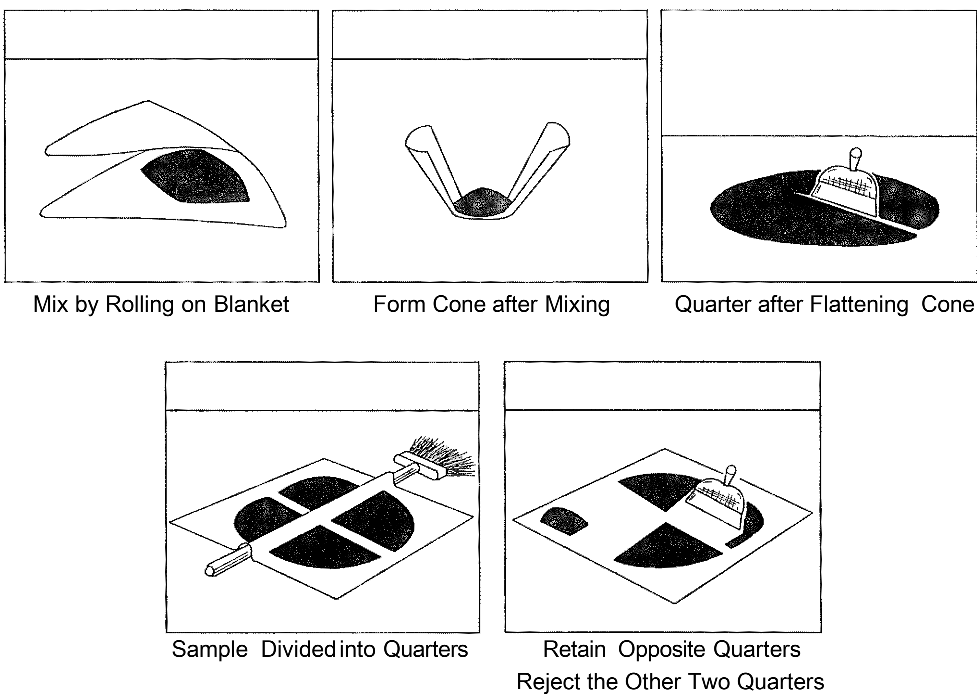


Figure 3-Quartering on a Canvas Blanket or Tear-Resistant Tarp

METHOD C—MINIATURE STOCKPILE SAMPLING (DAMP FINE AGGREGATE ONLY)

11. APPARATUS

11.1. Apparatus shall consist of a straightedge; straightedged scoop, shovel, or trowel for mixing the aggregate; and either a small sampling thief, small scoop, or spoon for sampling.

12. PROCEDURE

12.1. Place the original sample of damp fine aggregate on a hard, clean, level surface where there will be neither loss of material nor the accidental addition of foreign material. Mix the material by turning the entire sample over at least three times until the material is thoroughly mixed. With the last turning, form the entire sample into a conical pile by depositing individual lifts on top of the preceding lift. If desired, the conical pile may be flattened to a uniform thickness and diameter by pressing the apex with a shovel or trowel so that each quarter sector of the resulting pile will contain the material originally in it. Obtain a sample for each test by selecting at least five increments of material at random locations f'om the miniature stockpile, using any of the sampling devices described in Section I1.1.

13. KEYWORDS

13.1. Aggregate; aggregate sample; mechanical splitter; quartering.

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[1] Technically equivalent but not identical to ASTM C702/C702M-11.
[2] Formerly T 248. First published as a practice in 2016.

Standard Method of Test for

Determination of Moisture in Soils by Means of a Calcium Carbide Gas Pressure Moisture Tester

AASHTO Designation: T 217-14

1. SCOPE

1.1. This test method is intended to determine the moisture content of soils by means of a calcium carbide gas pressure moisture tester. The manufacturer's instructions shall be followed for the proper use of the equipment.

1.2. The following applies to all specified limits in this standard: For the purposes of determining conformance with these specifications, an observed value or a calculated value shall be rounded off "to the nearest unit" in the last right-hand place of figures used in expressing the limiting value, in accordance with ASTM E 29.

