FIELD TECHNICIAN
CERTIFICATION WORKBOOK

ARIZONA TECHNICAL TESTING INSTITUTE

Revised NOVEMBER 2025

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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INTRODUCTION:

- The ATTI Field Technician Certification program evaluates the competency of applicants performing sampling and testing of soils, aggregates, bituminous materials, and 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. If the test method is failed a second time, the applicant must schedule a retest within 1 year at a cost of $250.00.

- 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 ATII 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.

RETEST:

- 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.

CANCELATION / NO SHOW POLICY:

- 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.

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 & 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 matches 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.

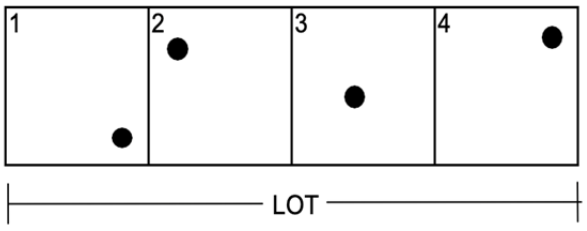


Figure 4. Sublots for stratified sampling.

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.

- 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 (AASHTO T27)) 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.

- 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 (AASHTO T191), nuclear density gauge (AASHTO T310), or one-point proctor test (AASHTO T271). Asphaltic concrete compaction is checked with the nuclear density gauge (AASHTO T355) or lab testing of cores (AASHTO T67) 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 PROCEDURES / REDUCING

*Sampling and reducing allows us to test **aggregate**, **asphalt mixtures**, and **asphalt materials** to ensure quality, consistency, and compliance with engineering and construction specifications. Sampling is the process of selecting a representative portion of a larger material stockpile, truckload, or batch. A good sample reflects the properties of the entire batch or lot of material. Poor sampling leads to misleading test results. Reduction is the process of dividing a large sample into a smaller, testable portion with attempting to not alter its characteristics. The significance of reducing large field samples is to break material down to more manageable sizes for lab testing. Also reducing ensures that smaller test samples still accurately reflect the entire batch.*

All sampling and reducing procedures that will be covered during ATTI:

- **AASHTO R90:** *SAMPLING AGGREGATE PRODUCTS*
- **AASHTO R97:** *SAMPLING ASPHALT MIXTURES*
- **AASHTO R66:** *SAMPLING ASPHALT MATERIALS*
- **AASHTO R76:** *REDUCING SAMPLES OF AGGREGATE TO TESTING SIZE*
- **AASHTO R67:** *SAMPLING ASPHALT MIXTURES AFTER COMPACTION (CORES)*

Learning objectives for these sections are:

- ***How to obtain a representative sample of aggregate, asphalt mixtures, and asphalt materials through various methods.***
- ***How to reduce samples, once collected, to their appropriate testing sizes.***
- ***Learn the basic terminology for sampling techniques, the kinds of materials used in construction processes, and the kinds of equipment the technician will encounter on site.***

PLEASE REFER TO THE PROCEDURE FOR MORE DETAIL. NOT ALL SECTIONS WILL BE COVERED BY ATTI. SECTION NUMBERS WILL BE PROVIDED FOR REFERENCE. SUBJECT TO CHANGE.

AASHTO R90:
SAMPLING AGGREGATE PRODUCTS

DEFINITIONS:

Nominal maximum size - *is the smallest sieve size through which the majority of the sample passes (up to 15% can be retained).*

Windrow - *is a long ridge of loose construction material.*

Stockpile - *is a collection of materials in piles that are segregated by type & size and intended for specific uses on a construction site.*

Increment - *is a portion of material that is collected by a sampling device in a single operation.*

SCOPE:

This practice covers the procedures for obtaining representative samples of coarse (CA), fine (FA), or combinations of both to determine compliance with all relevant specifications. **1.1.**

EQUIPMENT:

4.0.

- **SHOVELS OR SCOOPS**
- **BROOMS, BRUSHES, AND SCRAPING TOOLS**
- **MECHANICAL SAMPLING SYSTEMS-** Normally, a **permanently attached** device that allows a sample container to **pass perpendicularly through** the entire **stream** or **diverts the material** into the container.
- **BELT TEMPLATE-** a device that is the **shape and width of the aggregate belt**. There should be enough space between the device to yield an increment of the required weight.
- **SAMPLING CONTAINERS- Bags** or other **containers** that **prevent loss or contamination of the sample.** Must also prevent damage to the contents from any mishandling. For moisture content samples, containers must prevent moisture loss.
- **SAMPLING TUBE – plastic, aluminum, or similar tube** whose diameter is **at least three times the nominal maximum aggregate size**; the end of the tube may be angled to assist in sampling.

SEE PROCEDURE FOR ADDITIONAL DETAILS & DIMENSIONS. NOT ALL EQUIP INFO IS COVERED IN THIS MANUAL

PROCEDURE

Aggregate sampling is the process of taking a large enough sample of aggregate that is as true to representative of the nature and condition of the aggregate in the field as possible. AASHTO T90 describes the amounts and methods of obtaining field samples for further materials testing from the various stages of the construction process.

- The technician shall use every precaution to **obtain samples that are representative** of the material. **5.1**
- Make sure all **equipment and containers** are **clean and dry** before sampling. **5.1.1**
- Field **samples** should meet or exceed **TABLE 1** found in the procedure. **5.2.**

Table 1—Recommended Sample Sizes

Nominal Maximum Size		Minimum Mass	
mm	(in.)	kg	(lb)
90	(3½)	175	(385)
75	(3)	150	(330)
63	(2½)	125	(275)
50	(2)	100	(220)
37.5	(1½)	75	(165)
25.0	(1)	50	(110)
19.0	(¾)	25	(55)
12.5	(½)	15	(35)
9.5	(⅜)	10	(25)
4.75	(No. 4)	10	(25)
2.36	(No. 8)	10	(25)

NOTE 1: *Sample size is based upon the test(s) required. Generally, the field sample size should be enough that if the technician splits it twice the result will be the approximate testing size amount.* ***(SECTION 5.2.)***

Record the sampling time or location or both. If being used for quality control or acceptance use a random sampling procedure to obtain the time and location. ***(SECTION 5.1.)***

FOLLOWING ARE THE DIFFERENT METHODS FOR SAMPLING OUTLINED IN THE PROCEDURE:

SAMPLING FROM CONVEYOR BELT USING A TEMPLATE:

By taking regular samples from the conveyor belt, technicians can obtain their representative samples at the production facility. This allows for corrective actions to be taken before potentially substandard aggregate is used or transported to the job site. (The method of sampling a technician employs are generally project and/or agency specific.)

1. Have the **belt stopped.** 5.3.1

2. Set the **sampling template** on the **belt** in a way that avoids adjacent material from falling into the space inside the template. 5.3.2

3. **Remove** the material from **INSIDE** the **template; including** any **material adhering** to the belt utilizing scoops and brushes. 5.3.3

4. If that increment is not enough **repeat the process** obtaining equal increments each time. **Combine** the increments to form a **single sample**. 5.3.4./ 5.3.5.

*When sampling aggregate from the conveyor belt avoid sampling from the beginning or the end of the aggregate run to avoid segregation of material. **(SECTION 5.3.)***

CLEAN ALL MATERIAL (INCLUDING FINES) OFF BELT.

*Be careful when sampling in the rain it can make removing the finer material more difficult due to material sticking to the belt or washing away. **(SECTION 5.3.3.)***

SAMPLING FROM CONVEYOR BELT DISCHARGE:

Similar to sampling from the conveyor belt with a template, this form of sampling can be utilized and may be easier to accomplish in certain instances. By taking regular samples from the conveyor belt, in general, technicians can obtain their representative samples at the production facility. This allows for corrective actions to be taken before potentially substandard aggregate is used or transported to the job site. (The method of sampling a technician employs are generally project and/or agency specific.)

1. The **sampling device** (manual or automatic) must be passed through the **full stream** of material as it runs off conveyor belt. 5.4.

2. Pass the **sampling device** through the full stream of material **once in each direction**. Sampling must be done at a **constant speed** and **perpendicular** to the flow of the material **without overflowing**. Alternatively, the full stream of material can be diverted into the container. 5.4.1

*Avoid sampling from beginning or end of aggregate run. **(SECTION 5.4.)***

EMPTY THE SAMPLING DEVICE. REPEAT AS NECESSARY.

3. **Empty** the sampling device into an appropriate **sampling container**. (***Considered 1 increment***) 5.4.1

4. If that increment is **not enough,** repeat the process obtaining equal increments each time. **Combine the increments** to form a **single sample**. 5.4.2 / 5.4.3.

When emptying the sampling device include all material that may adhere to the device. ***(SECTION 5.4.1.)***

SAMPLING FROM TRANSPORT UNITS:

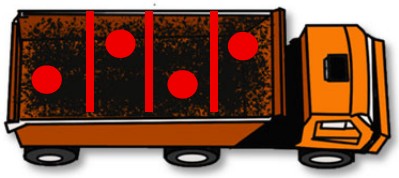
Sampling from transport units ensures that samples taken are representative of the entire batch being delivered to the job site. This ensures that the material actually delivered conforms to the required specifications. (The method of sampling a technician employs are generally project and/or agency specific.)

1. **Visually divide** the transport unit into **four** quadrants. 5.5.1

2. Pick **a quadrant** and identify a **random sampling location** within. 5.5.2

3. **Remove** approximately **1 ft** of material from the top of the sampling area. **Obtain an increment** from the exposed surface and **repeat the process** in each of the remaining quadrants. **Combine** increments into one sample. 5.5.3 / 5.5.4.

VISUALLY DIVIDE INTO 4 QUADRANTS



OBTAIN AN INCREMENT FROM EACH QUADRANT

REMOVE APPROXIMATELY 1FT

SAMPLING FROM ROADWAY- BERM OR WINDROW:

Sampling aggregate and soils from a windrow (a long pile or ridge of material) or berm (a raised strip or mound of material) is an essential procedure in obtaining a representative sample for later testing at the job site itself. (The method of sampling a technician employs are generally project and/or agency specific.)

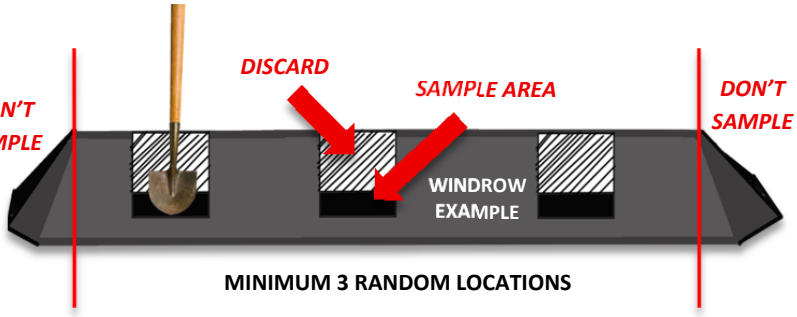
WINDROW

BERM

Make sure NOT to take the sample or any increment from the beginning or end of the windrow or berm. ***(SECTION 5.6.1.)***

1. **Remove** the **top 1/3** of the windrow or berm **before** taking increment.

5.6.2

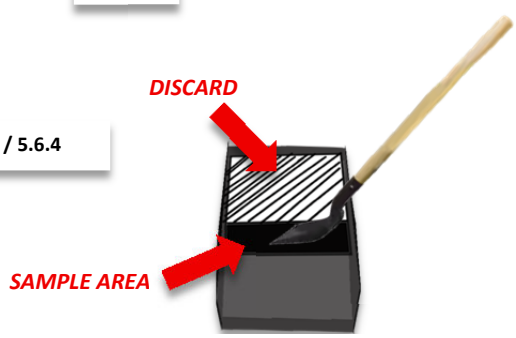


2. Obtain a minimum of **3 approximately equal increments** from **random** locations along the windrow or berm.

5.6.3

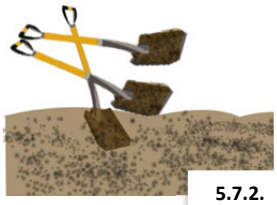
3. **Fully** insert the **shovel** into the location **(exclude underlying material),** roll back and lift the shovel slowly so as not to lose any material. **Combine** the increments to form a **single sample**.

5.6.3.1 / 5.6.4



SAMPLING FROM ROADWAY- INPLACE:

Sampling aggregate and soils from the roadway in place is a commonly quick but least sophisticated way to obtain representative samples for analysis. (The method of sampling a technician employs are generally project and/or agency specific.)

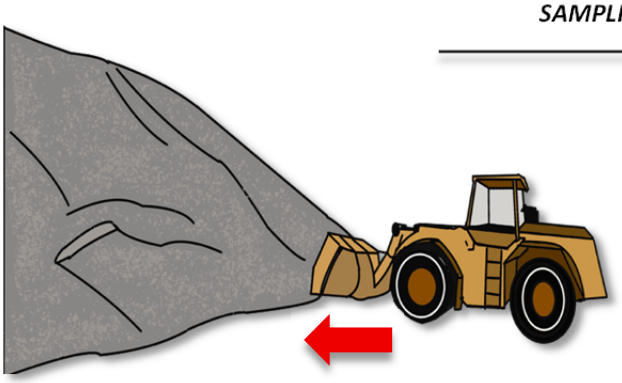


5.7.2.

1. **Obtain** representative sample **after spreading** and **before compacting**.

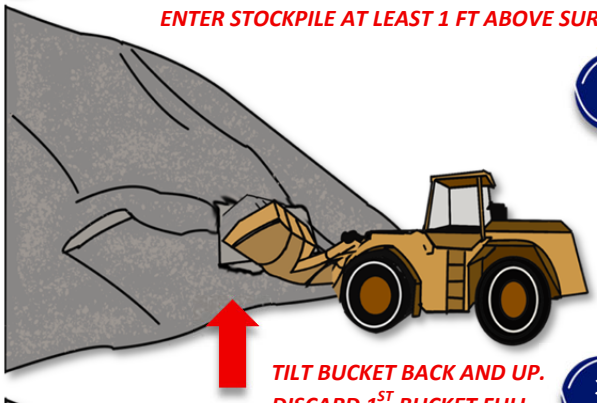
5.7.1.

SAMPLING FROM STOCKPILE – FRONT LOADER PAD:



Stockpiled materials will often experience segregation, where fine particles settle at the bottom and larger particles accumulate at the top and the sides. Using a front loader to sample and mix material from different layers of the stockpile helps ensure that the sample taken is representative of the entire stockpile, rather than just the surface or just one section. (The method of sampling a technician employs are generally project and/or agency specific.)

ENTER STOCKPILE AT LEAST 1 FT ABOVE SURFACE



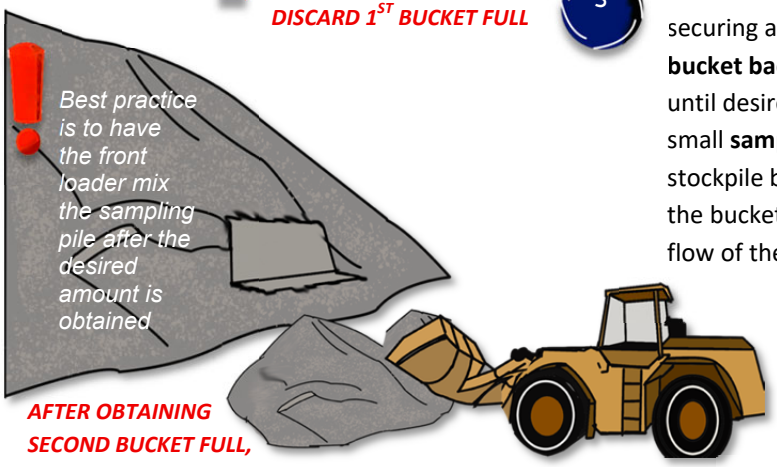
1. The **front loader** must enter the stockpile with the bucket at least **1ft (0.3m) above** the ground **without contaminating the stockpile.** **5.8.1.1**

2. Discard the **1st bucket** full. **5.8.1.2**

TILT BUCKET BACK AND UP. DISCARD 1ST BUCKET FULL

3. Have the front loader **re-enter** the stockpile securing another **bucket full then tilting the bucket back and up**. Keep taking buckets full until desired amount is obtained. Create a small **sampling pile at the base** of the stockpile by gently rolling the material out of the bucket at a sufficient height to permit free flow of the material. **Repeat as necessary**. **5.8.1.3 / 5.8.1.4.**

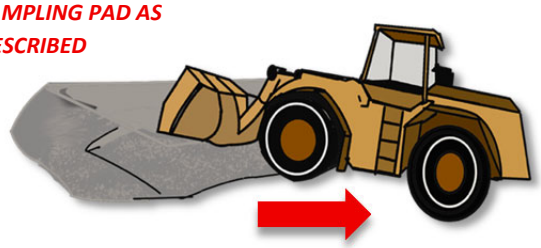
Best practice is to have the front loader mix the sampling pile after the desired amount is obtained



AFTER OBTAINING SECOND BUCKET FULL, BEGIN CREATING SAMPLING PAD AS DESCRIBED

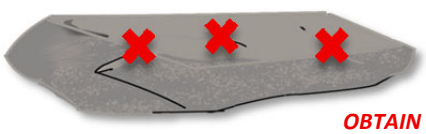
4. Have the loader create a **flat surface** by back dragging the pile. **5.8.1.5**

5. Obtain **increments** from at least **3 randomly** selected locations on the flat surface at least **1 ft (300mm)** from the edges. **5.8.1.6**



BACK DRAG MATERIAL TO FLATTEN SURFACE

6. **Fully insert the shovel** into the location, roll back, and lift the shovel slowly **(excluding the underlying material)** so as not to lose any material. **Combine** each increment to form a **single sample.** **5.8.1.7 / 5.8.1.8**

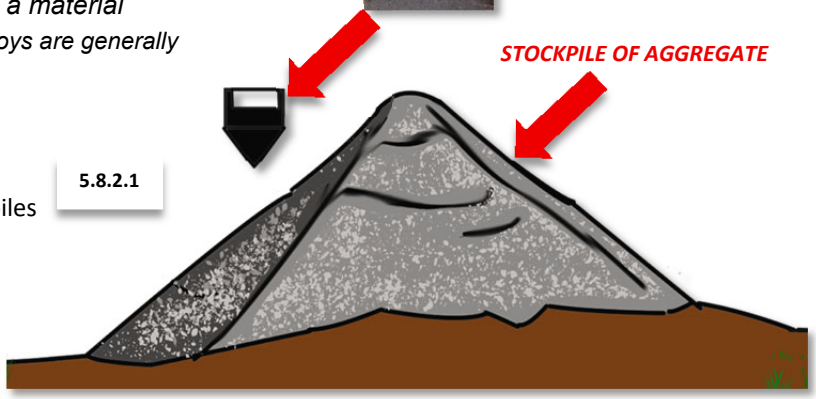


OBTAIN INCREMENTS FROM AT LEAST 3 RANDOM LOCATIONS AT LEAST 1 FT FROM EDGES

SAMPLING FROM STOCKPILE – HORIZONTAL SURFACE ON FACE:

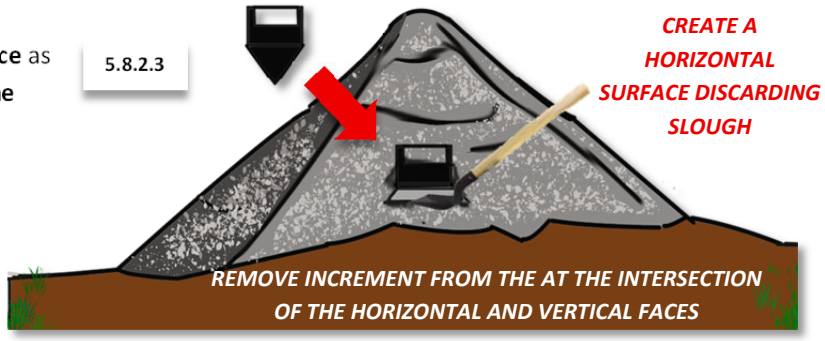
Sampling from the face of the stockpile utilizing the following procedure helps mitigate some of the material segregation issues had while obtaining a representative sample from a material stockpile. (The method of sampling a technician employs are generally project and/or agency specific.)

ADOT SAMPLING SHIELD (FLAT BOARD)



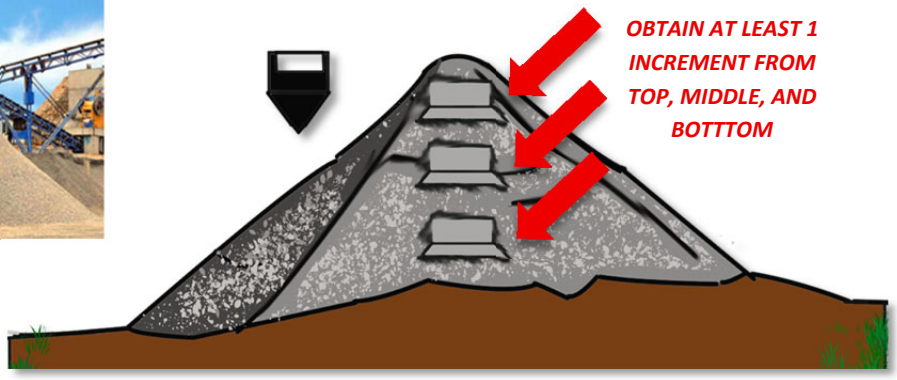
1. Create **horizontal surfaces** with vertical faces in the **top, middle, and bottom third** of the stockpiles with a shovel or loader. **5.8.2.1**

2. **Insert** a **flat board** against the **vertical face** behind the sampling location to prevent sloughing. **Discard slough** material to **create horizontal surface**. **5.8.2.2**



3. **Obtain sample** from the **horizontal surface** as close as possible to the **intersection of the horizontal and vertical faces**. **5.8.2.3**

4. Obtain at least **1 increment** of approximately equal size from **each** of the **top, middle, and bottom thirds** of the pile. Combine all increments into a single sample. **5.8.2.4 / 5.8.2.5.**



Please refer to approved agency or companies' internal procedures and forms. This EXAMPLE does not necessarily demonstrate all that may be required.

6.

SECTIONS NOT COVERED:

Please refer to the standard for any material not covered. Not all methods are covered:

- ***SAMPLING FROM STOCKPILE- FINE AGGREGATE (ALTERNATE TUBE METHOD) (SEC:5.9)***

AASHTO R97:

SAMPLING ASPHALT MIXTURES

DEFINITIONS:

Asphalt Mixture – *is a composite of asphalt (binder), aggregates, and other components used to pave roads and parking lots.*

Asphalt paver – *is a machine used to lay, spread, and compact asphalt.*

Paver auger – *is a screw like component on an asphalt paver that moves asphalt product from the conveyor to screed.*

Compaction (Asphalt) – *is the process of reducing the volume of asphalt and aggregate in hot mix asphalt concrete by applying external forces.*

EXAMPLE SIZE FOR SAMPLING PLATE: *procedure states that an example of an acceptable plate is 15 inches square while following the additional requirements discussed. This is just an example it must be sized to accommodate sample size requirements.* ***(SECTION 4.6.1.)***

SCOPE:

1.1.

This standard practice covers the procedures for sampling of asphalt mixtures at point of manufacture, storage, or delivery. Samples obtained by this procedure may be used as representative samples of asphalt mixtures to determine compliance with requirements of the specifications under which the asphalt mixture is furnished.

EQUIPMENT:

4.

- **SAMPLING CONTAINERS – cardboard boxes, metal buckets, stainless steel bowls** or **pans**, or other appropriate containers.
- **MECHANICAL SAMPLING SYSTEMS –** a **permanently attached device** that allows a **sample receptacle to pass perpendicularly** through the **entire stream** of material or **diverts the entire stream** of material into the container by manual, hydraulic, or pneumatic operation.
- **SHOVELS OR METAL SCOOPS – shovels at least 5.5 inches wide.**
- **BELT TEMPLATE-** A template that is the **width and shape** of the **asphalt mixture stream belt**.
- **SAMPLING PLATE – Thick metal plate**, **minimum 8 gauge**, sized to accommodate **sample size requirements**. **Wire** long enough to **reach** from **center of paver** to **outside** of **farthest auger extension attached** at **one corner**. **Each corner** of the plate should **have 0.25-inch diameter hole**.
- **COOKIE CUTTER SAMPLING DEVICE – Steel angle with two 100mm by 150mm by 9mm handles** sized to accommodate sample size. **Minimum 2 inches smaller** than the **sampling plate** when used together.
- **RELEASE AGENT –** nonstick spray.

SEE PROCEDURE FOR ADDITIONAL DETAILS & DIMENSIONS. NOT ALL EQUIP INFO IS COVERED IN THIS MANUAL

MANY DIFFERENT SAMPLING LOCATIONS AND TECHNIQUES ARE COVERED IN THIS STANDARD, EXERCISE CARE THAT SAMPLES ARE OBTAINED ACCORDING TO THE APPROPRIATE REQUIREMENTS:

PROCEDURE:

Sampling asphalt for materials testing is the process of collecting representative samples of asphalt material from the various stages of the construction process to evaluate its quality, compliance with specifications, and expected performance.

- Make sure asphalt samples are **covered** to **prevent contamination** from dust or other foreign matter. **5.1.2**
- Consult the **test method** for the sample **size**. **Obtain sufficient quantity to perform all testing.** **5.2.**

When sampling asphalt mixtures, inspect for uniformity and utilize random sampling or stratified random sampling. Select a minimum of 3 locations to best represent the material being tested. ***(SECTION 5.1.1.)***

- Make sure the **containers** and sampling **equipment** are **clean and dry** before sampling. **5.3.1**
- Use **cardboard boxes, metal containers, or other acceptable containers** for **dense-graded mixture samples**. **5.3.2**

If using containers that are made of absorbent materials and the mix is hot open-graded mixture then allow to cool in stainless steel bowls or pans first so there is no loss of binder. ***(SECTION 5.3.3.)***

SAMPLING USING ATTACHED SAMPLING DEVICE:

1. An **attached sampling device** is defined as permanent and allows a sampling receptacle to **pass through** the entire stream of asphalt mixture **perpendicularly twice**, once in each direction without overfilling. The device may be hydraulic or pneumatic. **5.4.1.**
2. **Lightly coat** the attached sampling receptacle with a **release agent** or **preheat** it, or both. **5.4.2.**
3. **Pass** the receptacle **twice through** the material **perpendicularly** without overfilling. **5.4.3.** **5.4.5.**
4. **Transfer** asphalt from sampling receptacle to **sample container** without loss of material. Repeat until the proper sample size is obtained. **5.4.4./ 5.4.5**

As an alternative the stream of asphalt mixture can be entirely diverted to get a representative sample. ***(SECTION 5.4.1.)***

SAMPLING FROM CONVEYOR BELT USING A SAMPLING TEMPLATE:

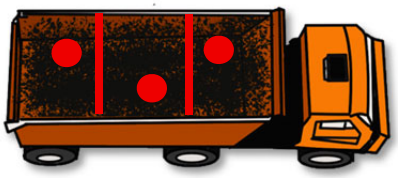
1. **Stop the belt** containing the asphalt mixture. **5.5.2.**
2. **Set the sampling template** into the asphalt **mixture on the belt**, **avoiding intrusion by adjacent material.** **5.5.3.**
3. **Remove the asphalt mixture** from **inside the template**, including **all fines**, and place in a sample container. **5.5.4.**
4. Obtain **equal sample increments** when one increment is inadequate for the required testing. **Combine** the increments to form a **single sample** of the required size. **5.5.5./ 5.5.6.**

Do not sample form the beginning or end of an asphalt mixture production run due to the potential for segregation. Make sure to capture fines that may stick to the belt. ***(SECTION 5.5.1)***

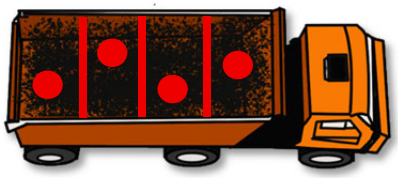
SAMPLING FROM TRANSPORT UNITS:

Transport units are, essentially, any vehicle approved to haul asphalt materials. Sampling from these vehicles is essential to ensure that the material being delivered to the construction site meets quality control standards and complies with project specifications. (The method of sampling a technician employs are generally project and/or agency specific.)

VISUALLY DIVIDE INTO 3 QUADRANTS



OR



VISUALLY DIVIDE INTO 4 QUADRANTS

OBTAIN AN INCREMENT FROM EACH QUADRANT

1. Visually **divide** the unit into **three or four** equal sections. **5.6.1**
2. Remove approximately **6 to 12 inches (0.15m to 0.3m)** of material from **the top of the section** you have decided to sample **5.6.2**
3. **Obtain the increment** from the exposed surface of that section. **Repeat for the remaining sections**. **5.6.2**
4. **Combine** all increments into **one sample.** **5.6.3**

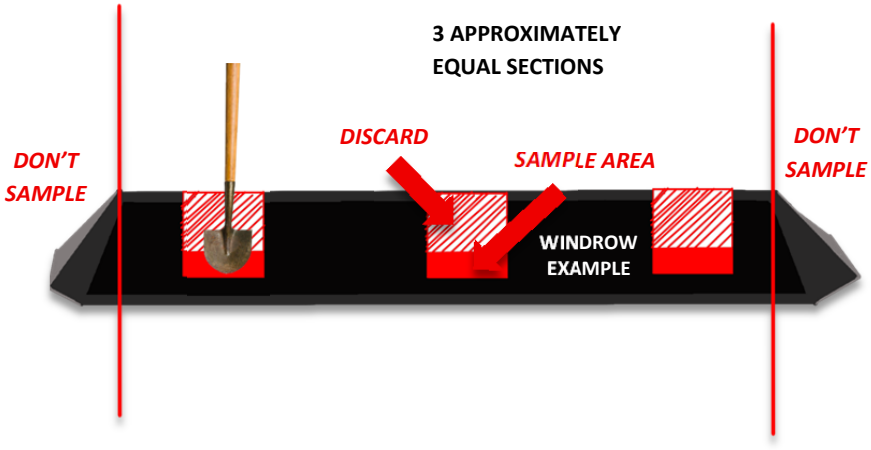
REMOVE APPROXIMATELY 6 TO 12 INCHES

SAMPLING FROM WINDROW:

When on site, the technician has an option to obtain their representative sample from a windrow which is a continuous, long pile, usually using a bottom-dump truck, where the material is deposited in a controlled manner to form a row of loose asphalt. This method is widely used in the industry. (The method of sampling a technician employs are generally project and/or agency specific.)

1. Visually **divide** the windrow section into approximately **3 equal** sections. **5.8.2.**
2. Remove approximately **1 ft (0.3m)** of material from the **top** of the windrow. **5.8.3.**

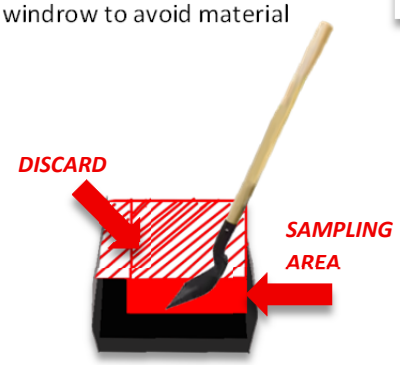
When obtaining a representative sample from the windrow of a transport unit make sure not to take any increment from the beginning or end of the windrow section. ***(SECTION 5.8.1.)***



3. Obtain **approximately equal** sample increments by fully inserting the shovel into the flat surface as vertically as possible, roll back, and lift the material slowly out of the windrow to avoid material rolling off the shovel. **Take care to exclude underlying material.** 5.8.3.

4. **Place** the **increment** into the **sample container** and repeat for the remaining thirds. 5.8.3.

5. **Combine** all increments to form **one sample of the required size.** 5.8.4.

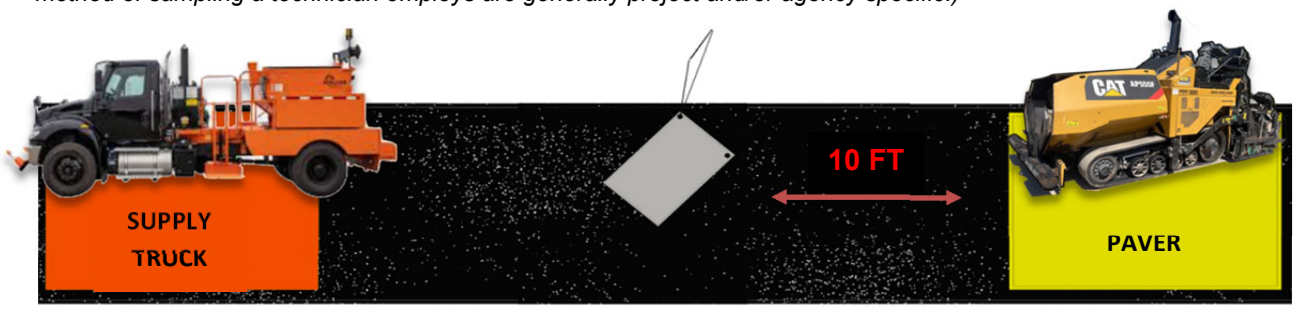


SIDE VIEW

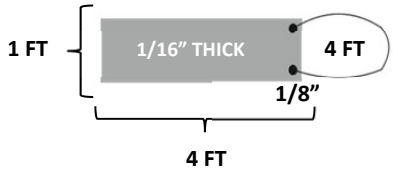
ASPHALT WINDROW EXAMPLE

SAMPLING PLATE METHOD:

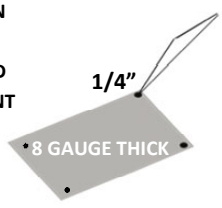
The plate method allows for the collection of a representative sample from a continuous asphalt layer being placed by the paver on grade or base material. Asphalt mixtures can vary slightly in its properties during placement it's important to obtain a sample that reflects the material being actually placed on the road. (The method of sampling a technician employs are generally project and/or agency specific.)



ADOT PLATE



DIMENSIONS CAN VARY; EXAMPLE SIZE IS DISCUSSED UNDER EQUIPMENT



AASHTO PLATE

1. The **plate** is to be placed at least **10 ft (3m) in front** of the **paver or pickup device**. **5.9.2.1.1.**

Sampling is accomplished behind the paver and in front of the roller. For safety, the ROLLER must remain at least 10 feet behind the sampling operation until the sample has been taken and the hole filled with loose asphalt mixture. ***(SECTION 5.9.1.)***

2. **No technician** is to be **between the supply trucks and paver** unless supply truck is moving forward. If this is the case then the **technician** needs to be at least **10 ft (3 m) behind** the **truck**. **5.9.2.1.2.**

The technician (if possible) must have contact and communication with the paving machine for safety. If not possible have a third party to assist. ***(SECTION 5.9.2.1.1.)***

3. If **obtaining a sample is unsafe**. **Stop** sampling **until** made **safe** or stop the **paving operation** while plate is being placed. **5.9.2.1.3**

4. **Remove loose material** from the location in front of the paver at least **2ft inside the edge of the mat.** **5.9.2.1.4**

5. **Lay down** the **plate diagonally** with the **direction of travel** of the paver (in front). The technician must keep the plate **flat and tight** to the base with the **lead corner facing the paver**. **5.9.2.2.**

6. **Hold** the **wire** attached to the outside corner of the plate **taut past the edge of the mat and secure it** as the paver operation passes over. **5.9.2.3 / 5.9.2.4.**

7. **After the paver has safely passed over, pull** the **wire up** through the fresh asphalt mixture to locate the corner of the plate. **5.9.2.5**

8. Using a **square pointed shovel remove** the **full depth** of the mixture from the plate. Take care to prevent sloughing of adjacent material. **5.9.2.6**

9. Place **all material, including** any that **adheres** to the **plate and / or the shovel** (scoop)), into a **sample container**. **5.9.2.7**

10. **Remove the plate** from the roadway. The **hole** left must be **filled** with loose asphalt before compaction. **5.9.2.9**

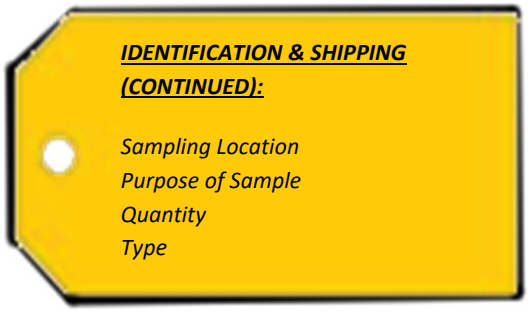
Thoroughly clean all equipment before any additional sampling.

SAMPLING FROM STOCKPILES (ASPHALT)

Techniques relating to sampling from asphalt stockpiles are identical to AASHTO R90- Sampling from Stockpiles (see procedure or pages 25- 26 in this manual) except for the following:

- **Remove** at least **4 inches (0.1 m)** from the **surface before sampling**. Asphalt mixtures in stockpiles may develop an oxidized crust. **5.11.**
- Also, if sampling from an **Asphalt Stockpile** with a front loader the **first bucketful** does **NOT** have to be **discarded**. **5.11.1.**

Please refer to approved agency or companies' internal procedures and forms. This EXAMPLE does not necessarily demonstrate all that may be required.



SECTIONS NOT COVERED:

Please refer to the standard for any material not covered. Not all methods are covered:

- ***SAMPLING FROM A PAVER AUGER (SEC:5.7.1)***
- ***PLATE METHOD – PLATE WITH COOKIE CUTTER (SEC:5.9.2.8)***
- ***NON-PLATE METHOD (SEC:5.9.3)***
- ***SAMPLING FROM A PAVER HOPPER (SEC:5.10.1)***
- ***SAMPLING FROM ASPHALT STOCKPILE – FRONT LOADER (SEC: 5.11.1 - partially discussed)***
- ***SAMPLING FROM ASPHALT STOCKPILE- HORIZONTAL SURFACE ON FACE (SEC: 5.11.1 - partially discussed)***

AASHTO R66:

SAMPLING ASPHALT MATERIALS

DEFINITIONS:

Asphalt Binder- *is a black viscous material created from petroleum refining. Acts as the glue that holds together the aggregates in asphaltic concrete.*

Emulsions – *are a liquid mixture of asphalt, water, and an emulsifying agent that is used in road construction and maintenance.*

Asphalt Cement Grades – *types of asphalt binder that vary in consistency and flow resistance.*

SCOPE:

This method covers sampling of asphalt materials at production facilities, storage facilities, transport units, or at the point of delivery. 1.1

MINIMUM SAMPLE SIZE:

SAMPLE SIZE:

- **1 Quart of Asphalt Binder** 4.1.1.
- **1 Quart of Emulsified Asphalt** 4.1.2.

CONTAINER:

TYPE OF CONTAINERS:

For Liquid Asphalt (not emulsions):

- **Double-seal friction-top can.**
- **Square Cans with screw tops.**
- **Small mouth cans with screw caps.**

5.1.1

D.F.T.C.

Double-seal Friction Top Can

For Emulsions:

- **Plastic wide-mouth jars.**
- **Bottles with screw caps.**

5.1.2

SIZE OF CONTAINER:

- **Size of container must accommodate the required amount of the sample.** 5.2.1

PROTECTION & PRESERVATION:

Protecting and preserving asphalt liquids after sampling is crucial to prevent contamination and maintain property integrity. Proper labeling is equally essential for accuracy in testing and for safety of the technician.

- All sample **containers** must be **new** and the **top must fit tightly** with the container**.** 6.1.
- To **prevent contamination**, tightly seal the container immediately after filling. 6.2.
- **Protect** emulsified asphalt samples from **freezing**. 6.4

IF A CONTAINER NEEDS CLEANING CAN THE TECHNICIAN USE SOLVENT?

ANSWER: *No. Solvent can't be used on any sampling container. If the container needs cleaning use only a clean dry cloth.* ***(SECTION 6.3.)***

- **DO NOT** sample **emulsified asphalt under pressure**. 6.4

NOTE 1: Pressure may allow trapped air, which could lead to inaccurate test results. Bubbles in the material are an indication of trapped air. ***(SECTION 6.4.)***

NOTE 2: The sampling container should be completely filled to minimize skin formation at the air- emulsion boundary. Alternately, one can fill the container until a small amount of space remains. Squeeze the container to cause the contents to fill to the top. Position the cap on the container and securely tighten it. The space remaining will aid in mixing the sample prior to testing. ***(SECTION 6.4.)***

- **Transferring samples** from one **container** to another must be **avoided, if possible**. 6.5.

- Properly **identify** sample containers with a **suitable marker after filling, sealing, and cleaning**. **Write** on the **body** of the container itself. 6.6.

- **DO NOT** write on the **lid**. 6.6.

If labels / tags are used, they have to be securely fastened to the side of the container and clearly marked. All Identification materials must maintain integrity at temperatures up to 392 degrees Fahrenheit. ***(SECTION 6.6.)***

PROCEDURE:

The following methods within the procedure are applicable to both emulsions and binder unless stated otherwise. Sampling emulsions at various points in the production or delivery process (e.g., from the tank, transport units, or the distributer truck), allows you to verify that the emulsion is consistent and homogeneous, and adheres to all applicable specs and provisions. Sampling asphalt binder is important in understanding how the asphalt mix performs in terms of durability, flexibility, and resistance to wear. It allows for the verification of binder quality, consistency, and compliance with the specifications and standards for the project.

SAMPLING AT PLACE OF MANUFACTURE

BULK STORAGE TANKS NOT EQUIPPED WITH MECHANICAL AGITATORS (LIQUID ASPHALT MATERIALS OR MATERIALS LIQUFIED BY HEATING):

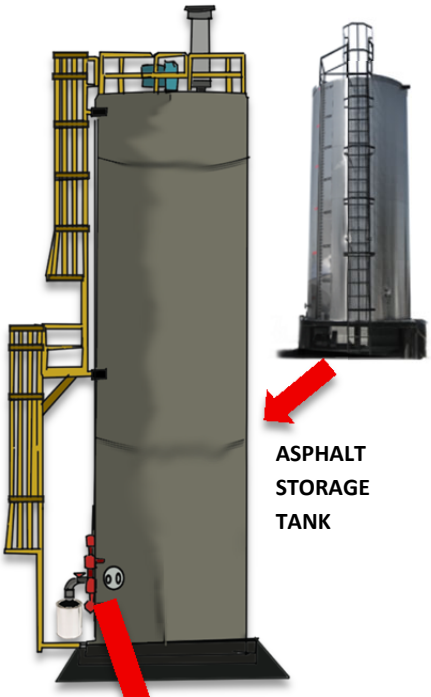
OBTAIN SAMPLE USING ONE OF THE FOLLOWING METHODS:

TANK TAP METHOD:

CLEARING OUT THE LINE:
When sampling it's mandatory to clear out the line by drawing and discarding a minimum of 1 Gallon of the material. (SECTION 7.1.1.)

1. Use the **valves** or taps at the **top, middle, and lower** locations of the tank to obtain test sample. ***Sample is obtained after clearing out the line.*** **7.1.1.**

2. If there is only **one valve** available at the **bottom** location then draw an **entire sample** ***(after clearing out the line)*** from that valve. **7.1.1**



ASPHALT STORAGE TANK

THIEF SAMPLER METHOD (NOT SUITABLE FOR ASPHALT BINDER):

1. **Samples will be obtained at the top, middle, and lower levels** of the tank by lowering a **thief sampler** into the material. ***(See procedure for additional details)*** **7.1.2.**

BULK STORAGE TANKS EQUIPPED WITH MECHANICAL AGITATORS (LIQUID ASPHALT MATERIALS OR MATERIALS LIQUIFIED BY HEATING):

1. When the tank is equipped with mechanical agitators and it is observed that adequate mixing has taken place, a single sample can be taken according to **TANK TAP METHOD** ***(SEC: 7.1.1.)*** OR **THIEF SAMPLER METHOD** ***(SEC: 7.1.2.)*** **7.2.**

VALVE ***(MAY LOOK DIFFERENT DEPENDING ON CONSTRUCTION)***

SAMPLING FROM TANK CARS, VEHICLE TANKS, OR DISTRIBUTOR TRUCKS:

WHERE IS THE VALVE (GENERALLY) LOCATED?

ANSWER: *Near the pump within the recirculation line.*

1. **All transport vehicle** will be equipped with a **sampling valve.** ***(see AASHTO R66 and/or refer to supplier procedures for details)*** **8.1.**

ASPHALT DISTRIBUTOR TRAILER

SOME ALTERNATIVES TO OBTAINING REPRESENTATIVE SAMPLES (IF ALLOWED BY THE PURCHASER):

- **DIP METHOD**- *taking a clean wide-mouth plastic jar or friction-top can in a suitable holder. A clean container must be used to take each sample, and the material sampled will then be transferred to another new and clean container for retaining or testing the sample.* 8.2.1

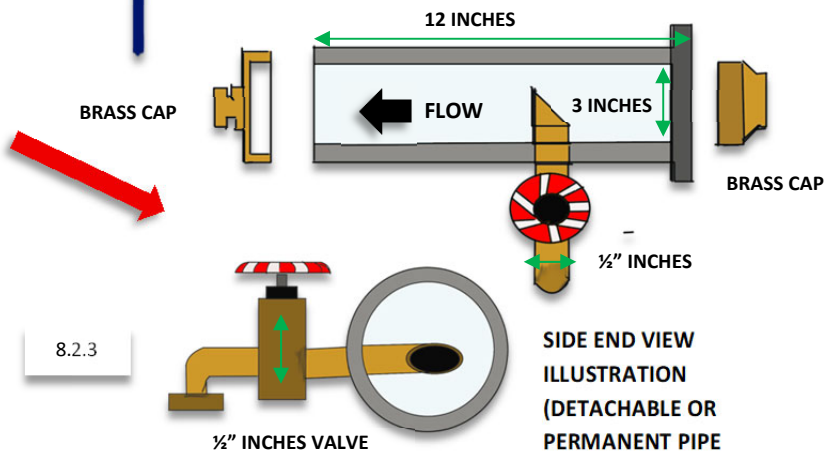
- **DETACHABLE OR PERMANENT PIPE FITTING**- *Similar design as the illustrated image. This will be inserted into the discharge line that is located between the unloading pipe and hose as close to the end as possible. Take the sample after 1/3 and not more than 2/3 of the load has been removed. Remember to draw and discard 1 gallon before taking the sample. Take sample slowly.* 8.2.2.

- **NOZZLE ON SPRAY BAR**- *if the distributor is not equipped with a sampling valve, sample from fully flushed spray bar nozzle.* 8.2.3

2. The **valve** will be installed at least **1 ft (305mm) from the shell** and have a **sampling valve label**. **8.1.**

3. **Before** the sample is taken a **minimum** of **1 gallon** will be **drawn** from the sample valve and **discarded** **(CLEARING OUT THE LINE)**. **8.1**

TOP VIEW ILLUSTRATION (DETACHABLE OR PERMANENT PIPE FITTING)



SIDE END VIEW ILLUSTRATION (DETACHABLE OR PERMANENT PIPE FITTING)

SAMPLING FROM PIPELINES DURING ASPHALT BINDER PRODUCTION (HMA HOT PLANT):

1. **Obtain** the sample from the **line feeding** the mixing plant while the plant is **in operation**. The sampling valve will be located downstream of any mix blending or other processing **11.1.**

2. The **diameter** of the sampling pipe will not be more than **1/8th of the diameter** of the **pipe line** and its opening should be turned to face the flow of the liquid. The pipe will be provided with a valve or plug cock and shall discharge into a sample receiver. ***(See the procedure and/or refer to the supplier for what a suitable in-line sampling pipe looks like.)*** **11.1.**

3. Before the sample is taken a minimum of **1 gallon** will be **drawn** from the sample valve and **discarded**. **11.1.**

SAMPLING AT POINT OF SHIPMENT DELIVERY:

1. **Sampling** must be performed as **soon as possible** after the asphalt material has **arrived** at the **plant site, storage site, or job site** or at the time of unloading. **14.1.**

The required number of samples shall be taken from each delivery of asphalt material or follow your agencies rules for the required number of samples to be taken. For small delivery units take samples necessary to represent a maximum of 10,000 gallons. ***(SECTION 14.2.)***

2. **Follow the method for** sampling from **Section 7**: ***(See page 36 of this manual)*** **14.3.1**

Sampling at point of shipment delivery is generally done on emulsions not binder.

OR

Bleeding through a sample valve or **tap** in the **TRANSFER LINE** during the unloading of the **middle third** of the load. Remember to **draw and discard minimum 1 gallon** before taking sample. **14.3.2.**

Tests for acceptability will be performed on one of the samples taken. Retain the other samples for retesting if the first fails. ***(SECTION 14.4.)***

SECTIONS NOT COVERED:

Please refer to the standard for any material not covered. Not all methods are covered:

- ***SAMPLING FROM TANKERS & BARGES (SEC:9.1.1.)***
- ***SAMPLING FROM PIPELINES DURING LOADING & UNLOADING (SEC:10.1.)***
- ***SAMPLING FROM DRUMS & BARRELS: (SEC:12.1)***
- ***SAMPLING SEMISOLID MATERIALS (SEC:13.1)***

AASHTO R76:

REDUCING SAMPLES OF AGGREGATE TO TESTING SIZE

DEFINITIONS:

Coarse Aggregate - *is a granular or irregular material that is typically larger than #4 (4.75mm) screen and is used in concrete.*

Fine Aggregate - *are the particles that pass through a #4 (4.75 mm) sieve and retain on a #200 (0.075mm) sieve.*

Splitting - *is the process of dividing a sample of aggregate into fractions that contain particles within specific limits. The resulting particle size distribution is called the gradation.*

Saturated Surface Dry - *the condition of the aggregate when all permeable pores of each particle are completely saturated with water and its surface has no free moisture.*

If the technician desires to utilize METHOD A for Fine Aggregate wetter than SSD. The entire sample can be dried to at least the SSD condition using temperatures that doesn't exceed specs for other potential testing. ***(SECTION 5.1.2.)***

SCOPE:

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

1.1.

METHOD:

There are several factors that influence the particular method that the technician will chose while working with this procedure. Three of those factors are material type, moisture content, and sample representativeness.

5.

- **The following is quick reference on the method selection for common types of material. There is a detailed description of each method with the type of equipment used.**

METHOD'S AT A GLANCE:

METHOD OF REDUCING

FINE AGGREGATE > SSD (WET) -------- A, B, C

FINE AGGREGATE DRIER SSD ---------- A

COARSE AGGREGATE ---------- A, B

COARSE & FINE AGGREGATE COMBINED (DRIER THAN SSD) ----- A, B

COARSE & FINE AGGREGATE COMBINED (WETTER THAN SSD) ----- B

Splitting aggregate down is necessary to ensure the final, smaller test sample accurately represents the larger field sample. The process allows for accurate testing of gradation, moisture content, and other performance characteristics of the material.

FINE AGGREGATE (DRIER THAN SSD)

METHOD A – MECHANICAL SPLITTER 5.1.

For fine aggregate drier than SSD, if the technician wants to utilize METHOD B or METHOD C. The sample can be moistened, and thoroughly mixed. Then reduced accordingly. ***(SECTION 5.1.1.)***

FINE AGGREGATE (WETTER THAN SSD)

METHOD C – MINATURE STOCKPILE 5.1.2

METHOD B - QUARTERING

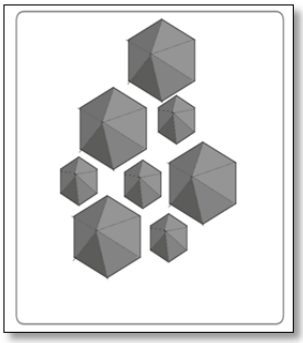
QUARTERING ON CLEAN AND LEVEL SURFACE 10.1.1

QUARTERING ON TARP 10.1.2

QUARTERING SECTORING 10.1.3

GOAL OF REDUCING:

Example of particle distribution of aggregate BEFORE reduction.



GOAL OF REDUCING:

Example of particle distribution of aggregate AFTER reduction.

*If a sample of **FINE AGGREGATE (WETTER THAN SSD)** is very large a preliminary split can be made using a mechanical splitter (METHOD A) with chute opening of 1 ½ inches or more. The sample can't be reduced less than 5000 grams. **(SECTION 5.1.2.)***

COARSE AGGREGATE

=

METHOD A – MECHANICAL SPLITTER **5.2.**

METHOD B - QUARTERING

QUARTERING ON CLEAN AND LEVEL SURFACE 10.1.1

QUARTERING ON TARP 10.1.2

~~**QUARTERING 10.1.3**~~

COARSE & FINE AGGREGATE (DRIER THAN SSD)

=

METHOD A – MECHANICAL SPLITTER **5.3.**

METHOD B - QUARTERING

QUARTERING ON CLEAN AND LEVEL SURFACE 10.1.1

QUARTERING ON TARP 10.1.2

~~**QUARTERING 10.1.3**~~

COARSE & FINE AGGREGATE (WETTER THAN SSD)

=

METHOD B - QUARTERING **5.3.**

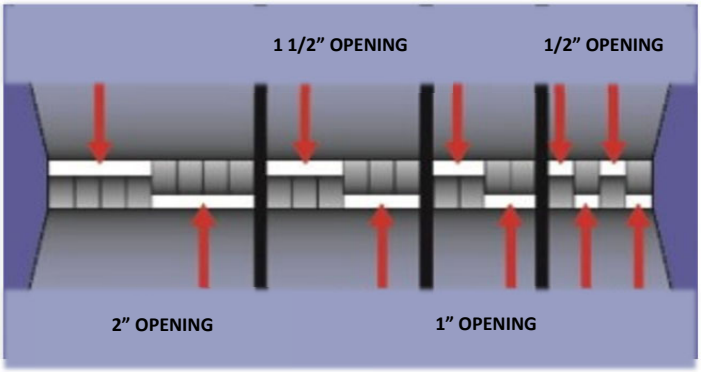
QUARTERING ON CLEAN AND LEVEL SURFACE 10.1.1

QUARTERING ON TARP 10.1.2

~~**QUARTERING 10.1.3**~~

NOTE 1:** Method (quick approximation) described in AASHTO T84 for determining saturated surface-dry condition is if the fine aggregate will retain its shape when molded in the hand. This can be considered to be wetter than saturated surface-dry. **(SECTION 5.1.1.)

NOTE 2:** The dryness of a sample can be tested by squeezing tightly a portion of the material in your hand. If it crumbles easily, you've reached the correct moisture range. **(SECTION 5.3.)



SAMPLING:

A properly taken field sample reflects the true composition, gradation, and properties of the entire lot or batch. If correctly done the final reduction to test size will also be representative.