Note 1- This method shall not be used on granular materials having particles large enough to affect the accuracy of the test- in general any appreciable amount retained on a 4.75-mm sieve. The super 200 D tester is intended to be used to test aggregate.

1.3. The values stated in SI units are to be regarded as the standard.

1.4. Refer to R 16 for regulatory information for chemicals.

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards:*
- M 231, Weighing Devices Used in the Testing of Materials
- R 16, Regulatory Information for Chemicals Used in AASHTO Tests
- *T* 265, Laborato1y Determination of Moisture Content of Soils

2.2. *ASTM Standard:*
- E 29, Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

3. APPARATUS

3.1. *Calcium Carbide Pressure Moisture Tester- A* chamber with attached pressure gauge for the water content of specimens having a mass of at least 20 g (Figure 1).

3.2. *Balance- Shall* conform to M 231, Class G 2.

3.3. *Steel Balls-Two* 31.75-mm (1.25-in.) steel balls.

3.4. *Cleaning brush* and *cloth.*

3.5. *Scoop- For* measuring calcium carbide reagent.

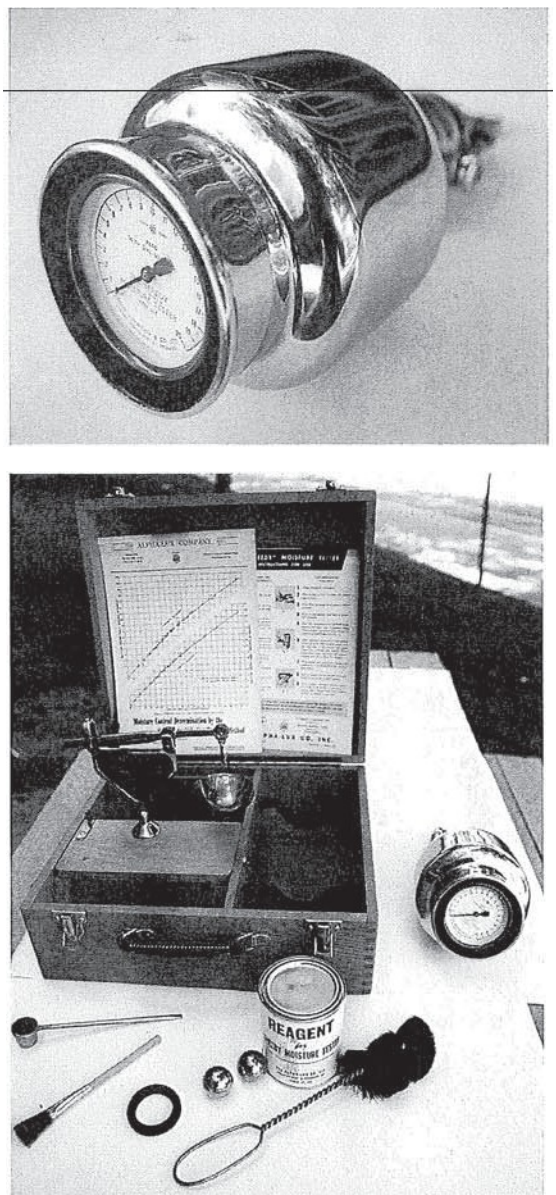

Figure 1- Calcium Carbide Gas Pressure Moisture Meter

4. MATERIAL

4.1. *Calcium carbide reagent.*

Note 2- The calcium carbide must be finely pulverized and should be of a grade capable of producing acetylene gas in the amount of at least 0.14 m^3/kg (2.25 ft^3/lb) of carbide.

Note 3- The shelf life of the calcium carbide reagent is limited, so it should be used according to the manufacturer's recommendations.

5. PROCEDURE

5.1. When using the 20- or 26-g tester, place three scoops (approximately 24 g) of calcium carbide in the cap of the moisture tester. When using the super 200 D tester to test aggregate, place six scoops (approximately 48 g) of calcium carbide in the cap of the moisture tester.

Note 4-Care must be exercised to prevent the calcium carbide from coming into direct contact with water.