For COARSE & FINE aggregate WETTER than SSD, If the technician finds it advantageous to utilize METHOD A the entire sample may be dried to where it appears dry or until clumps can be broken up, using temperatures that don't exceed any specs other potential testing. ***(SECTION 5.3.)***

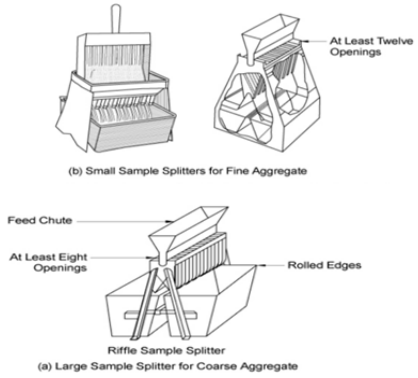
- Obtain samples of aggregate according to **AASHTO R90**, or as **required by individual test methods.** **6.1.**

METHOD A – MECHANICAL SPLITTER:

EQUIPMENT:

SAMPLE SPLITTER ***(SEE PROCEDURE FOR ADDITIONAL DETAILS ON EQUIPMENT)*****:**

- Sample **splitters MUST** have an **even number** of **equal-width chutes**. At least **8 chutes** for **coarse aggregate**, and **12 chutes** for **fine aggregate**. **7.1.**
- **Discharge** will be on **either side** of the splitter with **two receptacles** to catch the material. **7.1.**
- If the material is **coarse or mixed aggregate** then the **minimum width** of the chutes must be **approximately 50% larger** than the **largest particle**. **7.1.**



- If the material is **dry fine aggregate** and **100% passes the 3/8" screen** the **minimum width** of the individual **chutes** shall be at least **50% larger** than the **largest particle** and the **maximum width will be ¾".** **7.1.**

Coarse aggregate with largest particle is ¼", what's the minimum width of the individual chutes using the mechanical splitter?

ANSWER: 3/8"

- The splitter will be equipped with **2 receptacles** to hold the **2 halves of the sample** following splitting. **7.1.**
- It will also be equipped with a **hopper or straightedge 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. Equipment will be constructed in such a way that the sample will flow smoothly without any restriction or loss of material. **7.1.**

NOTE 3: *The mechanical splitters for coarse aggregate should be used on particles 1 ½" or less.* ***(SECTION 8.1.)***

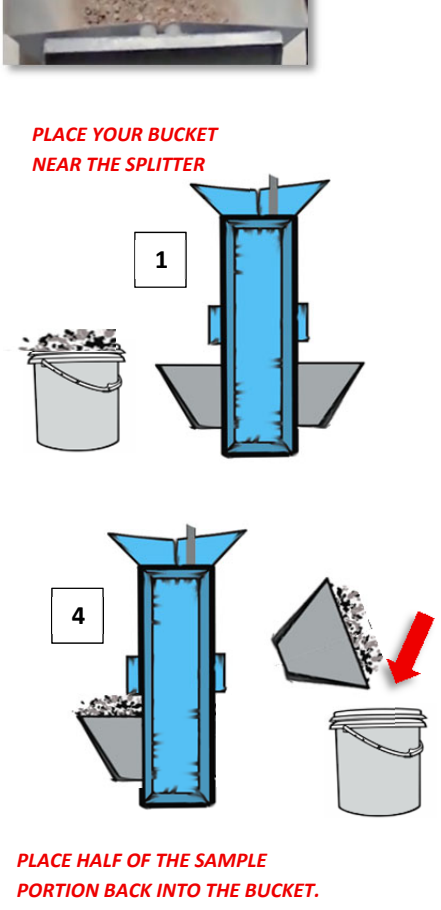
PROCEDURE:

Each agencies / company's splitter equipment may look different but the construction of the apparatus will generally be the same. ***Summary:*** *A large sample is placed in the hopper and slowly and evenly released or evenly distributed over the chutes. Material will fill each receptacle then the process will be repeated until the approximately correct test amount is achieved.*

1. Place the **sample** in the **hopper or pan** and distribute sample from **edge to edge**. Introduce at a **rate** that allows **approximately equal amounts** of material to **flow freely** through the chutes. **8.1.**

2. Reintroduce **one portion** of the sample from one of the receptacles back **into the splitter** while placing the **other portion into a container**. **8.2.**

3. Keep **splitting** until the sample is **reduced** to the size required for that intended test. **8.2.**

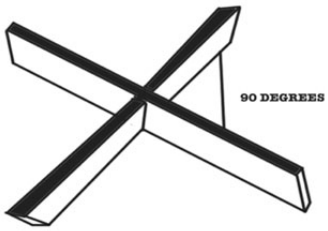


METHOD B – QUARTERING:

EQUIPMENT:

9.

- **STRAIGHT EDGE OR SHOVEL**
- **SPATULAS OR TROWELS**
- **BROOM OR BRUSH**
- **STICK OR PIPE**



ILLUSTRATED QUARTERING TEMPLATE (EXAMPLE OF DIMENSIONS)

- **TEAR RESISTANT RECTANGULAR TARP- appropriate** for the **amount** and size of the material being reduced.
- **QUARTERING TEMPLATE:** In the **shape of 90° sides that exceed the diameter** of the **flattened cone** of material. The **height** of the sides must **be sufficient to extend above the thickness** of the flattened cone of the sample. ***(See procedure for additional details)***

PROCEDURE:

10.1.1 Quartering on a Clean, Hard, Level Surface:

For quartering, use the procedure described in Section 10.1.1., 10.1.2.,10.1.3 or any combination.

STOCKPILE ON CLEAN, HARD, LEVEL SURFACE.

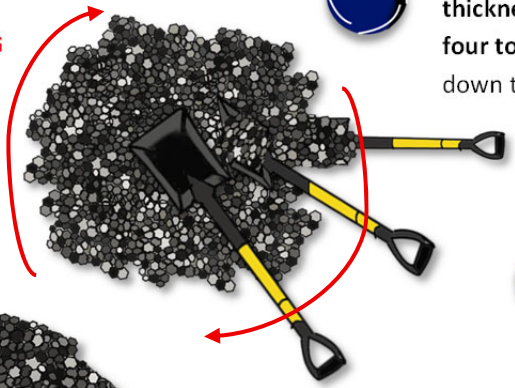
1 Place the **sample** on a **clean, hard, level surface** where there will **NOT** be loss of material or contamination by foreign material.

10.1.1.1.

2 **Turn the entire** sample over at least **three times** to **mix** the sample. Deposit each individual lift on top of the preceding lift. By the **last turn** ensure that the material has been formed into a **conical pile.**

10.1.1.2

GO AROUND THE PERIMETER TURNING THE SAMPLE TO MIX



3 **Carefully flatten** the **conical** pile to a **uniform thickness.** The **diameter** should be approximately **four to eight** times the thickness by pressing down the top with a shovel or trowel.

10.1.1.3

CREATE A CONICAL PILE

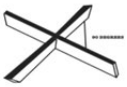
4 **Divide** the **flattened** mass into **approximately four equal parts**. With a:

10.1.1.4

Shovel

Straight edge

Trowel

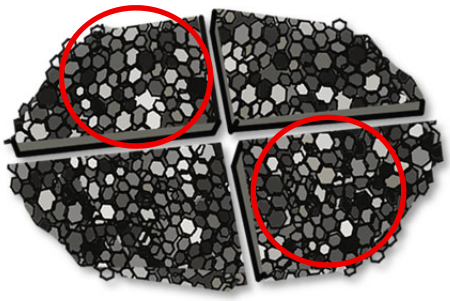


Quartering Template

FLATTEN SAMPLE.
DIAMETER = 4 TO 8 TIMES THE THICKNESS

5 **Remove** the **two diagonally opposite** quarters **(*including all the fine material using a brush*). S**et aside the unused quarters for later testing. **Repeat** the above steps until **the required amount** is achieved.

10.1.1.5 / 10.1.1.6.



SAMPLE IS OBTAINED FROM THE COMBINED DIAGONALLY OPPOSITE QUARTERS.

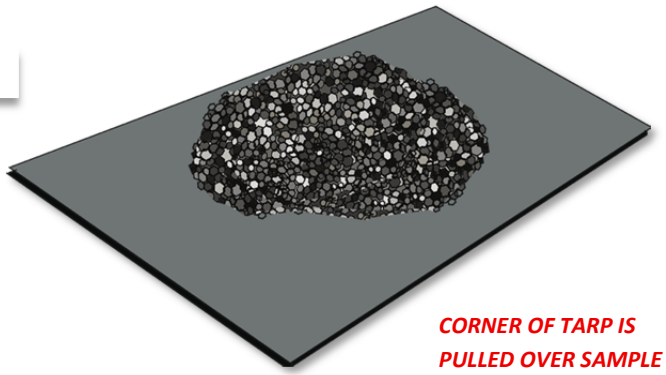
10.1.2 Quartering on a Tarp:

As an alternative to Quartering on a Clean, Hard, Level Surface (Section 10.1.1) or when the floor surface is uneven.

SAMPLE IS PLACED ON A TARP

1 ***1st way to use the tarp:*** Place the sample on a tarp and mix with a shovel or trowel, leaving the sample in a conical pile. Flattening, then dividing. All steps will be identical (except for the sample placement on a tarp) to ***Quartering on a Clean, Hard, Level Surface Section 10.1.1.***

10.1.2.1.

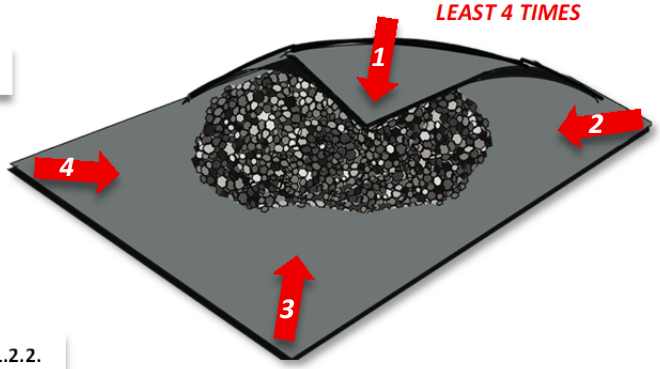


OR

CORNER OF TARP IS PULLED OVER SAMPLE TOWARD DIAGONALLY OPPOSITE CORNER. AT LEAST 4 TIMES

1 ***2nd way to use the tarp:*** Place the sample **on a tarp** and **lift each corner** of the tarp and **pull it over the sample toward diagonally opposite corner**. This action causes the material to be rolled and subsequently mixed.

10.1.2.2.



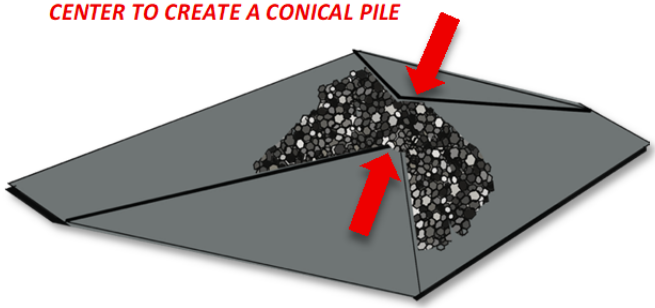
2 **Roll** the material **at least four** times until it is **thoroughly mixed**.

10.1.2.2.

3. Pull **each corner** of the tarp **toward the center** of the pile so the material will be molded into a **conical pile.**

10.1.2.3.

PULL EACH CORNER TOWARD THE CENTER TO CREATE A CONICAL PILE



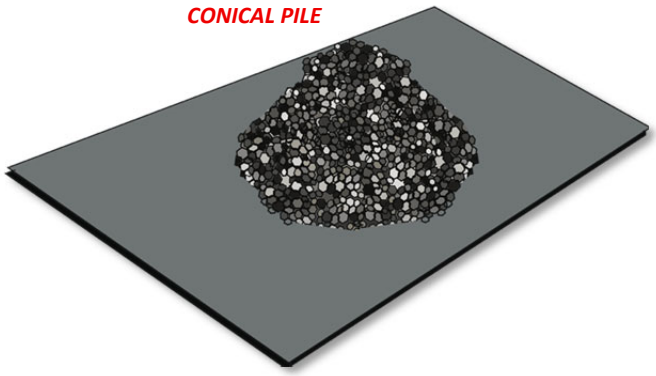
4. **Flatten** the pile. ***(described in Section 10.1.1.3 Quartering on a Clean, Hard, Level Surface)***

10.1.2.4.

5. **Divide** the sample by **inserting a stick (or pipe)** beneath the tarp and **under the center of the pile, then lift both ends** of the stick (or pipe), dividing the sample **into two approximately equal parts.**

10.1.2.5.

CONICAL PILE



6. **Remove** the stick (or pipe), leaving **a fold of the tarp between the divided portions.**

10.1.2.6.

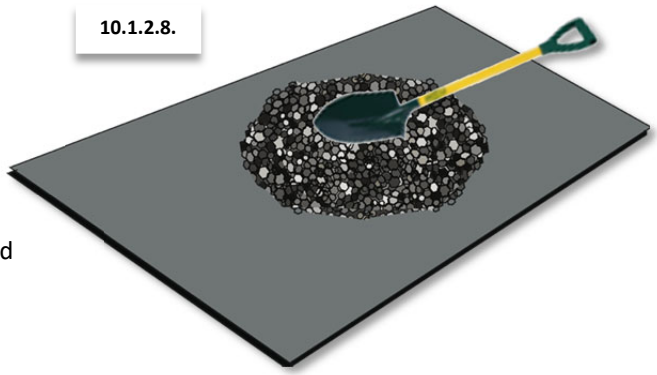
7. **Insert** the stick (or pipe) under the center of the pile **at right angles to the first division** and again **lift both ends** of the stick (or pipe), **dividing** the sample into **4 approximately equal parts**

10.1.2.7.

FLATTEN SAMPLE.
DIAMETER = 4 TO 8 TIMES THE THICKNESS

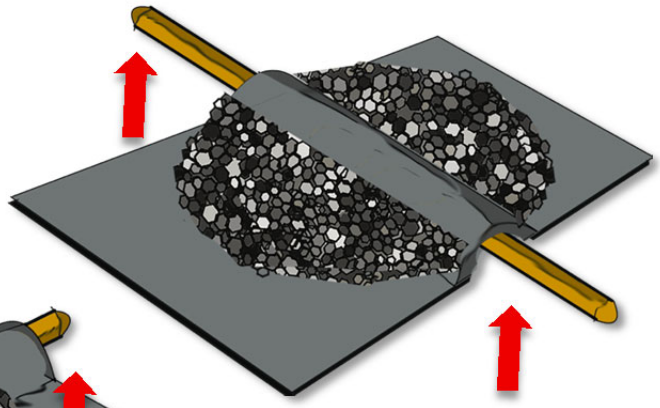
8. **Remove two diagonally opposite quarters, including all the fines left on the tarp.** The two unused quarters may be set aside for later use or testing.

10.1.2.8.

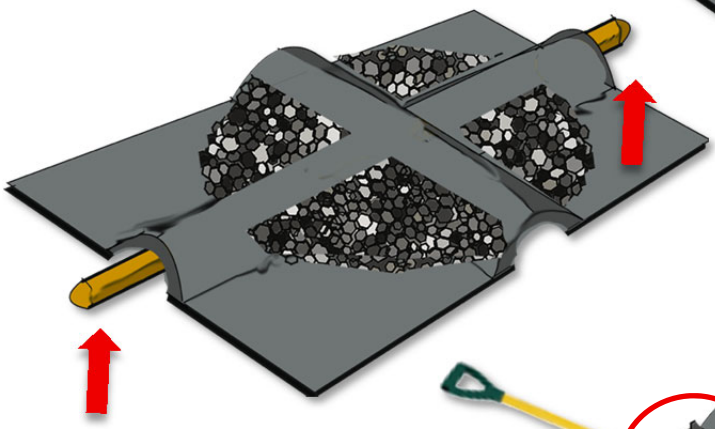


9. **If necessary, repeat these steps** until the required sample size is obtained. **The final reduction will consist of 2 diagonally opposite quarters.**

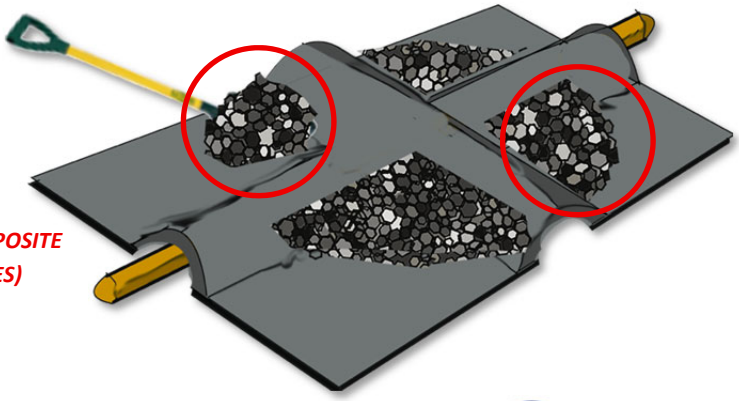
10.1.2.9. / 10.1.2.10.



REMOVE STICK AND INSERT THROUGH THE CENTER AT A RIGHT ANGLE TO THE FIRST DIVISION. LIFT BOTH ENDS



INSERT STICK (OR PIPE UNDER CENTER OF PILE. LIFT BOTH ENDS DIVIDING HALF THE PILE



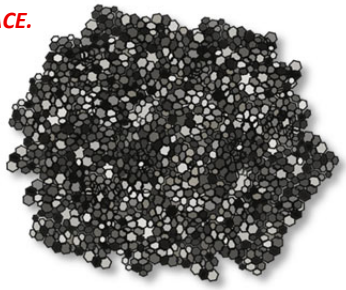
REMOVE TWO DIAGONALLY OPPOSITE QUARTERS (INCLUDING ALL FINES)

10.1.3 Quartering Sectoring:

1. Place the **sample** on a **clean, hard, level surface** where there will **NOT** be loss of material or contamination by foreign material.

10.1.3.1

STOCKPILE ON CLEAN, HARD, LEVEL SURFACE.



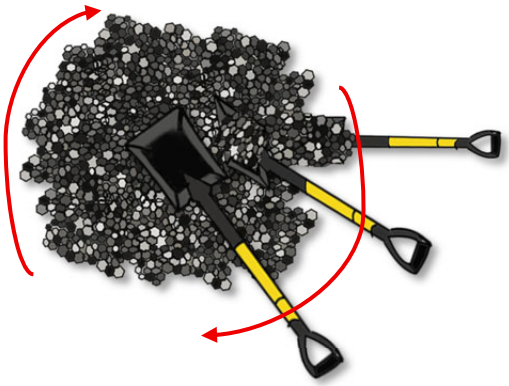
2. **Turn the entire** sample over at least **three times** to **mix** the sample. Deposit each individual lift on top of the preceding lift. By the **last turn** ensure that the material has been formed into a **conical pile.**

10.1.3.2

3 **Carefully flatten** the **conical** pile to a **uniform thickness.** The **diameter** should be approximately **four to eight** times the thickness by pressing down the top with a shovel or trowel.

10.1.3.3

GO AROUND THE PERIMETER TURNING THE SAMPLE TO MIX



4 **Divide** the **flattened** mass into **approximately four equal parts**. With a:

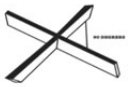
10.1.3.4

CREATE A CONICAL PILE

Shovel

Straight edge

Trowel



Quartering Template

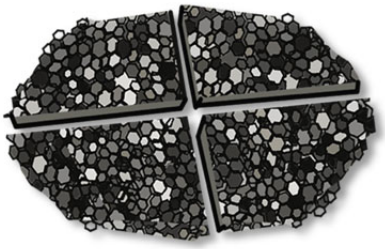
5 Use a **straight edge** to slice through the center of one of the **quarters until it reaches the outer edge of the quarter.** Achieve complete separation.

10.1.3.5

FLATTEN SAMPLE.
DIAMETER = 4 TO 8 TIMES THE THICKNESS

6 **Pull or drag the sector from the quarter** with two straightedges or hold one edge of the straight-edge in contact with a quartering device.

10.1.3.6.

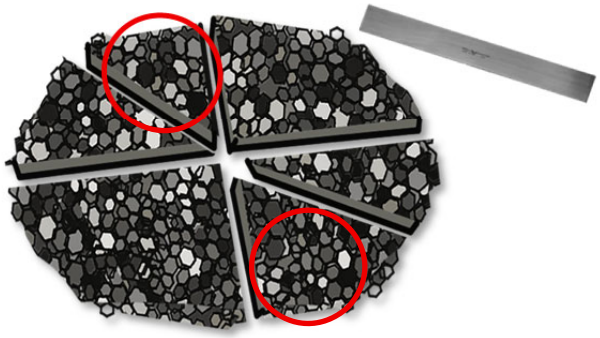


SPLIT INTO QUARTERS.

7 **Remove approximately equal sectors** from **diagonally opposite quarters** and combine. **Repeat procedure until the required amount is obtained.**

10.1.3.7

DIVIDE THE QUARTERS IN HALF AND SAMPLE IS OBTAINED FROM THE COMBINED DIAGONALLY OPPOSITE SECTORS.



METHOD C – MINATURE STOCKPILE SAMPLING:

EQUIPMENT:

- **STRAIGHT EDGE, FLAT BOTTOM SCOOP, SQUARE POINT SHOVEL, OR TROWEL –** for mixing the aggregate.
- **A SMALL SAMPLING THIEF, SMALL SCOOP, OR SPOON –** for sampling**.**

11.

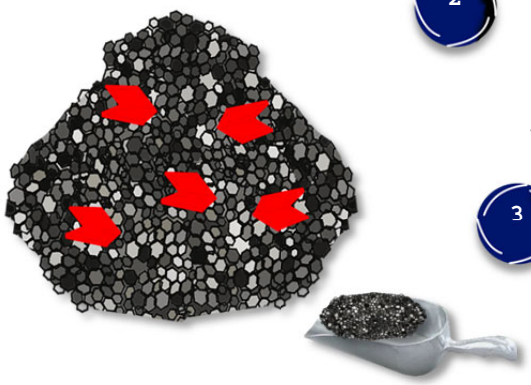
PROCEDURE:

This method is specifically designed for damp fine aggregate. By thoroughly mixing the sample and taking portions from different random locations, the method ensures the final test sample has the same characteristics as the original larger sample

1 Place the original **damp fine aggregate** sample on **a clean, hard, level surface** where there will **NOT** be loss of material or contamination from foreign material.

12.1.

AT LEAST 5 RANDOM INCREMENTS



2 **Turn** the **entire sample** over **at least three times** to mix. Deposit each individual lift on top of the preceding lift. By the **last turn** ensure that the material has been formed into a **conical pile. Verify** that the material is **thoroughly mixed**.

12.2./ 12.3.

3 **Obtain** a test sample by selecting at least **5 increments from random locations**. Using any of the sampling equipment described in Section 11.

12.4.

The conical pile may be flattened to a uniform thickness and diameter by pressing the top with a shovel or trowel so that each quarter sector of the resulting pile will contain the material originally in it. ***(SECTION 12.3.)***

AASHTO R67:

SAMPLING ASPHALT MIXTURES AFTER COMPACTION (CORES)

DEFINITIONS:

Cores - *is a reliable method for the extraction of representative samples from completed asphalt or concrete installations.*

Lift - *is a layer of asphalt pavement that is applied to a base or previous layer.*

SCOPE:

This standard covers the process for removal of core samples for laboratory testing. Core diameter range maybe from 2 inches to 12 inches.

1.1.

EQUIPMENT:

- **CORE DRILLING MACHINE-** Must be **power driven** and capable of obtaining a **core to the full depth** of the **asphalt mixture**. Have a rigid frame or platform so that the core barrel can be **maintained perpendicular to the surface during the drilling process.** The core drilling machine must be of sufficient horsepower and have the ability to reach a sufficient depth to **minimize distortion** of the compacted cores.

4.

- **CORE DRILL BIT –** The **cutting edge** of the core **drill bit** must be made of **hardened steel or other suitable material with diamond chips** embedded in the metal **or see manufacturer's recommendation**. The inside diameter of the core barrel must be specified.

- **SEPARATION EQUIPMENT – A saw** or **other method** that provides a clean, smooth, plane, layer to be tested without damage.

SEE PROCEDURE FOR ADDITIONAL DETAILS & DIMENSIONS. NOT ALL EQUIP INFO IS COVERED IN THIS MANUAL

EXAMPLE OF CORING MACHINE:

- **RETRIEVAL DEVICE-** A **device** that will **remove the core without affecting** the **integrity of the specimen.**

- **COOLING AGENT – Water, Ice, Dry Ice, or liquid nitrogen.**

- **SAMPLE MARKING TOOL- A lumber crayon, paint stick, pen, or other suitable marking tool** to mark the core for labeling, identifying the separation layers, identifying the layer to test.

- **PACKAGE CONTAINERS-** Suitable packaging containers for **securing and transporting the core samples.**

PROCEDURE:

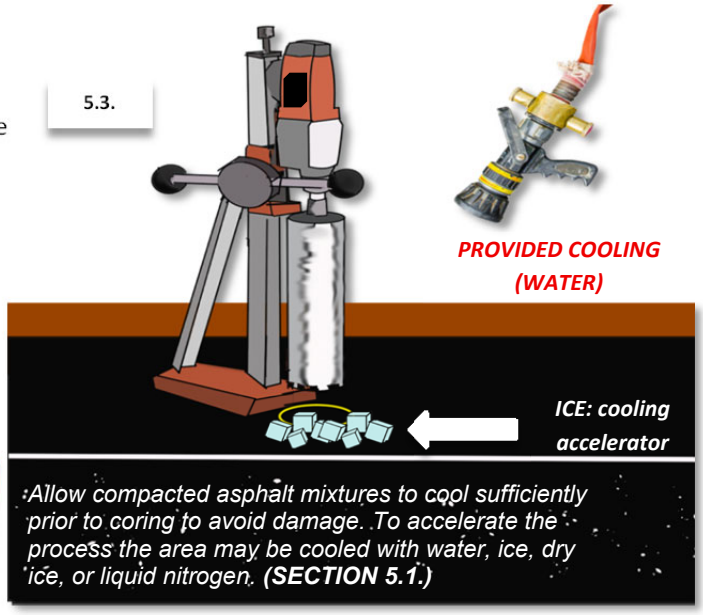
Coring asphalt is a common practice in the construction of roads and pavements. The process involves extracting a cylindrical sample (core) from an asphalt pavement using a core drill. This sample is then analyzed to assess the properties and condition of the pavement.

1. Ensure that a means, such as water or air, to aid in the removal of cuttings and to minimize the generation of heat caused by friction is provided.

5.2.

2 **Position** the **core drilling machine** over the **desired sampling location**. **Begin** the machine **(along with the water or air)** and **advance slowly** until it contacts the asphalt surface.

5.3.



CAN I CORE BEFORE THE MATERIAL IS COMPACTED?

ANSWER: No only core after it is compacted and after it has cooled sufficiently!

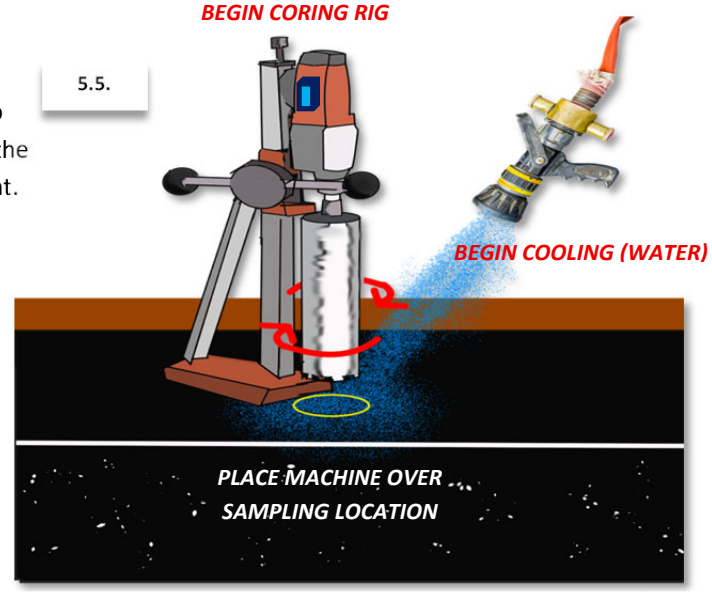
*Allow compacted asphalt mixtures to cool sufficiently prior to coring to avoid damage. To accelerate the process the area may be cooled with water, ice, dry ice, or liquid nitrogen. **(SECTION 5.1.)***

3 Keep the core bit **perpendicular to the surface** while **applying constant pressure downward**.

5.4.