5.2. Weigh a sample of the exact mass specified by the manufacturer using the balance included with the instrument, and place the sample in the body of the tester and the calcium carbide reagent in the cap. Alternatively, the reagent may be placed in the body and the sample in the cap to facilitate cleanup after the test. When using the 20- or 26-g-sized tester, place two 31.75-mm (I.25-in.) steel balls in the body of the tester with the sample.

Note 5-The procedure for placing the soil specimen and calcium carbide reagent into the tester should be in accordance with Sections 5.1 and 5.2 or the manufacturer's instructions.

Note 6-Manufacturer's instructions shall be followed for the use of steel balls, particularly when testing sand.

Note 7- If the moisture content of the sample exceeds the limit of the pressure gauge (12 percent moisture for aggregate tester or 20 percent moisture for soil tester), a one-half size sample must be used and the dial reading must be multiplied by 2. This proportional method is not directly applicable to the dry mass percent scale on the super 200 D tester.

5.3. With the pressure vessel in an approximately horizontal position, insert the cap in the pressure vessel and seal the unit by tightening the clamp, taking care that no carbide comes in contact with the soil until a complete seal is achieved.

5.4. Raise the moisture tester to a vertical position so the soil in the cap will fall into the pressure vessel.

5.5. Shake the instrument vigorously so a11 lumps will be broken up to permit the calcium carbide to react with all available free moisture. When steel balls are being used in the tester and when using the large tester to test aggregate, the instrument should be shaken with a rotating motion so the steel balls or aggregate will not damage the instrument or cause soil particles to become embedded in the orifice leading to the pressure diaphragm.

Note 8- Shaking should continue for at least 60 s with granular soils and for up to 180 s for other soils so as to permit complete reaction between the calcium carbide and the free moisture. Time should be permitted to allow dissipation of the heat generated by the chemical reaction.

5.6. When the needle stops moving, read the dial while holding the instrument in a horizontal position at eye level.

5.7. Record the sample mass and the dial reading.

5.8. With the cap of the instrument pointed away from the operator, slowly release the gas pressure. Empty the pressure vessel and examine the material for lumps. If the sample is not completely pulverized, the test should be repeated using a new sample. Clean the cap thoroughly of all carbide and soil before running another test.

Note 9- When removing the cap, care should be taken to point the instrument away from the operator to avoid breathing the fumes, and away from any potential source of ignition for the acetylene gas.

5.9. The dial reading is the percent of moisture by wet mass and must be converted to dry mass. With the super 200 D tester, the dial reading is the percent of moisture by dry mass and no fu11her calculation is required.

6. CALCULATION

6.1. The percentage of moisture by dry mass of the soil may be determined from the correction curve (Figure 2).

6.2. A correction curve similar to Figure 2 is normally supplied with each moisture tester. Each moisture tester, however, should be checked for the accuracy of its gauge, and for the accuracy of its correction curve.

6.2.1. The accuracy of the moisture tester gauge should be checked by using a calibration kit (available from the manufacturer), equipped with a standard gauge. In case of discrepancy, the gauge on the tester should be adjusted to conform with the standard gauge.

6.2.2. The accuracy of the correction curve should be checked by comparing curve-corrected moisture contents to moisture contents of locally prepared soils determined using T 265. In case of discrepancy, develop a new correction curve based on moisture contents determined from T 265.