4 Continue **drilling to the bottom or slightly below** the asphalt mixture being sampled to **allow full separation** of the core sample at the desired depth from the underlying pavement.

5.5.



5 After drilling, **separate** the **core sample from the underlying layers** using the **retrieval device (or other appropriate way) without damaging or distorting the sample**. **Brush** off or use **water** to **wash off** any loose particles on the sample. If taken over a granular base, carefully remove any embedded granular material.

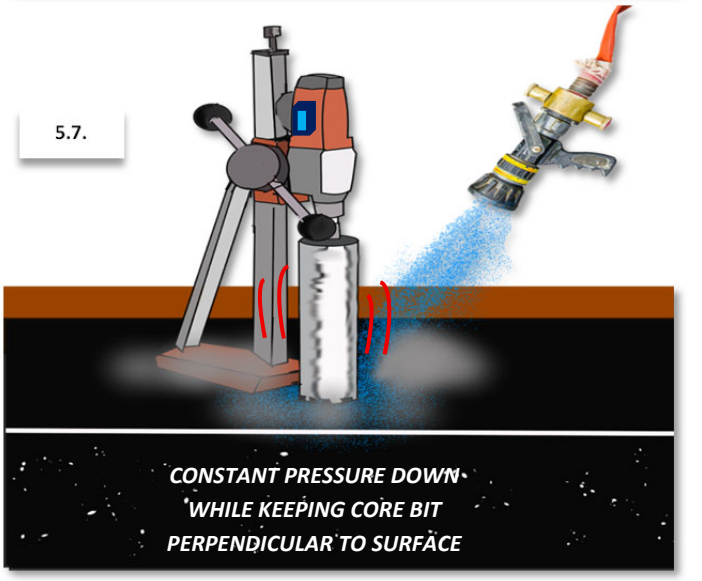
5.6.

6 **Clearly label** the core with the marking tool.

5.7.

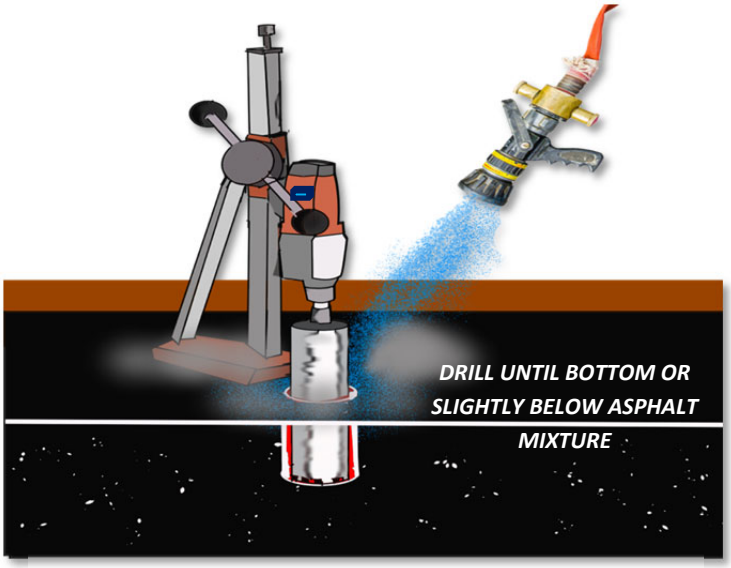
7 **Fill the resulting hole** with **asphalt mixture**, non-shrink grout, or other suitable material. Compact the material in multiple lifts if necessary. **Make sure the final surface is level** with the surrounding surface.

5.8.



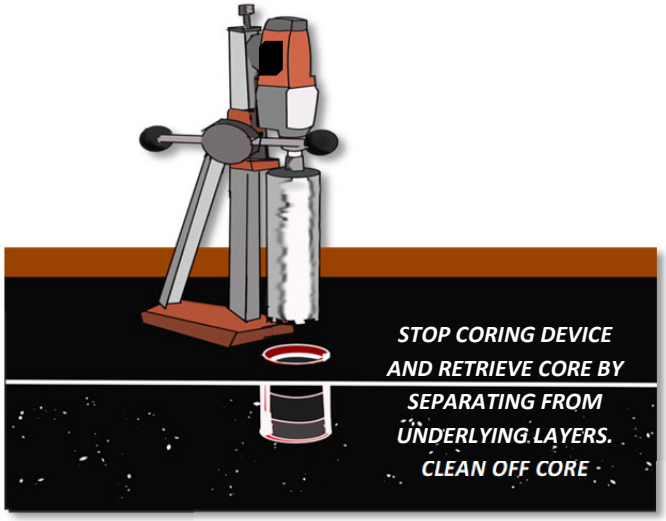
WHAT HAPPENS IF CONSTANT PRESSURE IS NOT APPLIED OR TOO MUCH PRESSURE IS APPLIED?

If constant pressure is not applied or too much pressure is applied then this may cause the core drill to bind or distort the core. ***(SECTION 5.4. NOTE 3.)***

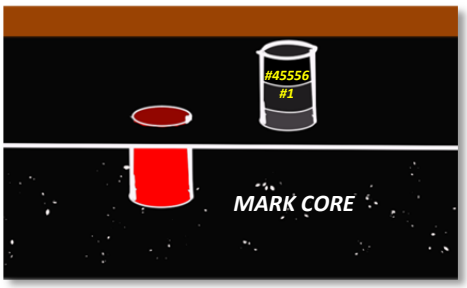


Open-Head **Closed-Head**

EXAMPLES OF CORE BITS:



NOTE 4: *If the core is damaged to a point that it cannot be used, a new core shall be obtained within 6 inches.* ***(SECTION 5.8.)***



Suitably packaging and transporting asphalt cores is essential to ensuring the integrity of the asphalt core specimens for later laboratory testing. Without proper care contamination, damage, and temperature changes can alter the cores properties making any subsequent test results unreliable.

- Place **cores** in suitable **protective containers**. If **multiple cores** must be **placed** in the same **container**, then **separate from one another using suitable separation material.** **6.1.**
- **Transport** samples in a way that **prevents** damage from **jarring, rolling, or impact with any object**. **6.2.**

NOTE 5: Examples of suitable containers:
concrete cylinder molds, PVC or HDPE pipe, coolers of various sizes

Examples of suitable separation material:
Crumpled up newspaper, soda transport material, Styrofoam cut appropriately ***(SECTION 6.1.)***

- **Prevent** cores from **freezing** or from **excessive heat**. 6.3.

NOTE 6: *In extreme temperature conditions, an insulated container should be used during transport.* ***(SECTION 6.3.)***

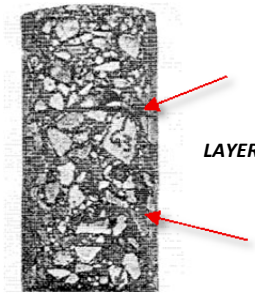
- If the core is **damaged significantly (or can't be used for its intended purpose)** during transport, then the core **cannot be used for testing**. 6.4

A layer is a distinct lift or course of asphalt (or other pavement material) that was placed and compacted separately during pavement construction.

LAYER SEPERATION:

- Using appropriate separation equipment, separate two or more pavement courses, lifts, or layer along the designated lift line. 7.1.

NOTE 7: *Lift lines are often more visible by rolling a wetted core on a flat surface.* ***(SECTION 7.1.)***



LAYERS/LIFTS

REPORT

8.1

IDENTIFICATION & SHIPPING

Date
Paving Date
Coring Location
Lift / Layer
Average Thickness (if required)

IDENTIFICATION & SHIPPING (CONTINUED)

IF KNOWN:
Nominal Maximum Aggregate Size
Asphalt Mixture Design Info
Grade of Binder

- **Please refer to approved agency or companies' internal procedures and forms. This EXAMPLE does not necessarily demonstrate all that may be required.**

PRACTICE QUESTIONS:

1. What is the minimum sample size for liquid asphalt & emulsions (according to AASHTO R66)?

    a. 1 quart for liquid asphalt & 1 quart for emulsions.
    b. 1 gallon for liquid asphalt & 1 quart for emulsions
    c. 1 quart for liquid asphalt & 1 gallon for emulsions

2. A Double-seal friction-top can is used to sample what type of material (according to AASHTO R66)?

    a. Emulsions
    b. Asphalt binder
    c. Soils

3. What kind of material does a technician use a wide mouth plastic jar to sample (according to AASHTO R66)?

    a. Asphalt binder
    b. Emulsions
    c. Soils

4. When sampling from a Windrow remove approximately _____ before taking your sample (according to AASHTO R97).

    a. 2 feet
    b. 1 foot
    c. 3 feet

5. What method is used to reduce fine aggregate (drier than SSD) (according to AASHTO R76)?

    a. METHOD A – Mechanical Splitter
    b. METHOD B – Quartering
    c. METHOD C – Miniature Stockpile

6. When transporting cores the technician has to protect them from _____ & excessive heat (according to AASHTO R67)?

    a. Rain
    b. Theft
    c. Freezing

7. When a front loader creates a flat pad to sample from how many random increments does the technician take to make up one sample (according to AASHTO R90)?

    a. 3
    b. 2
    c. 1

ANSWERS:

1. a
2. b
3. b
4. b
5. a
6. c
7. a

In Place Density NON- Nuclear & Associated Procedures

There are various tools utilized by the soil testing technician to determine the density of soil. In-place density testing provides essential data that ensures foundation stability, maintaining quality control, designing safe structures, and complying with specs. Non-Nuclear density testing is a very straight forward methodology and very cost effective in providing accurate measurements. Rapid test methods were developed specifically for the field technician so real time results could be achieved, saving both money and time. Procedures such as the Moisture Content by Calcium Carbide Method (which is a rapid test to determine moisture content) and One-Point Method for Determining Maximum Dry Density & Optimum Moisture (which is for determining the dry density & moisture content for soil rapidly in the field without having to return to the lab) aid in the determination of whether proper compaction has been achieved.

All in place density procedures (non-nuclear), max dry density & optimum moisture, and volume measure calibration procedures covered by ATTI:

- **AASHTO T191:** *DENSITY OF SOIL IN-PLACE BY THE SAND CONE METHOD*
- **AASHTO T217:** *MOISTURE CONTENT BY CALCIUM CARBIDE METHOD*
- **AASHTO T272:** *ONE-POINT METHOD FOR DETERMINING MAXIMUM DRY DENSITY & OPTIMUM MOISTURE*
- **ANNEX T99:** *CORRECTION FOR MAX. DRY DENSITY & OPTIMUM MOISTURE CONTENT FOR OVERSIZED PARTICLES*
- **AASHTO T19 SECTION 8:** *CALIBRATION OF MEASURE*

Learning objectives for these sections are:

- ***How to perform and calculate in place density and moisture.***
- ***How to properly calibrate a volume measure.***
- ***How to determine max dry density and optimum moisture along with graphing.***
- ***How to correct max dry density and optimum moisture if the sample contains oversized particles.***
- ***Learn the basic terminology for density determination.***

PLEASE REFER TO THE SECTION FOUND IN THE PROCEDURE FOR MORE DETAIL. THE SECTION NUMBER WILL BE PROVIDED FOR REFERENCE. SUBJECT TO CHANGE.

AASHTO T191:

DENSITY OF SOIL IN-PLACE BY THE SAND-CONE METHOD

DEFINITIONS:

In-Place Dry Density- *is a measure of how compact a material is, and is calculated by comparing its weight to the volume of space it occupies.*

Volume – *a measure of a region within 3-dimensional space.*

Dry Mass – *the weight of the material after the water content has been removed.*

SCOPE: 1.1

This method is intended for determining the in-place density of soils. The equipment described in this method is restricted to tests in soils containing particles 2 inches or less in diameter.

EQUIPMENT: 3.

- **DENSITY APPARATUS WITH BASE PLATE-** Consists of **1 gallon jar** and **detachable apparatus** that consists of a **cylindrical valve with a hole ½" in diameter and a small funnel on one end connecting to a larger diameter funnel one on the other end.** The valve must have stops to prevent the valve from rotating the valve past the completely open or completely closed position. **Base plate** will be constructed of metal and be rigid. There must be a **flanged center hole to accommodate the larger diameter funnel end**.
- **CALIBRATION CONTAINER** – a **cylindrical container with a known volume**. The calibration container will be dimensionally approximate to the largest test hole that will be dug. **Calibrated according to AASHTO T19 Section 8**.
- **SAND –** any **clean dry free-flowing uncemented sand**. Very **few**, if any, of the particles can **pass the #200 (0.075 mm)** or can be **retained** on the **#10 (2.00 mm)** screen. **Several bulk density determinations** should be made using the same representative sample for each determination. To be **acceptable**, the sand will not vary in bulk **density more than 1 percent**.
- **BALANCES / SCALES -** that have the requirements of **AASHTO M231 (G2 & G20).** Readable and sensitive to the **nearest 0.1 grams** & one that is readable and sensitive to the **nearest 0.01 lbs (5 grams).**
- **EQUIPMENT –** small pick, chisels, spoons, buckets with lids, brushes, something to measure with ALSO drying equipment may be necessary.

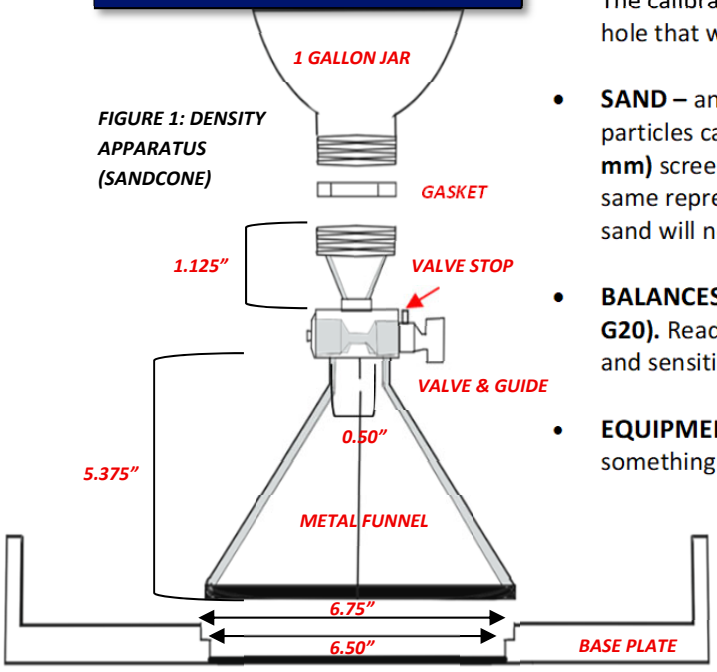


FIGURE 1: DENSITY APPARATUS (SANDCONE)

SEE PROCEDURE FOR ADDITIONAL DETAILS & DIMENSIONS. NOT ALL EQUIP INFO IS COVERED IN THIS MANUAL

***Sand Cone Density Test*- is an accurate and reliable test method that measures the in-place density of soils. Results from this field test are compared to the Proctor test results of the similar soil. The ratio of the two results will then provide the percent compaction. Since the results of Proctor tests vary widely with soil types, the best results are achieved using lab samples from the same source used in the field. This method is widely applied because of its accuracy and reliability; and its long history of accepted results.**

CONE CORRECTION:

The cone correction is, a factor for the sand used to fill the cone and the hole recess of the plate. If this displacement is not accounted for, the calculation of the in-place density would be too high, leading to inaccurate test results. This ensures that the volume of sand actually used to fill the hole (and not the apparatus) is accurately measured.

- **Fill** the apparatus with **dried sand**. The apparatus can **be filled while the funnel is still attached** or **filled after removing the funnel** then, when filled reattaching the funnel as before. Ensure that the sand is dried and conditioned to a similar state as it will be during testing. **4.1.1**

- **Weigh and record** the sand cone apparatus filled with sand. Record the weight to the nearest **0.01 lbs (or nearest 1 gram [conversion needed]).** ***Record this weight as M1 to follow the AASHTO calculation / example*** **4.1.2**

- Place the base plate on **clean, level, plane surface**. Invert the sand cone filled with sand and **seat the funnel in the recess of the base plate**. **4.2.1**

- **Open** the **valve fully** and allow the sand to **flow until it stops**. **4.2.2**

- **Close the valve** sharply and fully, remove the apparatus and **weigh** with the remaining sand in the device. ***Record this weight as M2 to follow the AASHTO calculation / example*** **4.2.3**

CONE CORRECTION CALCULATION:

Cc = M1 – M2

Cc = cone correction;
M1 = Weight of apparatus filled with sand;
M2 = Weight of apparatus after opening the valve and flow have ceased;

EXAMPLE:

WEIGHT OF APPARATUS FILLED: ***10.23 lbs.***

WEIGHT OF APPARATUS EMPTIED: ***6.97 lbs***

10.23 – 6.97 = 3.26

Cc (CONE CORRECTION): ***3.26 lbs***

BULK DENSITY SAND:

The bulk density of sand factor (also called the sand factor) is a calibration factor used in the sand cone test to convert the weight of the sand (used to fill the hole) into a volume measurement.

- **Replace** the sand used during the cone correction procedure. Close the valve and **weigh and record apparatus to the nearest 0.1lbs (or nearest 1 gram [conversion needed]).** ***Record this weight as M3 to follow the AASHTO calculation / example*** **4.3.1**

- Place the calibration container on **clean, level, plane surface.** Carefully place the **base plate on the calibration container.** Invert the sand cone filled with sand and **seat** the **funnel in the recess of the base plate**. **4.3.2**

- **Open the valve fully** and allow the sand to flow until it stops. **4.3.3.**

- Once flowing has **stopped**, close the valve sharply & completely, remove from the base plate and **weigh and record to the nearest 0.01 lb. (or nearest 1 gram [conversion needed]).** ***Record this weight as M4 to follow the AASHTO calculation / example.*** **4.3.4**

- To calculate the **mass of the sand needed to fill the container, funnel, and base plate**. **Subtract M4 from M3, record your answer to the nearest 0.01 lb. or nearest 1 gram [conversion needed]).** **4.3.5.**

- Then calculate **the mass of the sand needed to fill the container only.** Subtract the cone correction (Cc) from the above result of M3 – M4 record **result to the nearest 0.01 lbs. (or nearest 1 gram [conversion needed]).** Repeat these steps / and calculations **three times then average the results**. Then finally, take this number and **divide it by the known volume** of the container. **Record your answer to the nearest *0.1 lb / ft^3(or kg/ m^3)*** **4.3.6. / 4.3.8.**

*Each container / bag of sand will have a unique cone correction and sand calibration factor. Each sand cone and base plate must be marked to indicate they are a set and the associated correction / density factors must be recorded. **(SECTION 4.4.)***

DENSITY OF SAND CALIBRATION FACTOR:

$$D_b = \frac{(M3 - M4 - Cc)}{Vc}$$

D_b= Sand calibration factor;
M3 = Weight of apparatus filled with sand;
M4 = Weight of apparatus after opening the valve and flow have ceased;
Cc = Cone correction;
V_c = ***volume of the calibration container (AASHTO T19)***

EXAMPLE

M3 – M4 – Cc = x
M3 – M4 – Cc = y
M3 – M4 – Cc = z

$$\frac{x + y + z}{3} = m \rightarrow \frac{m}{V_c} = D_b$$

1ST TRIAL RESULT: 13.56 lbs – 4.18 lbs – 3.26 lbs = 6.12 lbs
2$^{ND\ T}$ TRIAL RESULT: 13.55 lbs – 4.16 lbs – 3.26 lbs = 6.13 lbs
3rd TRIAL RESULT: 13.57 lbs – 4.20 lbs – 3.26 lbs = 6.11 lbs

$$\frac{6.12 + 6.13 + 6.11}{3} = 6.12 \text{ lbs} \rightarrow \frac{6.12}{0.0739} = 82.8\ lb / ft^3$$

ANSWER

V_c = *0.0739 ft^3 (SEE CALCULATION FROM AASHTO T19 (CALIBRATION))*

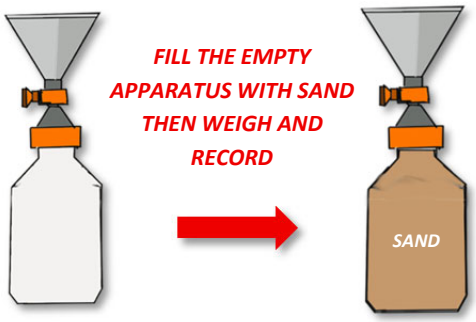
HOW DO I OBTAIN MY DENSITY FACTOR IF I WEIGH EVERYTHING TO THE NEAREST 1 GRAM?

- All previous steps were weighed and recorded to the nearest 1 gram.
- **Taking our example if all our results averaged equaled 2776 grams (6.12 lbs, approximately)**
- The conversion is 1lb = 453.6 grams
- **So, our new equation would look like** $\frac{2776}{(453.6 * 0.0739)} = 82.8\ lb / ft^3$

SUMMARY: *Fill the apparatus then weigh. Level and prepare the testing surface. Place base plate and dig hole from the center of the plate. Collect soil from the hole dug and weigh. Place apparatus over the hole, open the valve and fill the hole with density sand. Remove the apparatus, weigh and then calculate.*

PROCEDURE:

1. **Fill** the apparatus with dried **sand. Weigh** the apparatus filled with sand and **record to the nearest *0.01 lbs.* (or nearest 1 gram [conversion needed]). *Record this weight as M5 to follow the AASHTO calculation / example.*** **5.1.1**



2. Prepare the testing location surface so that it is **level and plane**. **5.1.2**

3. **Seat the base plate** on the level & plane surface. **Dig the test hole** inside the **opening of the base plate**. Place all loosened **soil in container** with a **top, be careful not to lose any material. To avoid moisture loss, keep the top on as you are digging only remove when actually placing material into the container then immediately replace the top.**

5.1.3.

4. Place the sand cone device on the **base plate** and **open** the **valve.** Close sharply after the sand has stopped flowing.

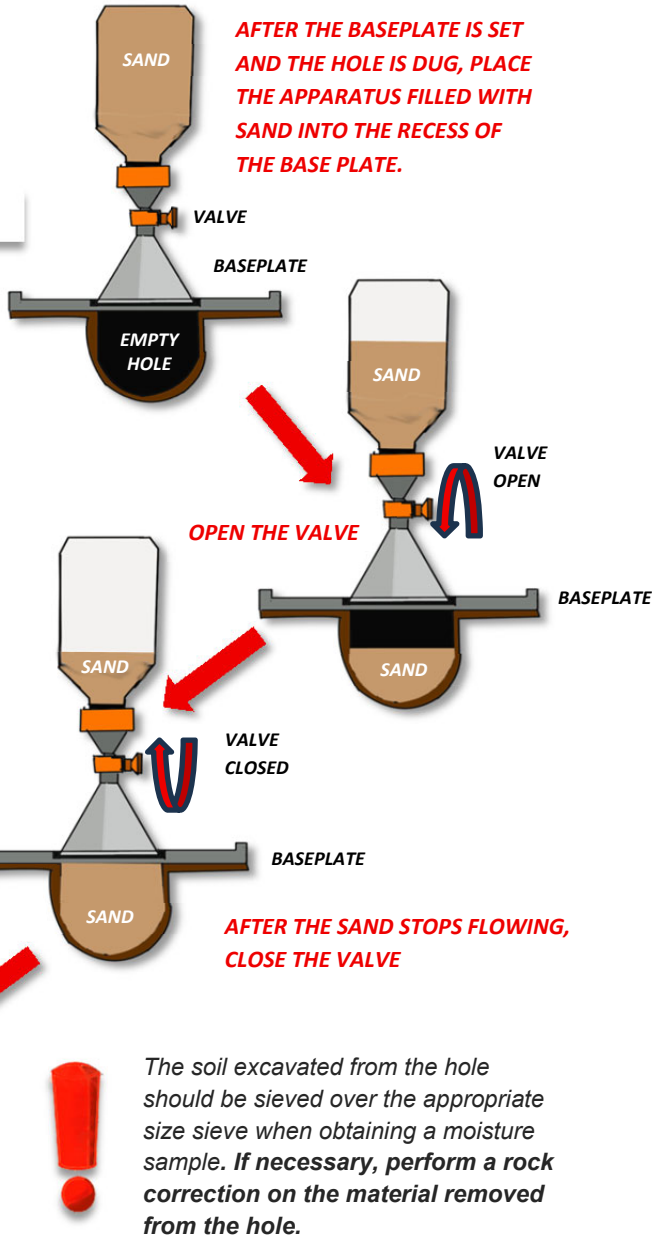
5.1.4

When digging, be careful not to disturb the soil that bounds the hole dug. Take extra care while digging in material that is more granular. ***(SECTION 5.1.3.)***

5. **Weigh** the apparatus with the remaining sand and **record to the nearest 0.01*lb.* (or nearest 1 gram [conversion needed]).** ***Record this weight as M6 to follow the AASHTO calculation / example.***

5.1.5

- ***SEE MOISTURE SECTION BELOW FOR ADDITIONAL STEPS***



AFTER THE BASEPLATE IS SET AND THE HOLE IS DUG, PLACE THE APPARATUS FILLED WITH SAND INTO THE RECESS OF THE BASE PLATE.

6. **Calculate and record** the volume of the test hole to the nearest **0.0001** ft^3

6.1.1.

WHAT IS THE VOLUME OF THE TEST HOLE WITH THE FOLLOWING VARIABLES?

Cone Correction: *3.26lbs*
Density of Sand: *82.8lbs/ft3*
M5: *14.59lbs*
M6*: 6.35lbs*

VOLUME OF TEST HOLE:

$$V_h = \frac{(M5 - M6 - Cc)}{D_b}$$

D_b =Density of Sand calibration factor;
M5 = Weight of apparatus filled with sand;
M6 = Weight of apparatus after opening the valve and flow has ceased;
Cc = Cone correction;
V_h = Volume of the test hole;

$$V_h = \frac{(? - ? - ?)}{?}$$

ANSWER: 0.0601 ft3

The soil excavated from the hole should be sieved over the appropriate size sieve when obtaining a moisture sample. ***If necessary, perform a rock correction on the material removed from the hole.***

MOISTURE:

The sand cone test gives you the in-place wet (bulk) density of the soil (moist soil weight / volume of hole). But field compaction standards are typically based on dry density (from Proctor test) compared to dry density of some in-place density method (in this case the sand cone method), so you must account for the effect of moisture.

7 **Weigh the material** that was removed from the **test hole**. 5.1.6.

Obtain the tare weight of the container so that the sample can be easily weighed.

8 **Mix** the material thoroughly, obtain a **representative sample** for moisture determination, **weigh and record**. 5.1.7

9 **Dry & weigh** the sample according to ***(see procedure for additional methods):*** 5.1.8.

AASHTO T 265: *Moisture Content of Soils*

OR

AASHTO T217: *Speedy Moisture Determination* (must be corrected to AASHTO T265)

*Calculate **the MOISTURE CONTENT** to the **nearest 0.1 % (SECTION 5.1.8.)***

DRY MASS OF THE MATERIAL:

$$M_{ds} = \frac{(M_{ws})}{(1+(\frac{w}{100}))}$$

M_{ds} = dry mass of the material removed from the test hole;
M_{ws} = wet mass of the material removed from the test hole;
w = percentage of moisture in material removed from test hole;

*Calculate the **DRY MASS OF THE MATERIAL** to the **nearest 0.01lb. (SECTION 6.2.1.)***

EXAMPLE

M_{ws} = 7.50 lbs ***([EXAMPLE] MATERIAL OBTAINED FROM HOLE)***

w = 2.2 % ***([EXAMPLE] OBTAINED FROM AASHTO T217)***

$$M_{ds} = \frac{(7.50\ lbs)}{(1+(\frac{2.2\%}{100}))}$$

ANSWER

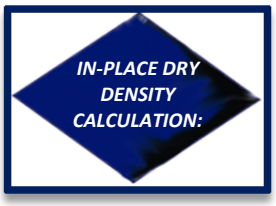
M_{ds} = 7.34 lbs

- The minimum test hole volumes suggested in determining the in-place density of soil mixtures are given in Table 1. This table shows the suggested minimum mass of the moisture content sample in relation to the maximum particle size in soil mixtures. 5.1.9.

TABLE 1: Minimum test hole volumes suggested by the procedure. Table shows the suggested minimum mass of the moisture content sample in relation to the maximum particle size in soil mixtures.

MAXIMUM PARTICLE SIZE		MINIMUM TEST HOLE VOLUME		MINIMUM MOISTURE
MM	ALTERNATE	cm3	ft3	CONTENT SAMPLE, GRAMS
4.75	#4 SIEVE	710	0.025	100
12.5	½ INCH SIEVE	1415	0.050	250
25.0	1 INCH SIEVE	2125	0.075	500
50.0	2 INCH SIEVE	2830	0.100	1000

The in-place density is the mass of soil (total, including water and solids) per unit volume as it exists in the ground. The dry density is the density of the soil excluding the water. In-place dry density of the soil in the field reflects how tightly soil is packed together after construction/compaction, omitting the influence of current moisture of the material.



WHAT IS THE IN-PLACE DRY DENSITY WITH THE FOLLOWING VARIABLES?

V_h = *0.0601* ft^3

M_{ds} = *7.34 lbs*

*Calculate the **IN-PLACE DENSITY** to the **nearest 0.1** lb/ft^3 (SECTION 6.3.1.)*

IN-PLACE DRY DENSITY:

$$D_d = \frac{(M_{ds})}{(V_h)}$$

D_d = in-place dry density of the material removed from the test hole;
M_{ds} = dry mass of the material removed from the test hole;
V_h = volume of the test hole;

- To calculate the percent compaction, divide the in-place density by the laboratory reference density and multiply by 100. Perform corrections for oversize material if necessary ***(see AASHTO T99).***

$$D_d = \frac{?}{?}$$

ANSWER: 122.1 lb/ft^3

WHAT IS THE PERCENT COMPACTION?

SANDCONE DRY DENSITY (IN PLACE) **= 122.1** lb/ft^3

LABORATORY MAXIMUM DRY DENSITY (EXAMPLE) **= 123.0** lb/ft^3

PERCENT COMPACTION = $\frac{?}{?}$ X 100

ANSWER: 99% compaction is achieved

AASHTO T217:

DETERMINATION OF MOISTURE IN SOILS BY MEANS OF A CALCIUM CARBIDE GAS PRESSURE MOISTURE TESTER.

DEFINITIONS:

Moisture Content by Wet Mass – *is the amount of water per unit mass of a wet material.*

Moisture Content by Dry Mass – *is the amount of water per unit mass of dry material. This is what the technician is trying to convert to.*

The speedy moisture tester quickly and accurately determines the wet mass moisture content of soils (or granular materials). Then with the correction curve the technician can determine the dry mass moisture content of the sample. This provides an easy way to calculate moisture content in the field.

SCOPE:

This test method covers determining the moisture content of soils by means of a calcium carbide gas pressure moisture tester. Follow manufacturer's instructions for proper use of the equipment. **1.1.**

EQUIPMENT: **3.**

- **CALCIUM CARBIDE PRESSURE MOISTURE TESTER -** A chamber with an **attached pressure gauge** for the water content of specimens having a **mass of at least 20g.**
- **BALANCE –** Will conform to AASHTO M231, Class G2 reads to the **nearest 0.1 grams**.
- **STEEL BALLS – Two 31.75 mm (1.25inch) steel balls**.

- **CLEANING BRUSH & CLOTH**
- **SCOOP –** for measuring out calcium carbide.

- **CALCIUM CARBIDE REAGENT –** must be finely pulverized and should be a grade **capable of producing acetylene gas** in the amount according to the procedure. Material **has a shelf life** and must be checked periodically.

SEE PROCEDURE FOR ADDITIONAL DETAILS & DIMENSIONS. NOT ALL EQUIP INFO IS COVERED IN THIS MANUAL

PROCEDURE:

SUMMARY: *Weigh the soil, place soil and steel balls into the tester chamber. Add calcium carbide reagent from the cap. Seal the lid tightly and shake vigorously to mix soil and reagent. Gas pressure increases, and the built-in gauge shows moisture content (usually on a wet-weight basis). Record the reading after pressure stabilizes.*

1. When using the **20 or 26 g** tester, place **3 scoops** of **calcium carbide** in the **cap** of the tester. **5.1.**

NOTE 4 - *Prevent the calcium carbide from coming into direct contact with water* ***(SECTION 5.1.)***

2. Weigh out a **20-gram test sample** *(or the exact mass per manufacturer instructions*) from the material obtained for the moisture content. Place that **sample** into the **body** of the tester. **Alternatively, the calcium carbide can be put into the body and the soil sample can be placed in the cap if desired.** **5.2.**

CALCIUM CARBIDE

3. Make sure the tester is **approximately horizontal**, then place **two 1.25" (31.75 mm) steel balls** into the **body** of the tester with the soil sample. **5.2.**

4. While still in an approximately **horizontal** position **insert the cap** into the top of the pressure vessel and **tighten the clamp. While performing this step ensure that no calcium carbide comes into contact with the soil until a complete seal is achieved.** **5.3.**

5. Then turn the tester to a **vertical** position so both the **soil and the calcium carbide** can come into contact. **5.4.**

6. **After contact is made, again position the vessel horizontally. Shake vigorously** in a **rotating** motion and in a way that won't cause damage to the equipment. The goal is **to completely break up all lumps** so that the calcium carbide has a chance to react with all the available free moisture. Shake for at least **60 seconds** for granular soils and **180 seconds** for other types of soil. **5.5.**

7. **Tip is to set** the vessel **down** on the table **horizontally** to let the **heat generated from the reaction to dissipate**. Once the needle stops moving **read** the dial at **eye level**. **5.6.**

8. **Record** both the **sample mass** and the **dial reading**. **5.7.**

9. Point the cap of the tester away ***(generally there is a vent near the seal of the cap. Ensure that the vent is pointed down and away)*** and **loosen the clamp slowly releasing the gas pressure.** **5.8.**

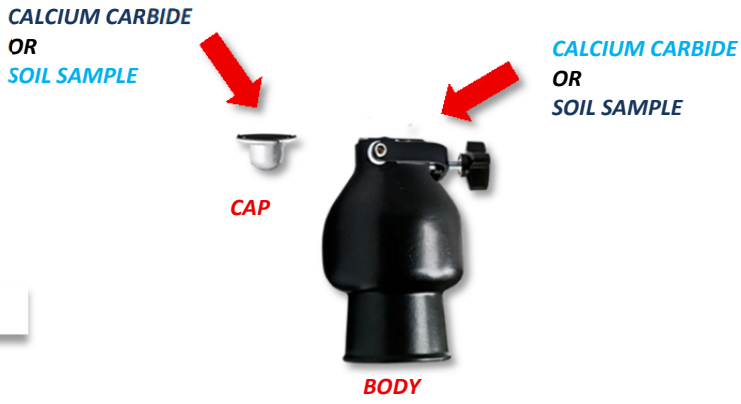
10. Empty the sample into a container (away from the technician) and **examine** for **lumps**. **If not fully pulverized perform the test again with a new sample.** **5.8.**

Make sure the tester and the cap is thoroughly cleaned of all carbide residue before running another test. ***(SECTION 5.8.)***

NOTE 5 *- Use the described procedure from 5.1. and 5.2. or use the manufacturer's instructions on how to place the soil sample and calcium carbide into the tester.* ***(SECTION 5.2.)***

NOTE 6 *– Follow the manufacturer's instructions on how to use the steel balls, especially when testing sand* ***(SECTION 5.2.)***

NOTE 7 *– If the moisture content of the sample exceeds the limit of the pressure gauge (12% moisture for aggregate or 20 % moisture for soil), a one-half size sample must be used and the dial reading must be multiplied by 2.* ***(SECTION 5.2.)***



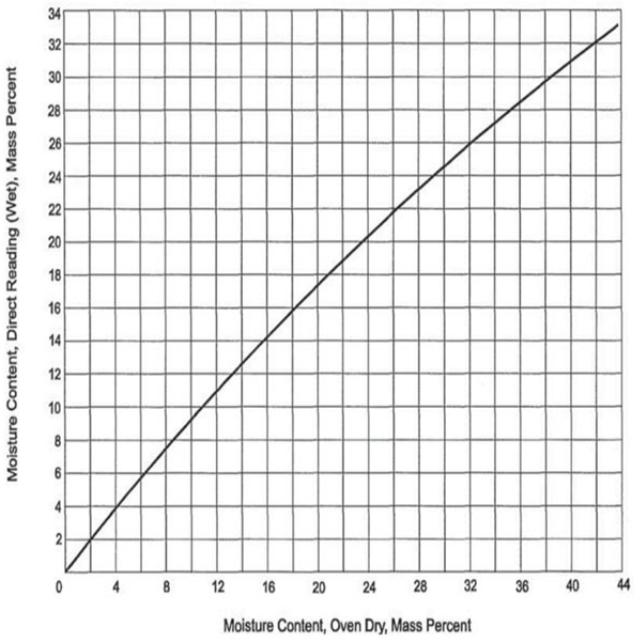
11

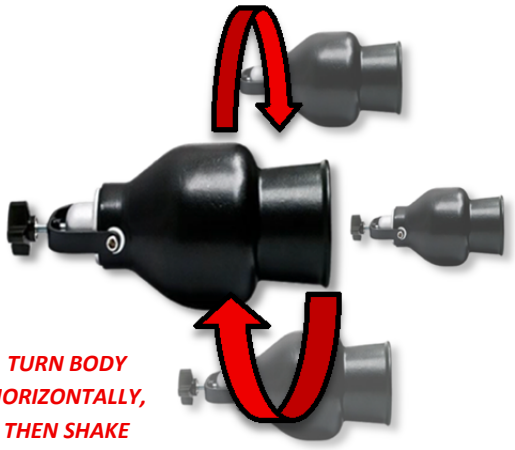
Convert Wet Mass from the dial to Dry Mass with a correction curve supplied by the manufacturer OR developed in house.

5.9. / 6.0

TURN BODY VERTICAL AFTER SEALED SO SOIL AND CALCIUM CARBIDE CAN COME INTO CONTACT

EXAMPLE OF CORRECTION CURVE DEVELOPED BY MANUFACTURER





TURN BODY HORIZONTALLY, THEN SHAKE VIGOROUSLY IN A ROTATING MANNER FOR 60 SECONDS FOR GRANULAR AND 180 SECONDS FOR OTHER SOIL TYPES

Example Speedie Moisture Tester

READ THE DIAL AT EYE LEVEL THEN CONVERT WET MASS TO DRY MASS BY THE CORRECTION CURVE CHART

CHEMICAL REACTION: $CaC_2 + 2H_2O \rightarrow C_2H_2 + Ca(OH)_2$

DEVELOPMENT OF CORRECTION CURVE

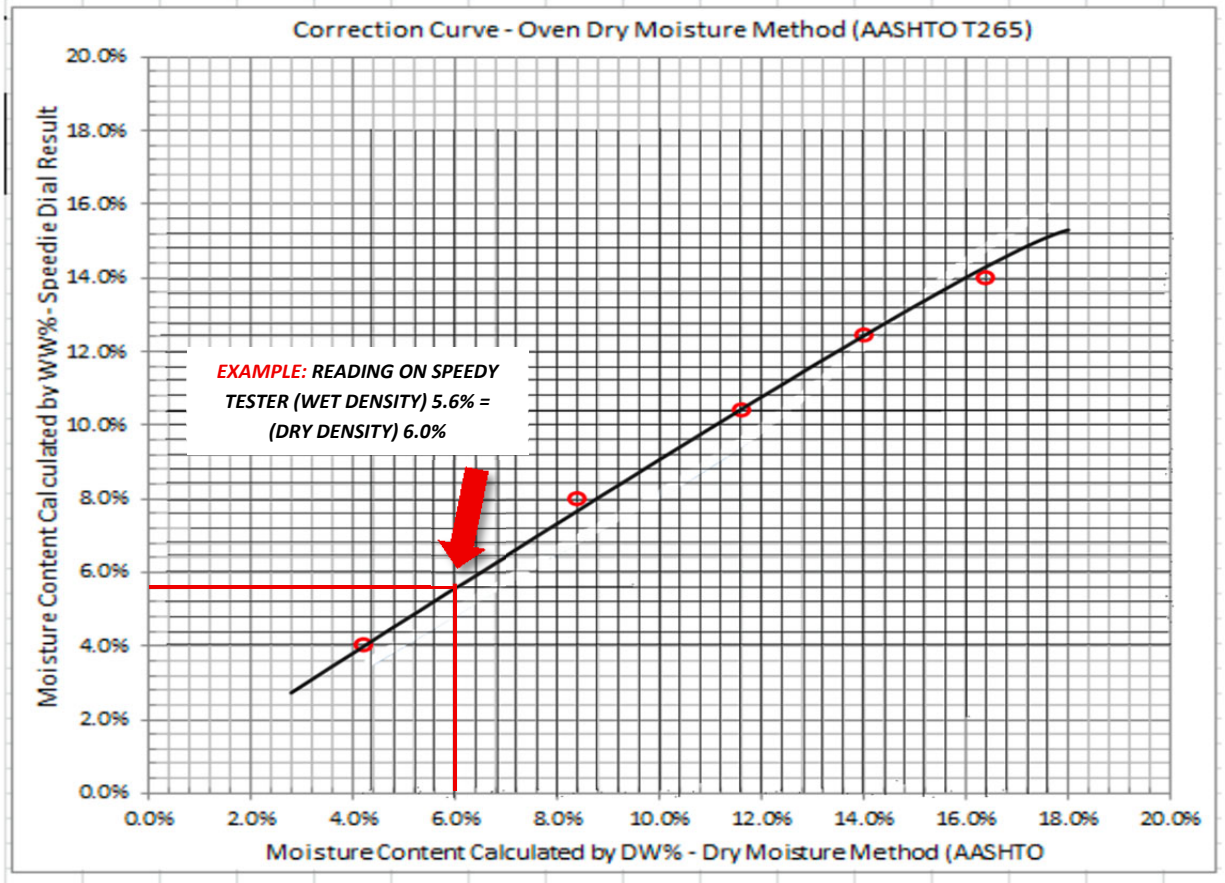
- The correction curve for moisture tester reading can either be **provided by the manufacturer or created (or extended) for local soils at known moisture contents.**

- The **accuracy of the correction curve should be checked** by comparing curve-corrected moisture contents to moisture contents of local soils determined using AASHTO T265. If desired the curves may be extended by additional testing.

- **(ADOT PROCEDURE):** Obtain **at least 5 soil samples** with varying degrees of moisture. **Take each sample and split in half**; **testing** one half **by AASHTO T217** the SPEEDY METHOD and the other half **by AASHTO T265**. **Repeat** this for **all 5 samples**. Take the result of the **moisture content determined by oven (X axis)** and the result of the **speedy moisture tester dial reading (Y axis)** of each sample and plot where these two numbers intersect, that will be your point. Once this is done for each of the five samples create a line of **linear regression (best fi**t) ***this is a straight of line as possible that best represents the relationship between the variables in a dataset***. This can be done by hand but generally accomplished using software such as EXCEL.

EXAMPLE OF CORRECTION CURVE DEVELOPED BY ADOT

Sample #	Speedie	Wet Wt.	Dry Wt.	AASHTO: T265 %Moisture
1	4.0 %	SEE AASHTO T265 FOR CALCULATION	SEE AASHTO T265 FOR CALCULATION	4.3 %
2	8.0 %			8.4%
3	10.4 %			11.6%
4	12.4 %			14.0 %
5	14.0 %			16.4 %



AASHTO T272:

ONE-POINT METHOD FOR DETERMINING MAX DRY DENSITY & OPTIMUM MOISTURE

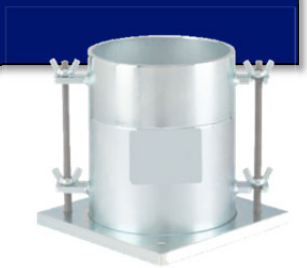
DEFINITIONS:

Max Dry Density - *refers to the maximum amount of dry soil mass that can fit within a given volume, indicating the point where further compaction will not increase density*

Optimum Moisture – *is the moisture level at which this densest state is achieved.*

Compaction - *is the process of pressing soil particles together to reduce the space between them, which increases the soil's density.*

Friable – *is easily crumbled.*



AASHTO T272 One-Point Proctor method is a shortcut compaction test that uses a single compaction point to match a soil to an already established reference curve or an existing family of proctor curves. It provides a fast way to determine maximum dry density and optimum moisture content for compaction control and as a quick assessment for any changes in material.

SCOPE:

This method is for the rapid determination of the maximum dry density and optimum moisture content of a soil sample using a one-point determination and an individual moisture / density curve or a family of curves.

1.1.(T272)

EQUIPMENT:

3. (T99)

SEE PROCEDURE FOR ADDITIONAL DETAILS & DIMENSIONS. NOT ALL EQUIP INFO IS COVERED IN THIS MANUAL

- **MOLD & ASSEMBLY (Mold, Collar, and Base Plate)-** solid wall, metal cylinders with dimensions outlined in Sections 3.1.1, 3.1.2 in the procedure. They must have a **detachable collar approximately 2.375 inches (60mm)** in height. The mold and collar will be constructed so that it can be fastened firmly to a **detachable base plate** made of metal. The base plate will **be plane to 0.005 inches** (0.13mm).

- **4" MOLDS: Volume- 0.0333 ± 0.0005** ft^3 (0.000943 ± 0.000014 m^3). **Inside Diameter- 4.000 ± 0.016 inches** (101.60 ± 0.40 mm). **Height- 4.584 ± 0.018 inches** (116.40 ± 0.50 mm).

- **6" MOLDS: Volume-** 0.0750 ± 0.0009 ft^3 (0.002124 ± 0.000025 m^3). **Inside Diameter-** 6.000 ± 0.026 inches (152.40 ± 0.70 mm). **Height-** 4.584 ± 0.018 inches (116.40 ± 0.50 mm).

- **RAMMER:** Either **Manual or Mechanical**. Metal rammer with **a mass of 5.5 ± 0.02 lbs (2.495 ± 0.009 kg).** Flat **circular face** of **2.000 ± 0.01 inches (50.80 ± 0.25 mm). Height** of drop from free fall of **12.00 ± 0.06 inches (305 ± 2 mm)**.

- **SAMPLE EXTRUDER**

- **BALANCE / SCALE-** conforming to the requirements **M231**, **Class G5-** sensitivity and readability to the nearest **1 gram**. Also, a balance conforming to **Class G2**- sensitivity and readability to the nearest **0.1 grams.**

- **DRYING OVEN –** Thermostatically controlled capable of maintaining temperature of **77 °F and 248 °F** (**25 °C and 120 °C**) **with an accuracy of ± 9 °F** (**± 5 °C). (If drying by oven is necessary)**

- **THERMOMETER –** measuring the oven temperature will meet the requirements of AASHTO M339 with a **temperature range** of at least **32 °F and 266 °F** (**0 °C and 130 °C**) **with and accuracy of ± 2.25 °F (± 1.25 °C).**

- **STRAIGHT EDGE- at least 10 inches in length** made of hardened steel with one **beveled edge.** At least one longitudinal surface (used for final trimming) will be **plane within 0.250 mm per 250 mm (0.1%) of the length** within the portion used for trimming.

EQUIPMENT CONTINUED:

- **SIEVES – ¾" and #4.**
- **MIXING TOOLS –** spatulas, spoons, …. etc.

SEE PROCEDURE FOR ADDITIONAL DETAILS & DIMENSIONS. NOT ALL INFORMATION IS COVERED IN THIS MANUAL

- **CONTAINERS –** Containers capable to handle constant heating and cooling and **resistant to corrosion**. Containers will have **close fitting lids** to prevent moisture loss before initial mass determination and to **prevent absorption of moisture** following drying and before final mass determination. **One container** is needed for **each moisture content determination**.

METHOD:

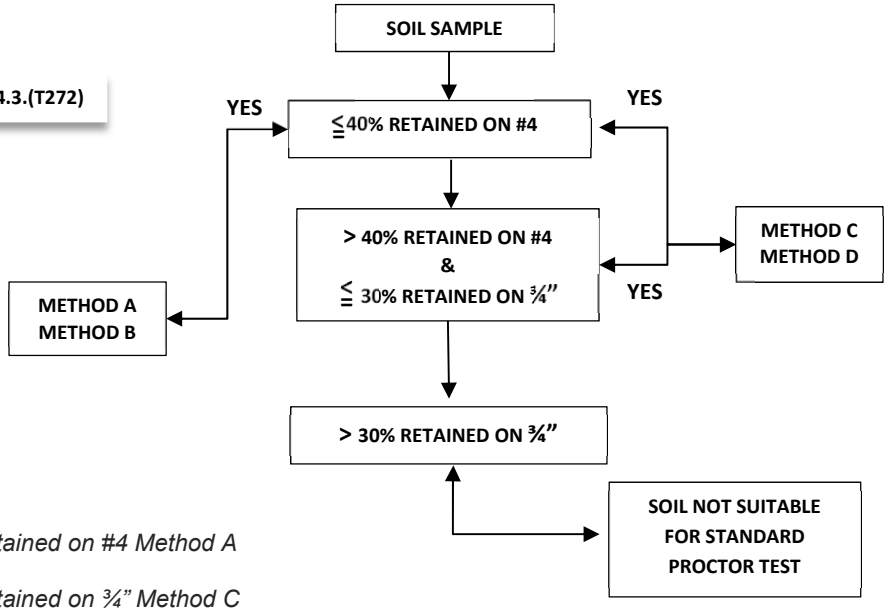
AASHTO T272 is the standard for performing the one-point proctor. The procedures and methods discussed in AASHTO T272 belong to AASHTO T99 both procedures are meant to be used in conjunction. Four methods are outlined (Method A, B, C, D). The method chosen for the compaction of the laboratory moisture / density relationship (proctor) must be the same used in the field to perform the one-point.

- The **One Point determination (T272)** is made by compacting soil according to **AASHTO T99**:
  - **Method A** – using a 4-inch mold: soil passing #4 screen.
  - **Method B** – using a 6-inch mold: soil passing #4 screen.
  - **Method C** – using a 4-inch mold: soil passing ¾" screen.
  - **Method D** – using a 6-inch mold: soil passing ¾" screen.

4.2.(T272)

- The **One Point** determination method **must match** the **individual moisture/density curve** (or family of curves) developed in the **lab**. **Method's must be the same!**

4.3.(T272)



Soil that has 40 % or less retained on #4 Method A OR Method B can be used.
Soil that has 30 % or less retained on ¾" Method C OR Method D can be used.
(SECTION 1.3.(T99))

See AASHTO T99 for the sample and sample preparation requirements for this procedure. For demonstration purposes the following discussion on procedure will reference Method A in AASHTO T99. Any method may be used.

SAMPLE:

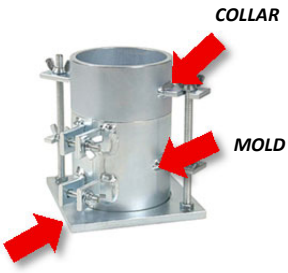
AASHTO T272 & AASHTO T99: METHOD A

- Obtain your **representative sample verify** that it is between **80 to 100% optimum moisture**. **Adjust** the moisture content **if necessary**. **7.1.(T272)**
- **Obtain representative sample** according **to the test method *(A, B, C, D)* in the procedure**. For Method A, the sample must be **large enough** that when the **oversized (retained on the #4 sieve) particles are removed 7 lbs (approximately 3175 grams) or more** of the sample remains **4.1.(T99)**
- If the sample from the field is **greater than Optimum *Moisture (too wet),*** follow the **drying** process from **AASHTO T99**. **4.2.(T99)**
- Sieve the soil sample over a **#4 screen**. When the sample has oversized-material refer to **AASHTO T99 ANNEX A1. (ROCK CORRECTION PROCEDURE) pg. 79-81 in this manual.** **4.3.(T99)**
- Reduce the **MINUS #4 material** down to **7 lbs (approximately 3175 grams) or more for testing according to AASHTO R76.** **4.4.(T99)**

PROCEDURE:

SUMMARY: *A soil sample is collected, sieved, and compacted in a mold in the field. The soil in the mold is compacted in three layers with 25 blows per layer from a 5.5-pound rammer dropped from a height of 12 inches. A moisture content sample is obtained and a rock correction is performed if necessary. The dry density and moisture content of the compacted specimen is plotted on a family of curves or in relation to a reference curve.*

1. **Weigh and record the mold and the baseplate** to the nearest **1 gram** (**0.005lbs**). **DO NOT include** the **collar** in the weight. **5.1.(T99)**



SPLIT MOLDS ARE GENERALLY PREFERRED FOR ONE-POINT PROCTORS DUE TO EASY EXTRUSION

2. Thoroughly **mix** the representative sample, make sure that the sample it is between **80% to 100% of optimum moisture**. Adjust the moisture, if necessary, to place the sample in this range. The maximum density determination will be **more accurate the closer** the moisture content is to the **optimum moisture content**. **7.1.(T272)**

3. Form a specimen by compacting the prepared soil in a **4-inch mold assembly in approximately 3 equal** layers. **5.3.(T99)**

4. The total **compacted depth** of the specimen will be **approximately 5 inches.** **5.3.(T99)**

NOTE 6 *– When developing a compaction curve for free draining soils* ***(such as uniform sands and gravels)*** *where seepage occurs at the bottom of the mold and base plate, taking a representative moisture content sample from the mixing bowl maybe preferred.* ***(SECTION 5.2.(T99))***

5 Place the loose soil into the mold and spread in a **layer of uniform thickness distributed evenly** in the mold. Make sure to **tamp the loose material down before compaction with the face of the hammer** ***(or another similar device having a face diameter of approximately 2 inches (50mm)).***

5.3.(T99)

6 Using the rammer compact **each layer** with **25** evenly distributed blows from a **12-inch height above the surface of the soil**. After the compaction of the first two layers, **make sure to trim off any material along the mold wall that *isn't compacted and redistribute along the surface.***

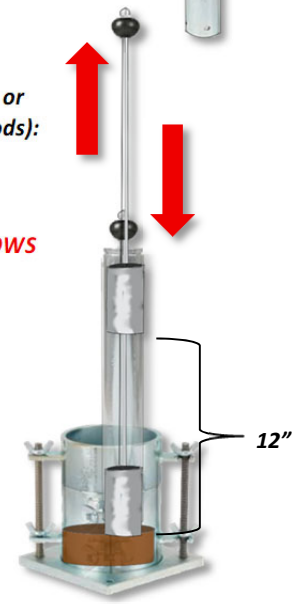
5.3.(T99)

METHOD A ***(see procedure or soils manual for other methods):***

3 LAYERS

25 EVENLY DISTRIBUTED BLOWS

FROM A 12 INCH HEIGHT

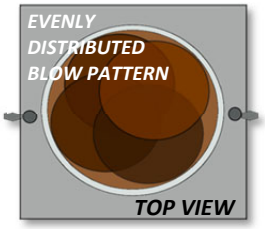


During compaction the mold assembly will rest on:
D.U.R.S
Dense
Uniform
Rigid
Stable foundation or base
(SECTION 5.3.)