6.2.3. The range of the factory-supplied or laboratory-determined curves may be extended by additional testing.

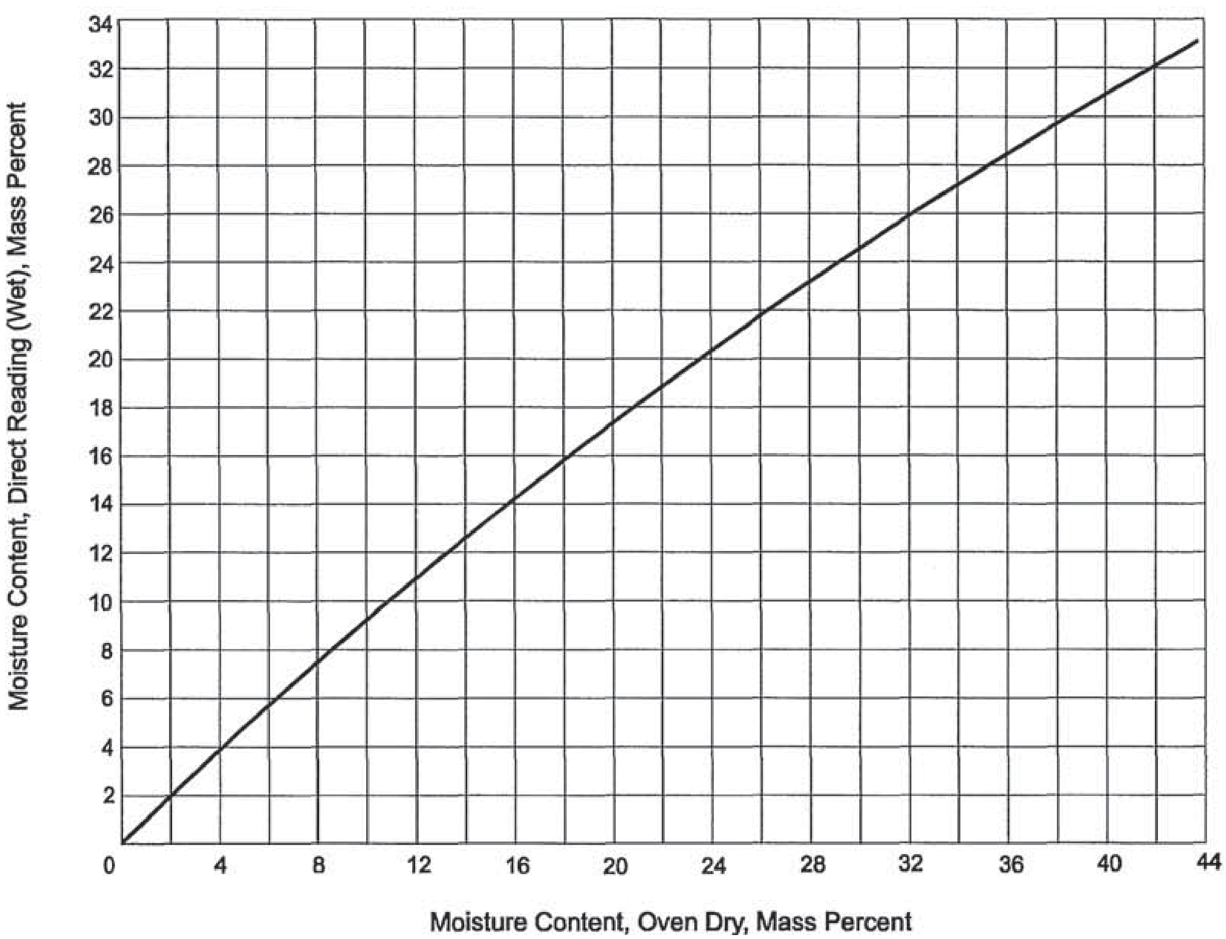

Figure 2- Correction Curve for Moisture Tester Reading (Example Only- Use the curve provided by the manufacturer with the specific apparatus, or a correction curve calibrated or extended for local soils at known moisture contents determined in accordance with Section 6.2.)

Note 10- It may be more convenient for field use of the apparatus to prepare a table of moisture tester readings vers us oven-dry moisture content for the moisture tester.

6.3. Determine the percentage of moistu re to the nearest 0.I percent.

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;

not

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.

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 (SI)(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:

$$^{\circ}C = \frac{5}{9} \times (^{\circ}F - 32)$$

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, $1 \times 10^4 = 10{,}000$; $1 \times 10^{-4} = 0.0001$).

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	$10^{·6}$	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	101s	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
mm2= square millimeter
m^3 = 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 $kg \cdot m/s^2$
1 pascal = 1 N/m^2
1 kilopascal = 1000 pascals
1 megapascal = 1 x 10^6 pascals
1 poise (absolute viscosity) = 0.10 $Pa \cdot s$
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.