NOTE 7 *– Satisfactory base to rest the mold assembly during compaction of soil:*

LABORATORY: examples- *a block of concrete (with a mass not less than 200 lbs supported by a relatively stable foundation); a sound concrete floor.*

FIELD: examples- *pavements; concrete box culverts, bridges, metal planed bases.*
(SECTION 5.3.(T99))



7 After all, **3 layers** have been **compacted completely remove the collar** and **trim the soil even with the top** of the mold with the **straightedge**.

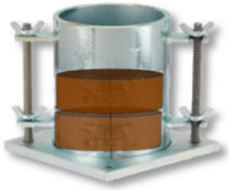
5.3.1.(T99)

COMPACT 1st LAYER. TRIM OFF MATERIAL ALONG THE MOLD WALL AND REDISTRIBUTE

8 **Weigh and record the mold, baseplate, and the sample** to the nearest 1 **gram** (**0.005lbs**). **DO NOT include** the **collar i**n the weight.

5.3.1.(T99)

COMPACT 2ND LAYER. TRIM OFF MATERIAL ALONG THE MOLD WALL AND REDISTRIBUTE



9 Calculate the **wet density in either** lb/ft^3 (or kg/m^3)

5.3.1.(T99)

COMPACT 3rd LAYER.

AFTER THE COLLAR IS REMOVED TRIM OFF THE EXCESS

WET DENSITY CALCULATION (LBS):

$$P_t = \frac{(A-B)}{(V)}$$

WET DENSITY CALCULATION (GRAMS CONVERTED TO LBS):

$$P_t = \frac{(A-B)}{(453.6 * V)}$$

12.1.(T99)

P_t = wet density of compacted soil in lb/ft^3 (kg/m^3);
A = Mass of the mold, base plate, and wet soil;
B = Mass of the mold, base plate;
V = Volume of the mold; *V= 0.0333 ft^3*

DENSITY WILL BE DETERMINED IN lb/ft^3 IN THIS MANUAL. SEE PROCEDURE FOR DETERMINING IN kg/m^3

EXAMPLE

A = 8.715 lbs

B = 4.330 lbs

$$\frac{(8.715 - 4.330)}{(0.0333)}$$

ANSWER:

P_t = *131.7 lb/ft^3*

EXAMPLE

A (grams) = 3953 grams

B (grams) = 1964 grams

$$\frac{(3953 - 1964)}{(453.6 * 0.0333)}$$

OR

P_t = *131.7 lb/ft^3*

How do you weigh & record to the nearest 0.005 lbs?

- Ensure that the balance display goes out to **at least 0.001 lbs some scales will weigh to the nearest 0.005 lbs automatically so these steps may not be necessary.**
- For example, when weighing the display shows **8.717 lbs.**
- **First divide 8.717 lbs by 0.005.** $\frac{8.717}{0.005}$
- **Result** is **1743.4. Round to the nearest whole number** in this case it will be **1743**.
- **Multiply 1743 by 0.005** = 8.715 lbs rounded to the nearest 0.005 lbs.

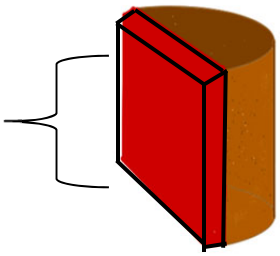
Obtaining the moisture content of the material is essential for the One-Point Proctor test. It allows for conversion of the wet density to dry density, plotting of the compaction curve, and the eventual determination of the optimum moisture content and maximum dry density for proper field compaction control.

MOISTURE CONTENT:

1 **Detach** the **base plate** and remove the material (using an extruder if necessary), if using a **split mold, unscrew the wing nut** so the mold can open and release the **sample**. **5.4.(T99)**

1 **Obtain** a representative **moisture content sample** from the specimen by slicing **vertically** through the **center of the molded material** and r**emoving one of the cut faces.** Then obtain the **sample from the exposed middle** removing the full height and width from the center of the molded specimen ***(see illustration).*** If the **material falls apart**, take your moisture content sample from the **center of the pile**. **5.4.(T99)**

RED AREA IS WHERE TO TAKE MOISTURE CONTENT SAMPLE FROM



1 **Weigh the sample immediately.** **5.4.(T99)**

1 Determine the **moisture content** using one of the following methods: **7.4. (T272)**

AASHTO 217

AASHTO T265

AASHTO T255

CALCULATION OF MOISTURE CONTENT (EXAMPLE T265 SEE SECTION IN MANUAL OR PROCEDURE FOR ADDITIONAL DETAILS):

$$W = \left[\frac{(W_1 - W_2)}{(W_2 - W_c)}\right] \text{ X } 100$$

EXAMPLE:

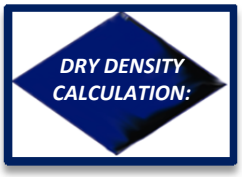
W_1 = *450.5 grams*

W_2 = *420.2 grams*

W_c = *120.2 grams*

ANSWER: *W = 10.1 %*

W = Moisture content in percent.
W_1 = Mass of the container and sample in grams.
W_2 = Mass of the container and oven-dried sample in grams.
W_c = Mass of the container in grams.



Dry density is the weight of dry soil (without any moisture) per unit volume of the compacted specimen. It's used to evaluate how well soil can be compacted and to establish the maximum dry density and optimum moisture content for field quality control.

DRY DENSITY CALCULATION: **12.2.(T99)**

$$P_d = \left[\frac{P_t}{(W+100)}\right] \text{ X } 100$$

W = Moisture content in percent of specimen.
P_t= Wet density of compacted soil in lb/ft^3 (kg/m^3);
P_d= Dry density of compacted soil in lb/ft^3 (kg/m^3);

EXAMPLE

P_t= *131.7 lb/ft^3*

W = *10.1 %*

$$\left[\frac{131.7}{(10.1+100)}\right] \text{ X } 100$$

ANSWER: P_d = *119.6 lb/ft^3*

DENSITY WILL BE DETERMINED IN lb/ft^3 IN THIS MANUAL. SEE PROCEDURE FOR DETERMINING IN kg/m^3

AT A GLANCE: DIFFERENCES BETWEEN METHODS

METHOD A:

- (After oversized material has been removed) Minimum 7lbs - ***may be adjusted for one-point determination***. **4.(T99)**
- Sieved over #4 screen.
- 4-inch Mold.
- 25 Uniformly Distributed Blows.

METHOD B:

- (After oversized material has been removed) Minimum 16lbs - ***may be adjusted for one-point determination***. **6.(T99)**
- Sieved over #4 screen.
- 6-inch Mold.
- 56 Uniformly Distributed Blows.

METHOD C:

- (After oversized material has been removed) Minimum 11lbs - ***may be adjusted for one-point determination***. **8.(T99)**
- Sieved over ¾" screen.
- 4-inch Mold.
- 25 Uniformly Distributed Blows.

METHOD D:

- (After oversized material has been removed) Minimum 25lbs - ***may be adjusted for one-point determination***.
- Sieved over ¾" screen.
- 6-inch Mold.
- 56 Uniformly Distributed Blows.

10.(T99)

REFERENCE CURVE (INDIVIDUAL MOISTURE/ DENSITY CURVE):
DEVELOPED ACCORDING TO AASHTO T99 (or T180) IN THE LABORATORY

ONE-POINT DETERMINATION:

- **Moisture content** must be **within 80 to 100 percent** of **the optimum moisture** of the reference curve. If the one point **does not** land in this range, then **compact another** specimen using the same material with an **adjusted moisture** content. **8.2.1.(T272)**

- Plot the one-point **moisture content as the X coordinate and the corresponding dry density as the Y coordinate. Plot the one-point on the same graph as the (already) developed reference curve.** **8.2.2.(T272)**

- Use the **maximum dry density and optimum moisture content** defined by the **reference curve** if the one-point dry density **falls directly on the curve** or **within** $\pm$ **2.0** lb/ft^3 of it**.** **8.2.3.(T272)**

- When **oversized particles** have been removed use **T99 ANNEX A1 ROCK CORRECTION** to determine the corrected maximum dry density and optimum moisture content. **8.2.3.1.(T272)**

Perform a full moisture / density relationship at the lab if the one-point determination does not meet the requirements.
REQUIREMENTS: the moisture content must fall within 80% to 100% of the optimum moisture of the reference curve & the dry density must either fall directly on or **within** $\pm$ **2.0** lb/ft^3 *of the reference curve.*

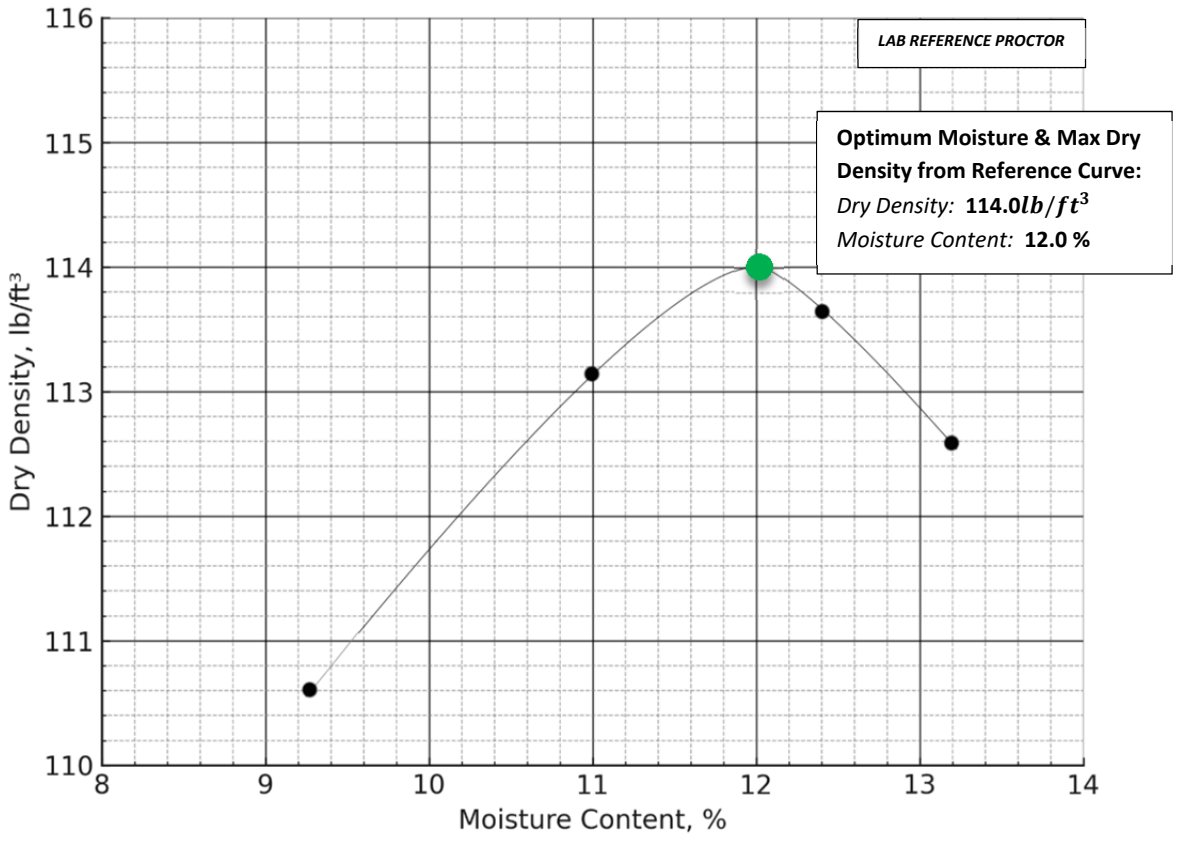
SECTION 8.2.4.(T272)

REFERENCE GRAPH EXAMPLE

Example of a reference curve that was completed by the lab.

Plot the reference proctor. The dry densities will be plotted on the Y axis and the moisture contents will be plotted on the X axis.

Calculate the Maximum Dry Density & the Optimum Moisture.



Calculate 80% of Optimum Moisture of the REFERENCE Proctor
EXAMPLE: 12.0 *0.8 = 9.6%
Then plot this point on the graph.

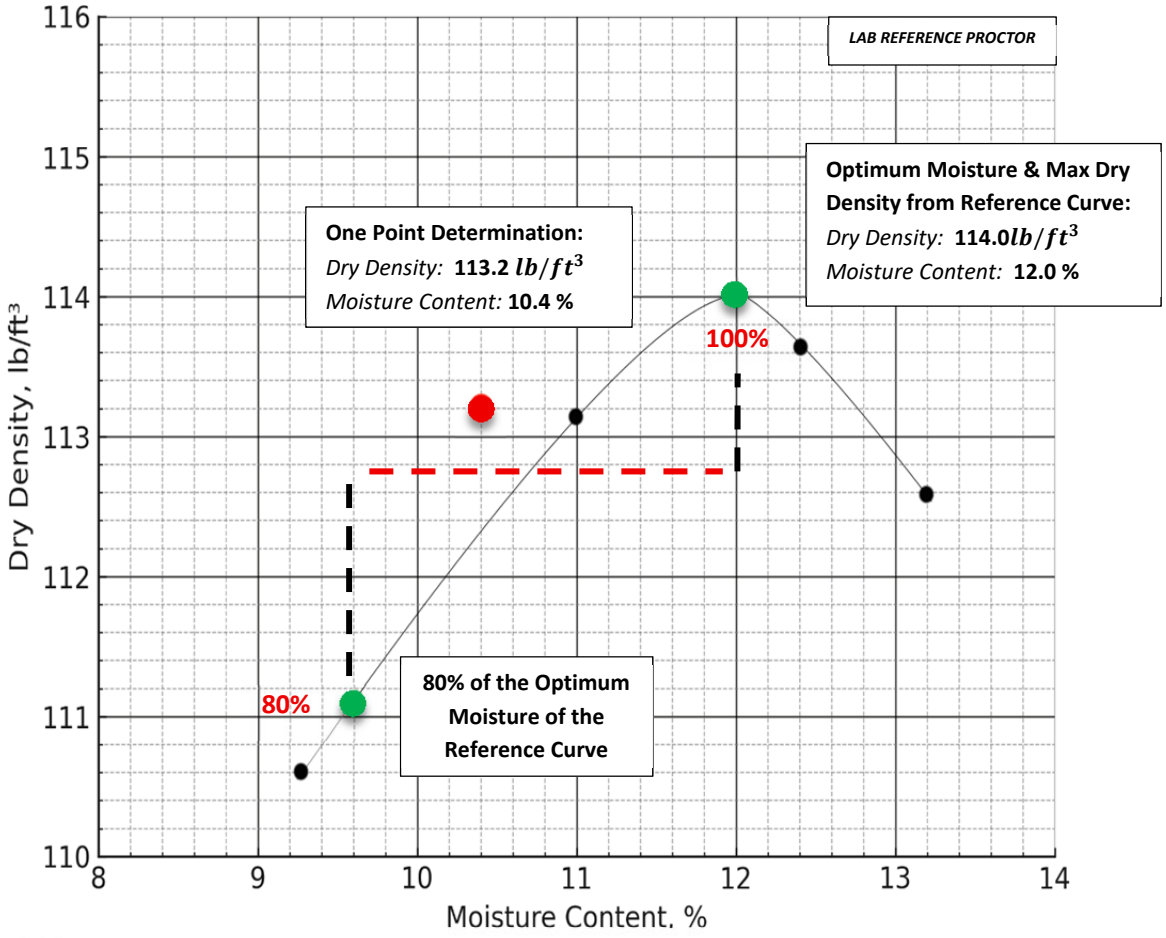
Plot your One-Point Determination.

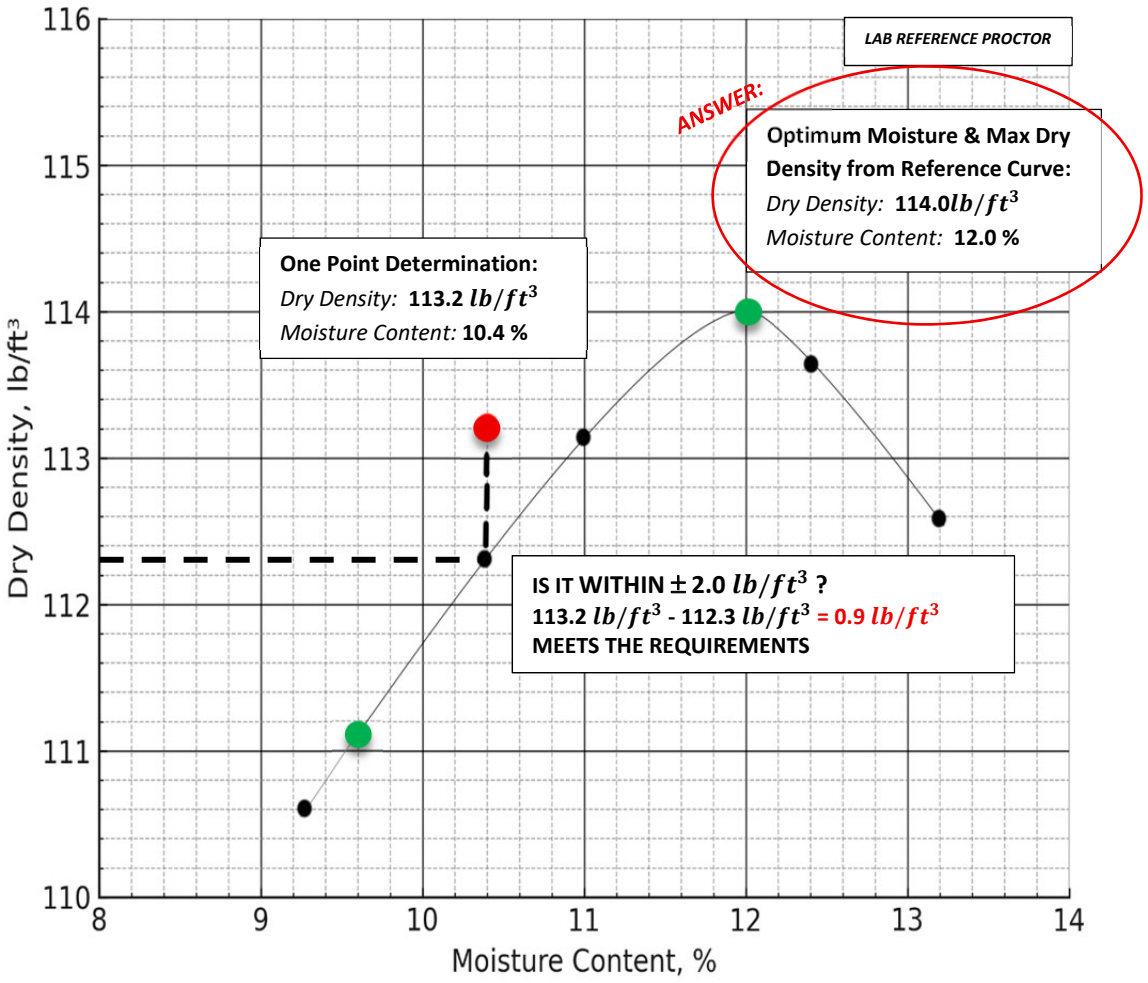
Does your One-Point fall between 80% and 100% of Optimum Moisture?

If NO then compact another specimen with the same material.

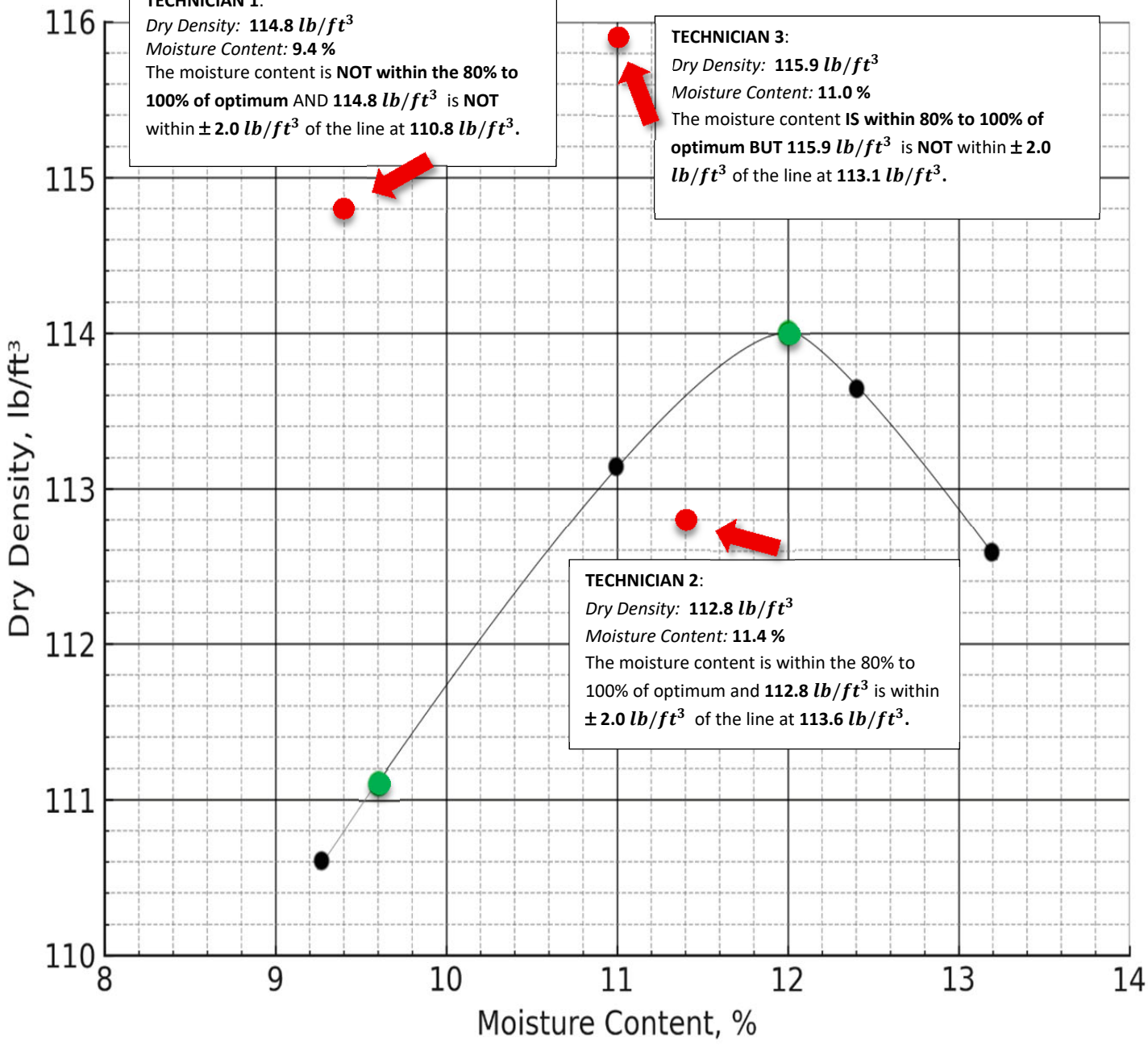
If YES then draw a vertical line from the One-Point until it intersects with the reference curve. Verify that the One-Point falls within ± 2.0 lb/ft^3 of it (or lands directly on the reference curve). Use the Optimum Moisture & Max Dry Density from the reference curve for your results.

Perform a full moisture / density relationship at the laboratory if the one-point determination does not meet any of these requirements.





Which technician met all the requirements for this procedure?



FAMILY OF CURVES: DEVELOPED ACCORDING TO AASHTO T99 (or T180) AND AASHTO R75 IN THE LABORATORY

- Plot the one-point **moisture content as the X coordinate and the corresponding dry density as the Y coordinate. Plot the one-point on the same graph as the (already) developed reference Family of Curves.** **8.3.1.(T272)**

- If the One Point Determination falls **DIRECTLY** on a **curve**, then utilize the **Maximum Dry Density and Optimum Moisture determined from that curve**. **8.3.2.(T272)**

- If the one point does **not fall directly on one** of the curves but **falls within** the **Family of Curves** draw a **new curve through the plotted one-point parallel** and close to the **shape** of the **nearest existing curve.** **8.3.3.(T272)**

- **Find** the **Maximum Dry Density and Optimum Moisture** content of the **new curve** by **finding** the **point** that **intersects** with the Family of Curves **Max Density Line (spine).** **8.3.4.(T272)**

- Ensure that **the moisture content must be within 80 to 100 percent** of the determined **optimum moisture content.** **8.3.4.(T272)**

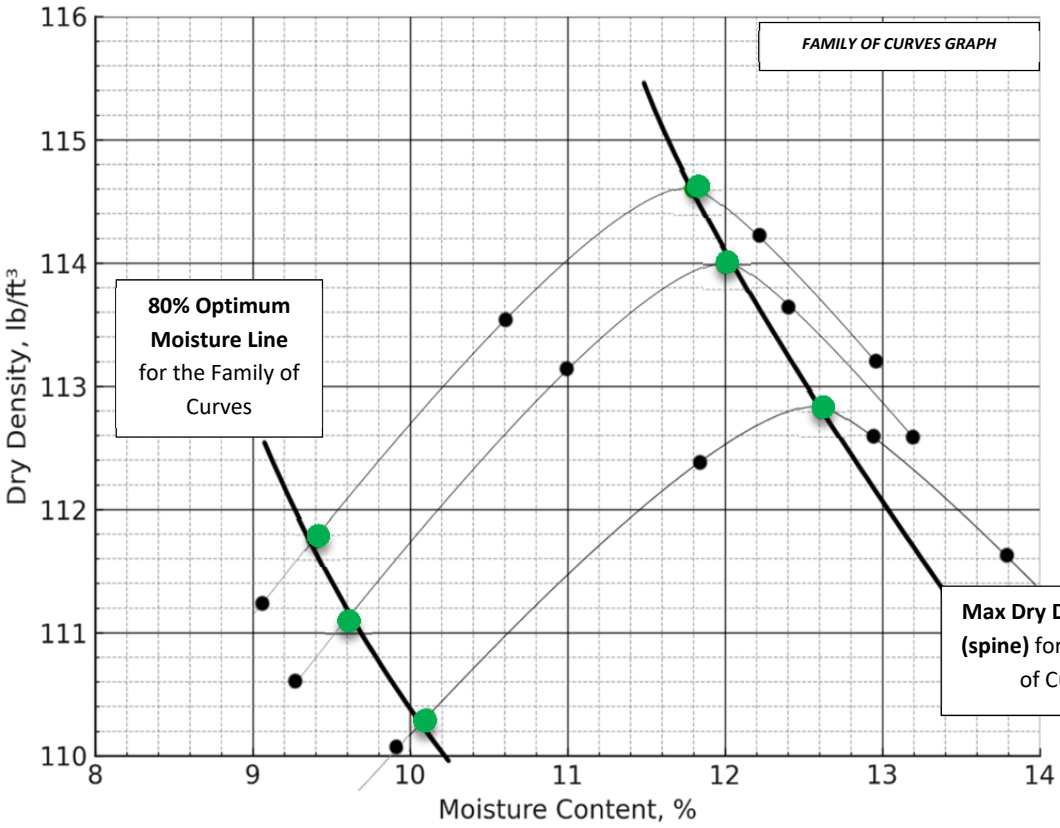
- When oversized particles have been removed use **T99 ANNEX A1** to determine **the CORRECTED maximum dry density and CORRECTED optimum moisture content.** **8.3.4.1(T272)**

- **Perform a full moisture/density relationship in the lab if the one-point determination does not fall within the family of curves or is 80 to 100 percent within optimum moisture.** **8.3.5.(T272)**

AASHTO R75:
DEVELOPING SOIL MOISTURE-DENSITY RELATIONS (FAMILY OF CURVES)

- Develop at least 3 curves (ensure they are all performed using the same Method).
- Select the highest and lowest maximum dry densities to determine the scale.
- Plot the maximum dry densities and optimum moistures of the selected curves on a graph.
- Draw a smooth, “best fit”, curved line through the maximum dry density points creating the spine of the soil moisture-density relationships.
- Remove any points that were not used to create the spine of the family of curves.
- Ensure to plot any additional points established that will be included in the Family of curves. When drawing it’s not necessary to include the portion of the curve over optimum moisture.
- Calculate 80 percent of optimum moisture for each curve and plot these.
- Draw a smooth, “best fit,” curved line connecting the 80 percent of optimum moisture points. This line should parallel the spine of the curves established earlier.

FAMILY OF CURVES GRAPH EXAMPLE

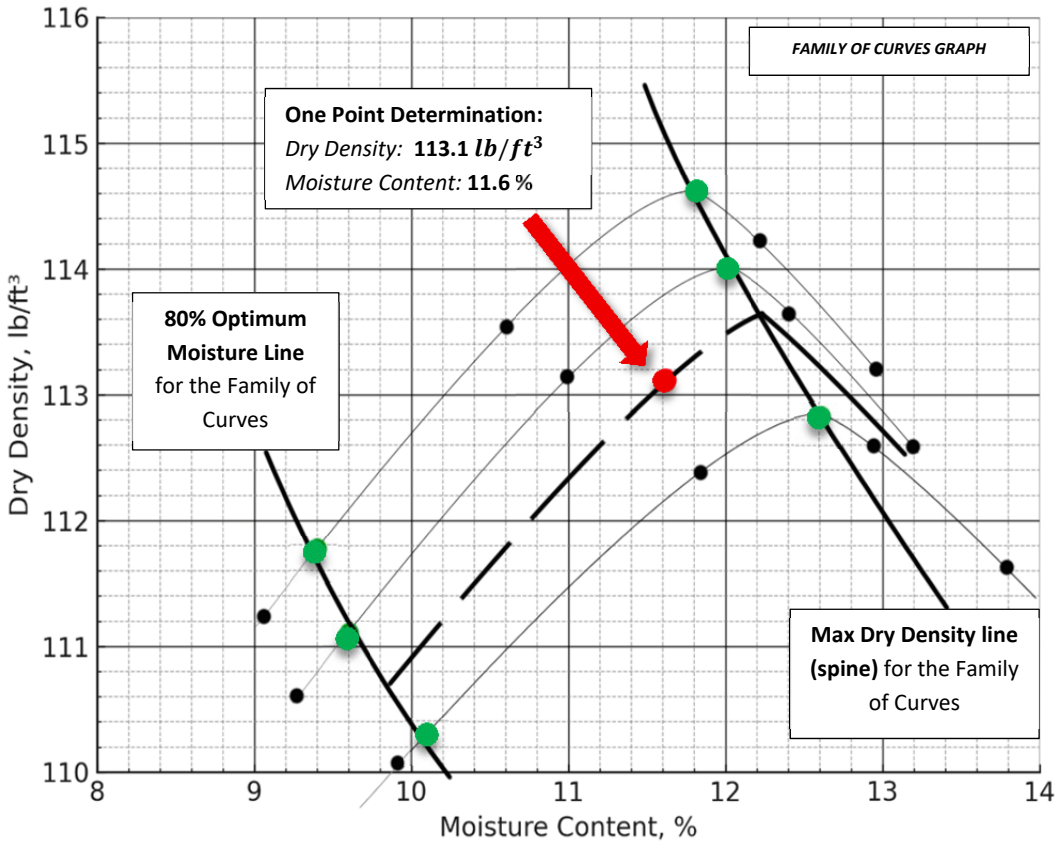


Example of a family of curves that was completed by the lab according to AASHTO R75.

Plot your One-Point Determination.

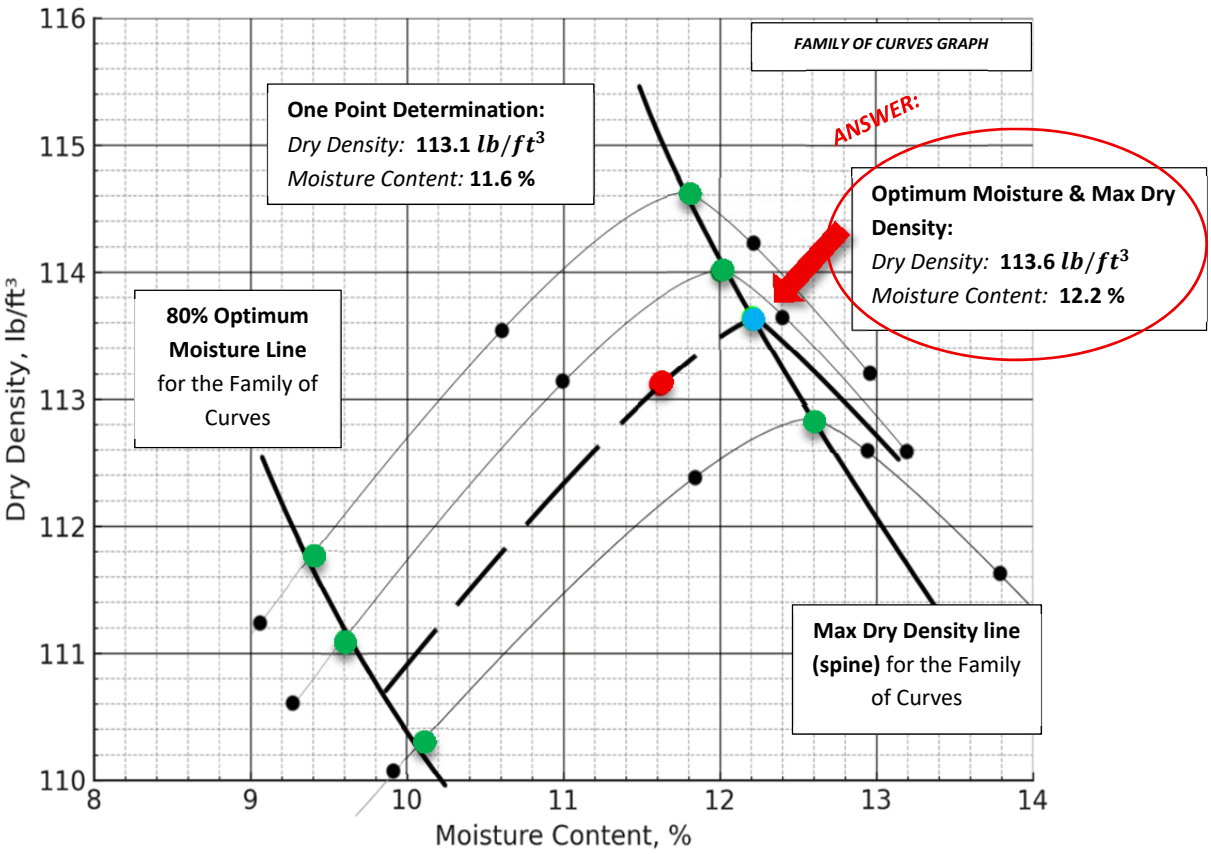
Does your One-Point fall between 80% and 100% of Optimum Moisture and does it fall within the developed Family of curves?

If NO then Perform a full moisture/density relationship in the lab.



If YES and it lands directly on one of the already developed curves then use the Optimum Moisture & Max Dry Density from the that curve for your results.

If YES and it does NOT land directly on one of the already developed curves then draw a new curve using the one-point parallel and close to the shape of the nearest existing curve. Find the point that intersects with the Family of Curves Max Density Line (spine). Use the Optimum Moisture & Max Dry Density from the that curve for your results.


FAMILY OF CURVES GRAPH
One Point Determination:
Dry Density: 113.1 lb/ft^3
Moisture Content: 11.6 %
ANSWER:
Optimum Moisture & Max Dry Density:
Dry Density: 113.6 lb/ft^3
Moisture Content: 12.2 %
80% Optimum Moisture Line for the Family of Curves
Max Dry Density line (spine) for the Family of Curves
Dry Density, lb/ft³
Moisture Content, %
116
115
114
113
112
111
110
8
9
10
11
12
13
14

AASHTO ANNEX T99:

CORRECTION FOR MAX. DRY DENSITY & OPTIMUM MOISTURE CONTENT FOR OVERSIZED PARTICLES.

SCOPE:

This section corrects the max dry density & optimum moisture of material retained on #4 screen (Method A & Method B) or the material retained on ¾" screen (Method C & Method D). The maximum dry density, adjusted for oversized particles and total moisture content, are compared with the field-dry density and field moisture content.

A1.1.

PROCEDURE:

In the field, oversize rock particles are part of compacted soil. An in-place density test could give much higher densities than your lab proctor's MAXIMUM DRY DENSITY with the same compactive effort. The purpose of a rock correction on a Proctor test is to adjust the laboratory-determined maximum dry density and optimum moisture content to account for coarse aggregate (rock) that is removed before the test. This process ensures the lab results are an accurate representation of the entire material used in the field. When done correctly, you should be able to compare field density tests such as AASHTO T310 (Nuclear Gauge) and AASHTO T191 (Sand Cone) to Proctor results and have confidence that your percent compaction is correct.

- This correction can be **applied** to the **sample** on which the **maximum dry density *(PROCTOR TEST)*** is performed. **A1.1.1.**

AND/OR

- The **sample** obtained from the field while preforming **in-place density**. **A1.1.2.**
- If the **in-place density procedure** being used is **AASHTO T310 (Nuclear Density Gauge (Soils))** then **obtain** the **sample according to AASHTO T310 Section 9. 6. – take the sample from directly underneath the gauge to a depth stated in the procedure.** **A1.1.2.**
- If the **in-place density procedure** being used is **AASHTO T191 (Density of Soil In-Place by the Sand-Cone Method)** then **obtain** the material for rock correction **from the soil that was excavated from the hole at a depth stated in the procedure.** **A1.1.2.**

*If there is no minimum specified to the technician then correction will be applied to samples with **more than 5 % by weight of oversized particles.** **(SECTION A1.1.3.)***

- **Sieve** the material over the **appropriate sieve**. If not drying the entire **sample**, then follow the **alternative drying method**. ***(See SECTION A1.3.2.)*** **A1.1.2.**
- **Bulk Specific Gravity (G_{SB})** of the oversized particles is **required** to determine the **corrected Maximum Dry Density.** Use **AASHTO T85 to obtain the bulk specific gravity value** and use that for the calculations for the Oversized Rock Correction. **Although, it is generally assumed for most construction activities that specific gravities are 2.600.** **A1.2.**
- **Determine the dry mass of the oversized and fine fractions one of two ways:** **A1.3.**

When calculating the percent of coarse and fine particles you use the dry weight!

The technician can **dry both portions in air or in an oven that does not exceed 140 °F**.

OR **A1.3.1/A1.3.2.**

[A1.3.2] Alternatively determine the **moist mass of both fractions, fine and oversized**. Obtain **moisture samples from the fine and oversized material**. Determine the moisture content of the fine particles and oversized particles of the material. The moisture contents can be determined by **T 265, T 217, or T 255.** If **the moisture content of the oversized particles is generally known**, **substitute** that moisture content in the **calculations**.

Example:

Lab Proctor: **112.9 lb/ft^3 @ 11.1 % Optimum moisture content.**
Amount of Wet Fine Material: **22.410 lbs.**
Amount of Wet Coarse Material: **7.850 lbs.**
G_{SB}: **2.562**
Moisture Content Coarse: **2.0%**
Moisture Content Fine: **10.6%**

HOW TO CHANGE A PERCENT (EX: 35%) TO ITS DECIMAL FORM FOR A CALCULATION?

$$\frac{Percent\ \%}{100}$$

EX: $\frac{35\ \%}{100} = 0.35$

Remember to change MOISTURE CONTENT to its decimal form before doing the calculation for dry mass.

CALCULATION FOR DRY MASS OF OVERSIZED & FINE PARTICLES

$$M_d = \frac{M_m}{(1+M_c)}$$

M_D = mass of dry material (fine or oversized particles);
M_m = mass of wet material (fine or oversized particles);
M_c = moisture content of respective fine or oversized particles (convert to decimal see note above);

CALCULATION FOR DRY MASS OF OVERSIZED & FINE PARTICLES

$$M_D = \frac{7.850\ lb}{(1+0.020)}$$

ANSWER: $M_D coarse$ = **7.696 lb.** ***(Dry mass of coarse particles)***

$$M_D = \frac{22.410\ lb}{(1+0.106)}$$

ANSWER: $M_D fine$ = **20.262 lb.** ***(Dry mass of fine particles)***

CALCULATION FOR THE PERCENTAGE OF OVERSIZED & FINE PARTICLES BY DRY WEIGHT OF THE TOTAL SAMPLE:

$$P_f = \frac{(100 * M_{DF})}{(M_{DF}+M_{DC})}$$

$$P_c = \frac{(100 * M_{DC})}{(M_{DF}+M_{DC})}$$

P_f = Percent of dry fine particles, whole %;
P_c = percent of oversized particles of sieve used, whole %;
M_{DF} = mass of dry fine particles;
M_{DC} = mass of dry oversized particles;

CALCULATION FOR THE PERCENTAGE OF OVERSIZED & FINE PARTICLES

$$P_f = \frac{(100 * 20.262\ lb)}{(20.262\ lb + 7.696\ lb)}$$

ANSWER: P_f = **72%**

$$P_c = \frac{(100 * 7.696\ lb)}{(20.262\ lb + 7.696\ lb)}$$

ANSWER: P_c = **28%**

Weigh and record material amounts to the ***nearest 1 gram or 0.005lbs.***

CALCULATION FOR THE CORRECTED OPTIMUM MOISTURE:

$$MC_T = \frac{(MC_F * P_f) + (MC_C * P_c)}{100}$$

MC_T = corrected optimum moisture content of the total sample, as a decimal;
MC_F = optimum moisture content of the fine particles, 0.1%;
MC_C = moisture content of the oversized particles,0.1%;
P_f = percent of fine particles of sieve used;
P_c = percent of oversized particles of sieve used;

CALCULATION FOR THE CORRECTED OPTIMUM MOISTURE:

$$MC_T = \frac{(11.1\% * 72\%) + (2.0\% * 28\%)}{100}$$

ANSWER:

MC_T = **8.6 %.**

CALCULATION FOR THE CORRECTED DRY DENSITY:

$$D_D = \frac{(100 * D_F * k)}{(D_F * P_c) + (k * P_f)}$$

D_D = corrected maximum dry density of the total sample (lb/ft^3);
D_F = maximum dry density of the fine particles, (lb/ft^3);
k = 62.4 X Bulk Specific Gravity (oven dry basis) of coarse particles (lb/ft^3);
P_c = percent of oversized particles of sieve used;
P_f = percent of fine particles of sieve used;

CALCULATION FOR THE CORRECTED DRY DENSITY:

$$D_D = \frac{(100 * 112.9 lb/ft^3 * 159.9 lb/ft^3)}{(112.9 lb/ft^3 * 28\%) + (159.9 lb/ft^3 * 72\%)}$$

ANSWER:

D_D = **123.0** lb/ft^3

DENSITY WILL BE DETERMINED IN lb/ft^3 IN THIS MANUAL. SEE PROCEDURE FOR DETERMINING IN kg/m^3

MORE ROCK CORRECTION EXAMPLES ARE AT THE END OF THE MANUAL!

AASHTO T19
SECTION 8:
CALIBRATION OF MEASURE

SCOPE:

*Section 8 of this standard covers the determination of the volume of a measure. This procedure is referenced in **AASHTO T272**: ONE-POINT METHOD FOR DETERMINING MAX DRY DENSITY & OPTIMUM MOISTURE & **AASHTO T191:** DENSITY OF SOIL IN-PLACE BY THE SAND-CONE METHOD.*

1.1.

Examples of Measures Utilized in Field Procedures:

EQUIPMENT:

- **BALANCE-** The balance will have sufficient capacity and be readable to the **nearest 0.1 lbs or 0.1 grams** & conform to the requirements of AASHTO M231.
- **MEASURE – A cylindrical container made of steel** or another suitable material. Refer to the test method's requirements for Measure/Container.
- **PLATE GLASS –** A piece of glass **at least ¼"** and **at least 1 inch larger** than the **diameter of the measure**.
- **GREASE-** A **suitable grease** that is normally used for water pumps, chassis, or similar.
- **THERMOMETER-** Having a range of **at least 50°F to 90°F (10°C to 32°C)** with an **accuracy of ±0.9°F (0.5°C)** following requirements of AASHTO M339.

5.

SEE PROCEDURE FOR ADDITIONAL DETAILS & DIMENSIONS. NOT ALL EQUIP INFO IS COVERED IN THIS MANUAL

Volume in materials testing is the amount of space that the soil OR aggregate sample occupy; whether it is soil in a Proctor mold or aggregate in unit weight measure. Volume includes the space taken up by:

- *the soil particles or the aggregate particles, and*
- *the air and water between them (voids of soil)*
- *or the space between the aggregate particles (voids for aggregates)*

For accurate measurement we need a precise measure of the space that the material will occupy. We use water to determine the known volume of the measure because it flows into every small corner and void inside the container and because the density of water is known at any temperature. Water allows us to calculate the true volume of the measure correctly.

FREQUENCY:

Calibration / verification intervals are determined by factors such as equipment usage, required measurement accuracy, instrument stability, environmental conditions, manufacturer recommendations, and specific project or agency requirements. The test methods for each procedure will dictate the criteria for calibration & verification of all equipment.

- Determine the **volume of the measure** at its initial use and at a frequency not to **exceed 12 months** or whenever there is reason to question the accuracy of its results. **Retain the calibration records according to AASHTO R18.**

8.1.

Summary: *Weigh and record empty measure (with glass plate) then fill the measure with water to the rim and cover with the glass plate so that there are no air bubbles. Clean off the measure. Weigh and record the measure, glass plate, and water. Measure the temperature of the water to get the density at that temperature then calculate.*

PROCEDURE:

- **First place a thin layer of grease** on the rim of the measure.

8.2.

1

- **Weigh** and **record** the mass of the **Glass Plate AND the Measure (*with grease on it)*** to the **nearest 0.1*lb (0.05 kg) or to the nearest 0.1 grams (or refer to your agency's procedure).***

2

8.3.

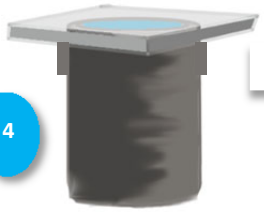
- **Fill the measure** with water that is **room temperature.**

8.4.

3

If calibrating the 6" proctor mold, apply the grease in a way to create a water proof seal on both ends of the mold. All other steps are the same.

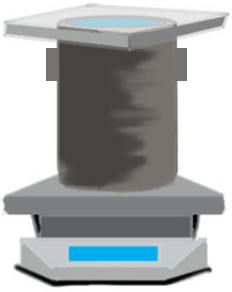
- **Cover** the **measure** with **the glass plate** in a way so as **not to have air bubbles** and excess water.



8.4.

4

- Weigh and record the mass of the **water, glass plate, and measure** to the **nearest 0.1*lb (0.05 kg) or to the nearest 0.1 grams (or refer to your agency's procedure).***



8.5.

5

- Measure the temperature of the water to the **nearest 1°F (or nearest 0.5°C).**

8.6.

6

- **DENSITY OF WATER TABLE: INTERPOLATE IF NECESSARY.**

°C	°F	kg/m^3	lb/ft^3
15.6	60	999.01	62.366
18.3	65	998.54	62.336
21.1	70	997.97	62.301
23.0	73.4	997.54	62.274
23.9	75	997.32	62.261
26.7	80	996.59	62.216
29.4	85	995.83	62.166

CALCULATION OF VOLUME:

$$V = \frac{(B-C)}{(D)}$$

V = Volume of the measure (ft^3);
B = Mass of the water, glass plate, and measure, (*lb.*);
C = Mass of the glass plate, and measure, (*lb.*);
D = Density of the water for the measure, (lb/ft^3);

OR

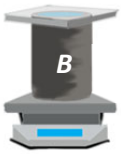
CALCULATION OF VOLUME (GRAMS CONVERTED TO LBS):

$$V = \frac{(B-C)}{(453.6 * D)}$$

Use this equation if weighed to the nearest 0.1 grams.

VOLUME WILL BE DETERMINED IN ft^3 IN THIS MANUAL. SEE PROCEDURE FOR DETERMINING IN m^3

EXAMPLE



= 20.3 lbs $\frac{(20.3-15.7)}{(62.261)}$

= 15.7 lbs

ANSWER: 0.0739 ft^3

= [75 Degrees] 62.261 lb/ft^3

PRACTICE QUESTIONS:

1. The one-point has to fall on the reference curve or within _____ of the curve at the one-point moisture content (according to AASHTO T272)?

    a. ± 2.5 lb/ft^3
    b. ± 3.5 lb/ft^3
    c. ± 2.0 lb/ft^3

2. How many Grams of Soil should be used for the average Calcium Carbide Moisture Tester (according to AASHTO T217)?

    a. 15 grams
    b. 20 grams
    c. 10 grams

3. When performing T272 One-Point Proctor (method from T99) Method A or Method B is used if ____ or less of the material is retained on the _____ screen?

    a. 40%, #4
    b. 30%, ¾”
    c. 30%, #4

4. AASHTO T191: When performing the procedure to determine the density of the soil as you dig out the hole and place the material into a container you must keep it covered to avoid losing moisture?'

    a. False
    b. True

5. AASHTO T19 SECTION 8: What is the first step when calibrating a measure?

    a. Weigh the measure to the nearest 0.1lb or agency determined weight.
    b. Apply thin layer grease to rim (or rims) and weigh.
    c. Fill the measure with room temperature water.

6. Oversized correction (ANNEX T99) is applied to samples that are more than _____ by weight of the sample.?

    a. 40%
    b. 10%
    c. 5%

7. AASHTO T191: What do you weigh the sand cone apparatus to during the cone correction step?

    a. 0.01kg
    b. 0.01lb
    c. 0.01grams

ANSWERS:

1. *c*
2. *b*
3. *a*
4. *b*
5. *b*
6. *c*
7. *b*

In Place Density Nuclear

In-place nuclear density testing is a sophisticated and widely used method in both geotechnical engineering / construction for determining the density and moisture content of soil and for determining densities of asphalt after being laid and compacted. AASHTO T265 and T255 are important because they provide standardized, reliable methods for determining the moisture content of soil and aggregate, which is crucial for engineering and construction quality control.

All Nuclear Density & Moisture Content determination procedures that will be covered during ATTI:

- **AASHTO T310:** *IN PLACE DENSITY AND MOISTURE CONTENT OF SOIL – AGGREGATE BY NUCLEAR METHODS*
- **AASHTO T355:** *DENSITY OF COMPACTED BITUMINOUS MIXTURES BY NUCLEAR METHOD*
- **AASHTO T265:** *MOISTURE CONTENT OF SOILS*
- **AASHTO T255:** *MOISTURE CONTENT OF AGGREGATES*
- ***FIELD DESCRIPTION AND IDENTIFICATION OF SOILS*** *(INFORMATIONAL ONLY; WILL NOT BE TESTED ON)*

Learning objectives for these sections are:

How to perform and calculate in place nuclear density and moisture testing for soils using the direct transmission method.

How to perform and calculate in place nuclear density testing for asphalt using the backscatter method.

How to properly perform and calculate moisture content procedures for both soils and aggregates.

PLEASE REFER TO THE SECTION FOUND IN THE PROCEDURE FOR MORE DETAIL. THE SECTION NUMBER WILL BE PROVIDED FOR REFERENCE. SUBJECT TO CHANGE.

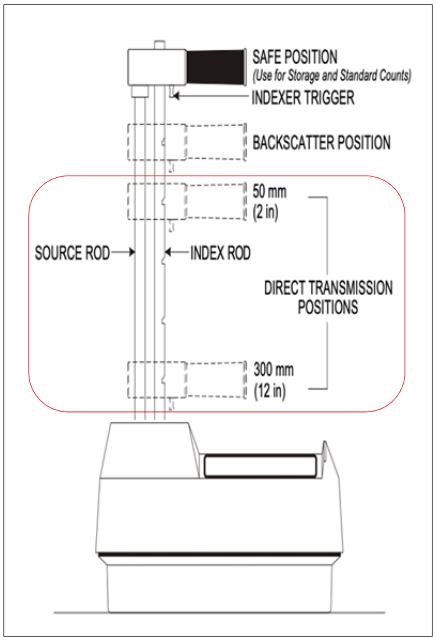
AASHTO T310:

INPLACE – DENSITY AND MOISTURE CONTENT OF SOIL / AGGREGATE BY NUCLEAR METHODS

DEFINITIONS:

Percent Compaction - *it means that the compacted soil has reached a percentage of its maximum possible dry density as determined by a laboratory proctor test.*

Direct Transmission – *is when the sensor (located in the back of the gauge) measures the amount of gamma radiation given off by the source rod. The less radiation detected by the sensor the higher the material's density.*



DIRECT TRANSMISSION MODE

SCOPE: 1.1.

This test method describes the procedure for determining the in-place density and moisture of soil and soil-aggregate by use of nuclear gauge. The density of the material may be determined by either direct transmission, backscatter, or backscatter/air gap ratio method. The moisture of the material is determined only from measurements taken at the surface of the soil.

EQUIPMENT: 5.

- **NUCLEAR DENSITY/ MOISTURE GAUGE (SEALED RADIATION SOURCE) with instruction manual-** gauge styles and construction vary be but generally the system contains:
  - a **sealed source** of high-energy gamma radiation, such a **cesium or radium**;
  - **gamma detector**- such as a Geiger-Mueller tube(s);
  - **fast neutron source**- a sealed mixture of a radioactive material such as americium, radium or californium-252 and a target material such a beryllium;
  - **slow neutron detector**- any type such as boron trifluoride or helium-3 proportional counter

SEE PROCEDURE FOR ADDITIONAL DETAILS & DIMENSIONS. NOT ALL EQUIP INFO IS COVERED IN THIS MANUAL

- **TRANSPORT CASE**
- **REFERENCE STANDARD / BLOCK –** a **block** of material used for **checking gauge operations**, correction of source decay, and to establish conditions for a reproducible reference count rate.
- **STRAIGHT EDGE / PLATE / LEVELING TOOL-** used for planning the test site and **for guiding the drive pin** to prepare a perpendicular hole.
- **DRIVE PIN –** a pin **not to exceed the diameter of the rod in** the direct transmission gauge by **more than 1/4" (6mm**), or as recommended by the gauge manufacturer, used to prepare a hole in the material under test for inserting the rod.
- **SLIDE HAMMER / HAMMER**
- **DRIVE PIN EXTRACTOR –** a tool that is used to **remove the drive pin** in a vertical direction so that the pin **will not distort the hole** in the extraction process.
- **RADIOACTIVE MATERIAL & CALIBRATION PACKET – CONTAINS:** daily standard count log, factory & laboratory calibration data sheet, Leak test cert, Procedure for handling, Shipper's declaration for dangerous goods, anything else required by local agencies.

AASHTO T310 is useful as a rapid, nondestructive technique for the in-place determination of the wet density and water content of soil and soil-aggregate. Generally, this method is used for quality control and acceptance testing of compacted soil and rock for construction and for research and development. Because it is nondestructive it allows for repetitive measurements at a single test location and statistical analysis of the results.

INTERFERENCES:

Interferences section details factors that can negatively impact the accuracy of nuclear gauge density and moisture measurements, such as oversized rock, large voids, chemical composition, sample heterogeneity, material density, and surface texture. Other potential interferences include nearby radiation sources and the proximity of the test site to vertical objects.