TABLE4

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 mm^3
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/m^2
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 withan 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		Sieve Designation	
Standard	Alternate	Standard	Alternate
125mm	5 in.	2.36 mm	No.8
106 mm	4.24 in.	2.00 mm	No. 10
100 mm	4 in.	1.70 mm	No. 12
90mm	3-1/2 in.	1.40mm	No.14
75mm	3 in.	1.18 mm	No. 16
63mm	2-1/2 in.	1.00 mm	No. 18
53mm	2.12 in.	850 µm	No.20
50mm	2 in.	710 µm	No.25
45mm	1-3/4 in.	600 µm	No.30
37.5 mm	1-1/2 in.	500 µm	No.35
31.5mm	1-1/4 in.	425 µm	No.40
26.5 mm	1.06 in.	355 µm	No. 45
25.0 mm	1 in.	300 µm	No. 50
22.4 mm	7/8 in.	250 µm	No.60
19.0 mm	3/4 in.	212 µm	No. 70
16.0 mm	5/8 in.	180 µm	No.BO
13.2 mm	0.530 in.	150 µm	No. 100
12.5 mm	1/2 in.	125 µm	No. 120
11.2 mm	7/16 in.	106 µm	No. 140
9.5mm	3/8 in.	90 µm	No. 170
8.0mm	5/16 in.	75µm	No.200
6.7mm	0.265 in.	63 µm	No.230
6.3mm	1/4 in.	53 µm	No.270
5.6mm	No. 3-1/2	45µm	No.325
4.75 mm	No.4	38 µm	No.400
4.00 mm	No. 5	32 µm	No.450
3.35 mm	No. 6	25 µm	No.500
2.80 mm	No. 7	20 µm	No.635

TABLE 7

SI* (METRIC) CONVERSION FACTORS

(Approximate equivalents, except as noted**)

CONVERSIONS TO SI UNITS					CONVERSIONS FROM SI UNITS				
Abbrev.!Symbo/	*When you know*	*Multiply by*	*To find*	*Symbol*	*Symbol*	*When you know*	*Mult/ply by*	*To find*	*Abbrev.!Symbol*
LENGTH					LENGTH				
in.	inches	25.4	millimeters	mm	mm	millimeters	0.03937	inches	in.
ft.	feet	0.3048**	meters	m	m	meters	3.28	feet	ft.
vd.	yards	0.9144**	meters	m	m	meters	1.09	yards	vd.
mi.	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi.
AREA					AREA				
so. in. or in'	square inches	645.2	sauare millimeters	mm'	mm'	square millimeters	0.0016	squareinches	so. in. or in'
sq. ft. or ft"	square feet	0.093	square meters		m"	souare meters	10.764	souare feet	so. ft. or ft'
so. vd. or vd"	souare vards	0:836	souare meters	m'	m•	sauare meters	1.19	souareyards	so.yd. oryd"
	acres	0.405	hectares	ha	ha	hectares	2.47	acres	
sq. mi. or mi"	square miles	2.59	square kilometers	km'	km'	souare kilometers	0.386	souare miles	so. mi. or mi'
VOLUME					VOLUME				
fl. oz.	fluid ounces	29.57	milliliters	ml	ml	millimeters	0.034	fluid ounces	fl. OZ.
aal.	aallons {liquid)	3.7854	liters *	I	I	liters***	0.264	oallons(liauid)	gal.
cu. ft. or ft°	cubic feet	0.028	cubic meters		m•	cubic meters	35.315	cubic feet	cu. ft. or ft�
cu.yd. oryd•	cubicyards	0.765	cubic meters	m•	m•	cubic meters	1.31	cubicvards	cu. vd. or vd�
MASS					MASS				
oz.	ounces	28.35	arams	a	Q	arams	0.035	ounces	oz.
lb.	pounds	0.454	kiloarams	ka	ka	kiloorams	2.205	oounds	lb.
T	short tons(2000 lb)	0.907	metric tons****	t	t	metric tons**""	1.102	shorttons(20001b)	T
T	short tons(2000 lb)	0.907		Mei	Ma	meaacirams****	1.102	short tons(20001b)	T

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