- **IN-PLACE DENSITY INTERFERENCES [CHEMICAL COMPOSITION]** – The **chemical composition** of the material (such as the presence of hydrogen) may **affect the measurement** and adjustments may be necessary. **4.1.1.**

- **IN-PLACE DENSITY INTERFERENCES [SENSITIVITY TO SURFACE]–** The gauge is **more sensitive** to the **density** of the material in **close proximity to the surface** in the **backscatter method**. **4.1.2.**

  NOTE 1** – The nuclear gauge density measurements are somewhat biased to the surface layer of the soil being tested. This has been mostly corrected out of the direct transmission method, and any remaining bias is insignificant. The backscatter method is still more sensitive to the material within the first several inches from the surface. Density measurements with direct transmission are the preferred method. **(SECTION 4.1.2.)

- **IN-PLACE DENSITY INTERFERENCES [OVERSIZED ROCK]** – **Oversize rocks or large voids** in the source detector path may **cause higher or lower density determination**s. If it is suspected that there is a lack of uniformity in the soil due to layering, or there are rocks, or voids, **excavate and visually examine the test site** to determine if the test material is **representative of the full material in general, and if rock correction is required.** **4.1.3.**

- **IN-PLACE DENSITY INTERFERENCES [VARIABILITY OF VOLUME]** – The sample **volume is approximately 0.0028 m^3(0.10 ft^3) for the backscatter method** and **0.0057 m^3(0.20 ft^3) for direct transmission method** when the test **depth is 150 mm (6 inches).** The **actual** sample **volume** is **indeterminate and varies with the gauge** and the density of the material. In general, the **higher the density the smaller the volume.** **4.1.4.**

- **IN-PLACE DENSITY INTERFERENCES [RADIOACTIVE SOURCES]** – Other radioactive sources must **not be within 30 feet (10 meters)** of the gauge operation. **4.1.5.**

- **IN-PLACE MOISTURE CONTENT INTERFERENCES [CHEMICAL COMPOSITION]** – The **chemical composition** of the material may affect the measurement, and adjustments may be necessary. **Hydrogen in forms other than water will cause measurements in excess of the true value.** Some chemical elements, such as boron, chlorine, and minute quantities of cadmium, will cause measurements lower than the true value. **4.2.1.**

- **IN-PLACE MOISTURE CONTENT INTERFERENCES [WATER @ SURFACE]** – The water content determined by this test method is **not necessarily the average water within the volume of the sample measured**. Measurements are heavily influenced by the water content of the material closest to the surface. The **volume** of **soil and rock** represented in the measurement is **indeterminate and will vary with** the **water content of the material.** In general, the greater the water content of the material, the smaller the volume involve in the measurement. At **160 kg/m^3(10 $lb./ft^3$), approximately 50 percent of the typical measurement results** from the water content of the upper **50 to 75 mm (2 to 3 inches).** **4.2.2.**

- **IN-PLACE MOISTURE INTERFERENCES [NEUTRON SOURCES]** – Other neutron sources must **not be within 30 feet (10 meters)** of the gauge operation. **4.2.3.**

STANDARDIZATION:

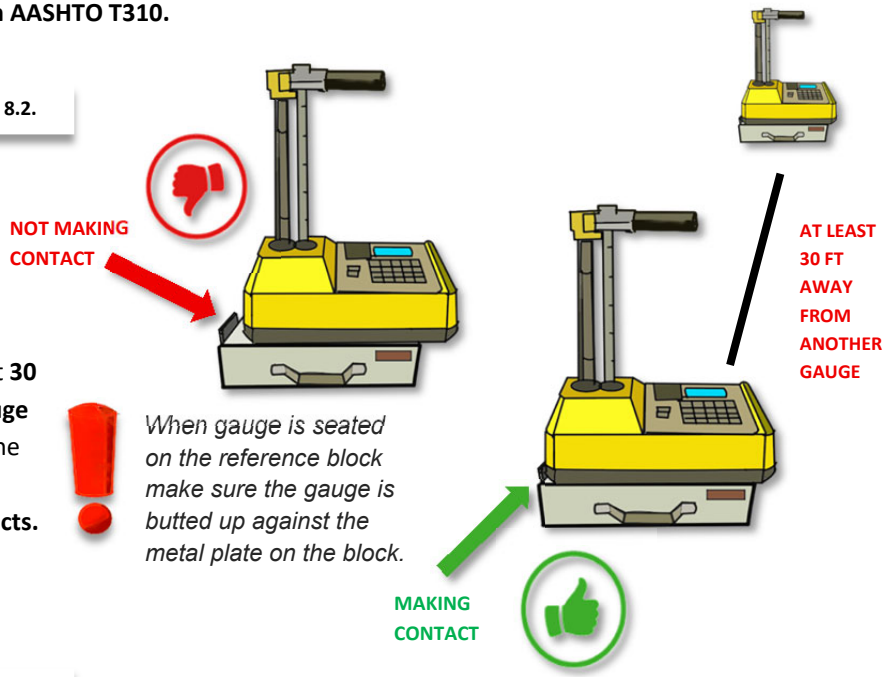
Nuclear gauge standardization, known as taking a "Standard Count," is performed to ensure the gauge's accuracy. This daily routine uses a standard block and is critical for obtaining reliable density and moisture measurements in tested materials.

- **Nuclear density/moisture gauges** are subject to **long-term aging** of the radioactive sources, detector, and electronic systems, which may **change** the relationship between **count rates and the material density and water content**. To offset this aging, gauges are **calibrated** as a ratio of the measurement count rate to a count rate made on a reference standard (or to an air gap count for the backscatter/air gap ratio method). The reference count rate should be roughly the same or greater than the range of measurement count rates acquired while using the gauge normally. **For information on calibration consult Annex A-WET DENSITY CALIBRATION AND VERIFICATION in AASHTO T310.**

8.1.

- **Standardization** of the gauge on the **reference standard / block is required** at the **start of each day.** Maintain a **permanent record** of all counts and associated data.

8.2.



- Perform the **standardization** at least **30 feet (10 meters)** from any **other gauge** or other radioactive sources. Also, the gauge should be **clear** of any **large masses of water or other large objects. Close proximity to these may affect the reference count rates. Take standard counts in the same environment as the actual measurement counts.**

8.2.

- Follow the **manufacturer's recommendations/ instructions** on how to **turn on** and **stabilize** the gauge. If the gauge is to be used either continuously or intermittently during the day, it is **best to leave it in the "power on" condition** to prevent having to repeat stabilization this provides more stable consistent results.

8.2.1

- While on the standardization/ reference block take at least **four repetitive readings** at the normal measurement period and **obtain** the **mean** (***Average)***. If available on the gauge, one measurement of four or more times the normal period is acceptable. **This is considered one standardization check.** ***Note: Most gauges have a built-in program that calculates four repetitive readings and analyzes the mean result against the previous 4 standard checks, mean values and will display whether it is satisfactory or not.***

8.2.2

If the gauge does not perform this step automatically, use the procedure recommended by the gauge manufacturer for determining compliance with the gauge calibration curves. Without specific recommendations from the gauge manufacturer use the following procedure:

- If the **mean of the 4 repetitive readings** is **outside the limits** set by the procedure's equation **repeat** the **standardization check**. If the **second check satisfies the equation the gauge is considered satisfactory but if it is still outside**, refer to the **annexes A & B**, **Sections A8 and B5** from the **procedure on how to check and verify the gauge**. If this verification shows that there is **no significant change** in the calibration curve**, establish a new reference standard count N_0**. If the verification check shows that **there is a significant difference** in the calibration curve, **repair and recalibrate** gauge. **8.2.3**

$$N_s = N_o \pm 1.96\sqrt{(N_o/F)}$$

where:

N_s = value of current standardization count;

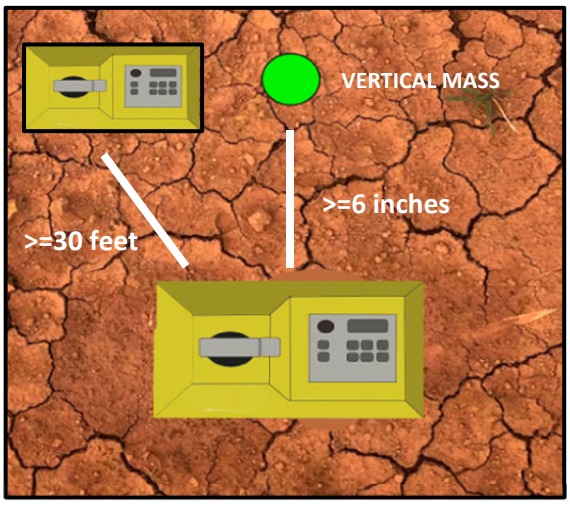
N_o = average of the past four values of Ns taken for prior usage; and

F = factory prescale factor (contact gauge manufacturer for the factor).

Summary: *Select a testing location and prepare this so there is maximum surface area contact between the nuclear gauge and the ground. Drive a pin into the ground to create a hole for the radioactive rod from the gauge. Insert the radioactive rod into the hole. Run the test. The nuclear gauge used emits gamma rays into the soil, and the amount of radiation that is reflected back to the detector is used to determine the material's density. The moisture content is measured simultaneously allowing real time decisions about compaction quality.*

THE FOLLOWING WILL DISCUSS DIRECT TRANSMISSION MODE. ON USING THE BACKSCATTER MODE, PLEASE REFER TO THE PROCEDURE

Select a test location where the gauge will be **at least 6 inches (150 mm) away** from any **vertical mass** and at least **30 feet away from other gauges or any other radioactive source** to get an accurate reading. ***If closer than 24 inches (600 mm) to a vertical mass (EX: trench) follow the manufacturer's guide for the correction procedure.*** **9.1. / 9.5.1.**



Remove any loose or disturbed material and any additional material, as necessary, to expose the area to be tested. **9.2.1**

At the testing location, prepare a **horizontal area** and **plane to a relatively smooth condition**. Make sure the area is large enough to accommodate the size of the gauge**. Ensure that maximum contact between the gauge and material being tested is achieved.** **9.2.2.**

Do not exceed 1/8-inch (3 mm) void beneath the gauge*. Use native fines or fine sand to fill the voids and smooth the surface with a rigid plate or other suitable tool. Do not exceed approximately 1/8 inch (3mm) of filler.* ***(SECTION 9.2.3.)***

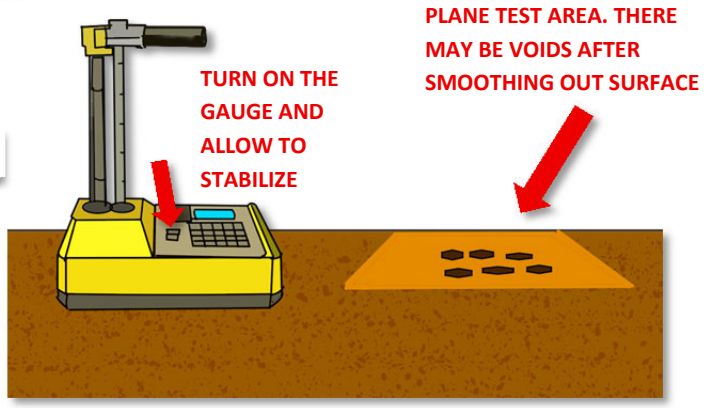
4. **Turn on** the gauge and allow to **stabilize (warm up)**. ***Follow manufacturer's guidelines/ instructions.*** 9.3.

NOTE 3 *– The placement of the gauge on the surface of the material being tested is critical to the successful determination of density. The optimum condition is total contact between the bottom surface of the gauge and the surface of the material. When optimal conditions don't exist, correct surface irregularities by the use of sand or similar filler material. The total area filled should not exceed 10 percent of the bottom area of the gauge. Several trials may be required to achieve these conditions.* ***(SECTION 9.2.3.)***

5. Create a **hole perpendicular to the prepared surface** with the guide plate, drive pin, and hammer. Ensure that the alignment of the hole will not cause the gauge to tilt when the source rod is lower in. Drive the pin **at least 2 inches deeper** than the desired measurement depth. 9.5.2

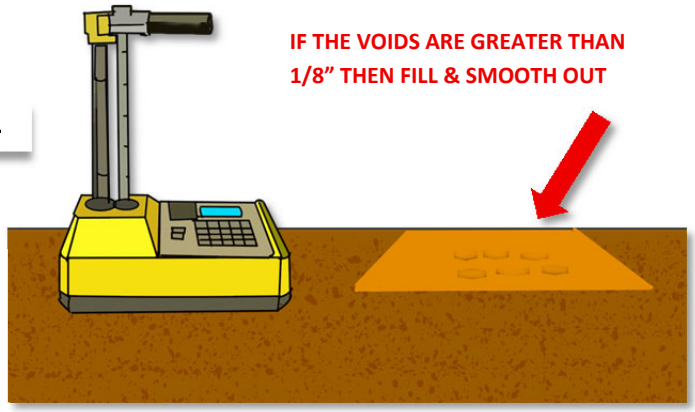
6. **Mark the perimeter of the guide plate (test area)** to make it easier to place the gauge so the source **rod is aligned with the hole**. 9.5.3.

7. **Remove the pin** and guide plate from the area **carefully** so that the **hole** does **not become distorted**, no damage occurs to the surface, and no material falls in. 9.5.4.



8. **Place** the gauge over the **test area**. Check to make sure that **maximum surface contact** is achieved. 9.5.5.

9. **Lower the source rod** into the hole to the **desired test depth**. Once lowered gently **pull back** on the gauge until the source rod **contacts the side** of the hole. 9.5.6.



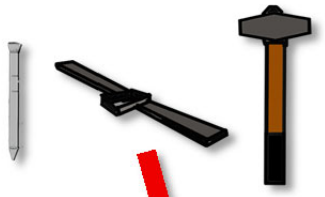
10. If the gauge requires **setting the depth selector to the same depth as the source rod**, **perform this step** before recording the automated (densities, moisture content, and weights) values. 9.5.8.

EQUIPMENT:

DRIVE PIN

PIN EXTRACTOR

HAMMER

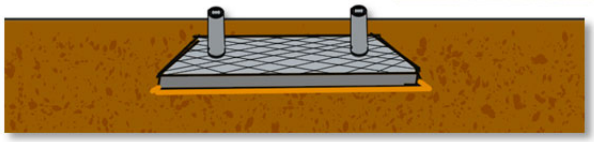


11 Start the measurement and record **one** or more **1-minute readings**. All **densities are recorded to 0.1 lb/ft^3 (or 1 kg/m^3).**

9.5.9.

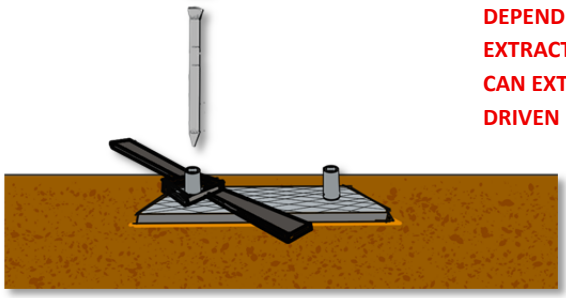
*NOTE 5 – The gauge may be rotated about the axis of the source rod to obtain more readings. **(SECTION 9.5.10.)***

PLACE YOUR GUIDE PLATE OVER THE TEST AREA. HAVE EQUIPMENT NEARBY



12 Determine the in-place **WET DENSITY** (**Dry Density, Water Content…whatever is required by agency)** directly displayed from the gauge or by use of the calibration curve previously established.

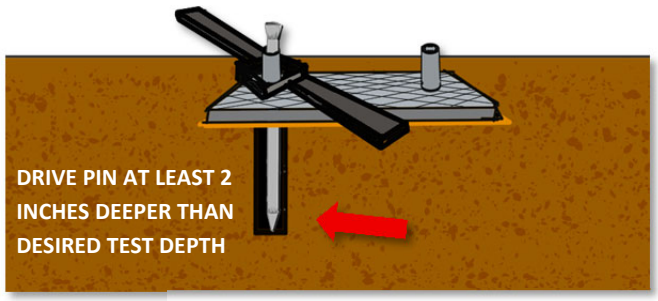
9.5.10.



DRIVE PIN INTO GROUND. SECURE WITH FOOT WHILE PERFORMING THIS ACTION. DEPENDING ON THE TYPE OF EXTRACTOR, ENSURE THAT IT CAN EXTRACT THE PIN ONCE DRIVEN

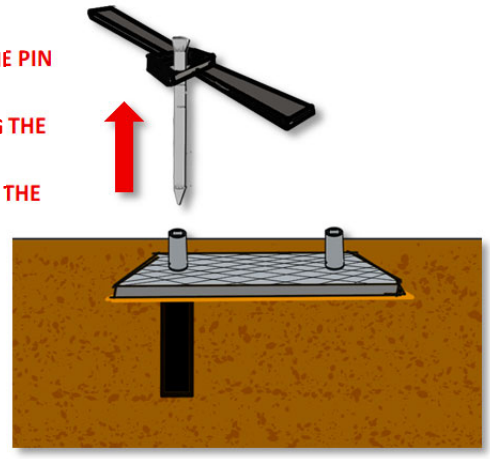
13 When taking a representative sample for **moisture content and or density determination or material for a rock correction (AASHTO T99 ANNEX) remove from directly underneath the gauge. Remove the approximate depth the rod was lowered when measuring.** (***For the Backscatter Mode remove the material to the depth of approximately 3 inches (75mm)).***

9.6.



DRIVE PIN AT LEAST 2 INCHES DEEPER THAN DESIRED TEST DEPTH

EXTRACT THE PIN WITHOUT DISTORTING THE HOLE OR DAMAGING THE



CALCULATIONS:

**Normally these results will be displayed on the gauge directly. Example of how to perform by hand.*

DRY DENSITY CALCULATION:

$$P_d = \left[\frac{P_t}{(W+100)}\right] \text{ X } 100$$

W = Moisture content in percent of specimen.
P_t = Wet density of compacted soil in lb/ft^3 (kg/m^3);
P_d = Dry density of compacted soil in lb/ft^3 (kg/m^3);

EXAMPLE

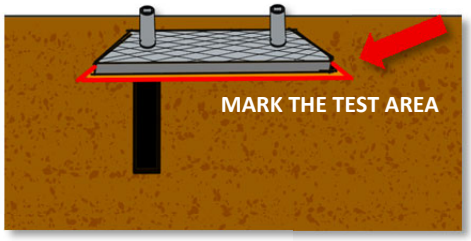
P_t = *131.7* lb/ft^3

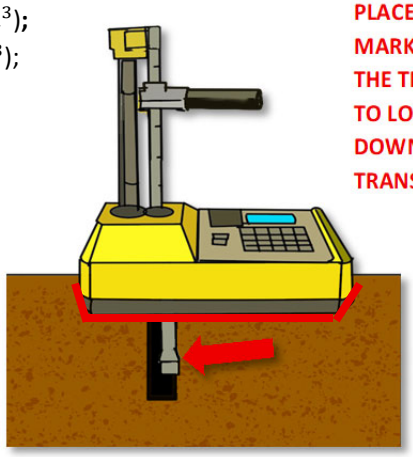
W = *10.1 %*

$$\left[\frac{131.7}{(10.1+100)}\right] \text{ X } 100$$

ANSWER: P_d = *119.6* lb/ft^3

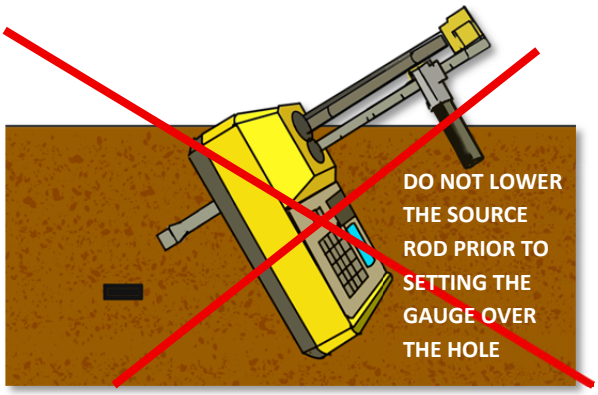
DENSITY WILL BE DETERMINED IN lb/ft^3 IN THIS MANUAL. SEE PROCEDURE FOR DETERMINING IN kg/m^3





PLACE THE GAUGE OVER THE MARKED TEST AREA. RELEASE THE TRIGGER ON THE HANDLE TO LOWER THE SOURCE ROD DOWN TO THE DIRECT TRANSMISSION MODE

AFTER THE ROD IS LOWERED PULL THE UNIT BACK UNTIL CONTACT IS MADE WITH THE SIDE OF THE HOLE. START THE GAUGE AND STEP BACK



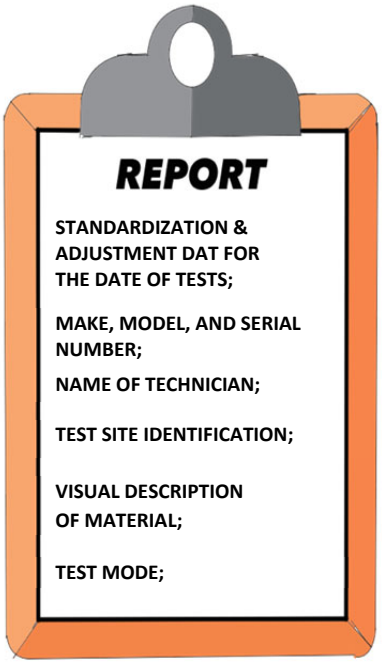
10.2.1.

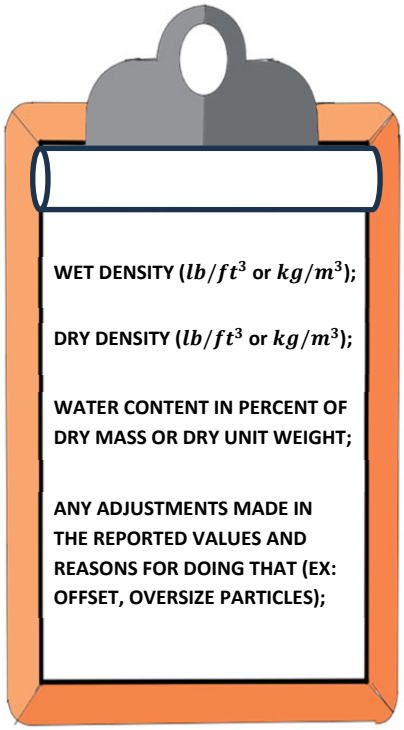
To express the in-place density as a percentage of some other reference density **(PERCENT COMPACTION)**, for example, the laboratory densities determined according to AASHTO T99, AASHTO T180, or AASHTO T272. This relation can be determined by ***dividing the in-place density by the laboratory reference density and multiplying by 100.*** Calculations for determining relative density are provided in ASTM D4253 or D4254. **Perform corrections for oversize material, if necessary.**

NOTE 4 *– As a safety precaution, do not extend a rod containing radioactive sources out of its shielded position prior to placing on the test site. Always align the gauge so as to allow placing the rod directly into the test hole from the shielded position.* ***(SECTION 9.5.6.)***

CALCULATION PERCENT COMPACTION:

$$\text{\% Compaction} = \frac{In\ Place\ Dry\ Density}{Maximum\ Dry\ Density} \text{ X } 100$$





EXAMPLE OF PRINT OUT FROM A TROXLER DENSITY GAUGE.

```
**********************************
PROJECT NUMBER:  1
SN: 59441  DATE:    3/16/2000
**********************************
STA # 1        2:30 PM    3/16/2000
DEPTH: 4 inches
TIME: 15 seconds UNITS: PCF
 Std Cnts: D 3445 M 26
Dens Cnt. 3568 Moist Cnt. 32
WD = -     DD = -
PR = 145.0%PR  =  -
 M = +     %M = +++++
Optional Data:
1234567890.1

---------------------------------
STA # 2        2:30 PM    3/16/2000
DEPTH: 6 inches
TIME: 15 seconds UNITS: PCF
 Std Cnts: D 3445 M 26
Dens Cnt. 3559 Moist Cnt. 27
WD = -     DD = -
PR = 145.0%PR  =  -
 M = +     %M = +++++
```

AASHTO T355:

DENSITY OF COMPACTED BITUMINOUS MIXTURES BY NUCLEAR METHOD

DEFINITIONS:

Back Scatter Mode – *when in back scatter mode the source is in the same plane as the sensor. The shielding within the gauge means that radiation given off the source must first be deflected by the material before reaching the sensor. The more radiation detected by the sensor the higher the material's density.*

SCOPE:

This method describes the procedure for determining the in-place density of ASPHALT MIXTURES by use of the nuclear gauge. The density of the material is determined by the backscatter/air-gap ratio method.

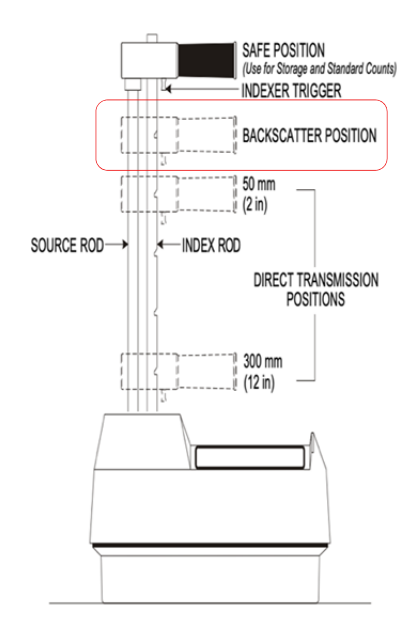
1.1.

EQUIPMENT:

- **NUCLEAR DENSITY/ MOISTURE GAUGE (SEALED RADIATION SOURCE) with instruction manual-** gauge styles and construction vary be but generally the system contains:
  - a **sealed source** of high-energy gamma radiation, such a **cesium or radium**;
  - **gamma detector-** such as a Geiger-Mueller tube(s);
  - **fast neutron source-** a sealed mixture of a radioactive material such as americium, radium or californium-252 and a target material such a beryllium;
  - **slow neutron detector-** any type such as boron trifluoride or helium-3 proportional counter

5.

SEE PROCEDURE FOR ADDITIONAL DETAILS & DIMENSIONS. NOT ALL EQUIP INFO IS COVERED IN THIS MANUAL



BACKSCATTER MODE

- **TRANSPORT CASE**
- **REFERENCE STANDARD / BLOCK –** a **block** of material used for **checking gauge operations**, correction of source decay, and to establish conditions for a reproducible reference count rate.
- **SITE PREPARATION DEVICE – a plate, straightedge**, or other suitable leveling tool.
- **FILLER MATERIAL – fine-graded sand** from the source used to produce the asphalt pavement or other acceptable materials.
- **RADIOACTIVE MATERIAL & CALIBRATION PACKET – CONTAINS:** daily standard count log, factory & laboratory calibration data sheet, leak test cert, Procedure for handling, Shipper's declaration for dangerous goods, anything else required by local agencies.

AASHTO T355 is useful as a rapid, nondestructive technique for the determination of the in-place density of asphalt mixtures. Generally, this method is used for quality control and acceptance testing of compacted asphalt mixtures for construction and for research and development. The results from this test allows for immediate adjustments to the compaction process, optimizes rolling effort, and helps prevent premature pavement failure due to poor compaction.

INTERFERENCES

Interferences section details factors that can negatively impact the accuracy of nuclear gauge density measurements, chemical composition, material density, and surface texture. Other potential interferences include nearby radiation sources and the proximity of the test site to vertical objects.

- **IN-PLACE DENSITY INTERFERENCES [CHEMICAL COMPOSITION]** – The **chemical composition** of the material may affect the measurement, and adjustments may be necessary

4.1.1.

- **IN-PLACE DENSITY INTERFERENCES [SENSITIVITY TO SURFACE]–** The gauge is **more sensitive** to the **density** of the material in **close proximity to the surface** in the backscatter mode.

4.1.2.

NOTE 2** – The nuclear gauge density measurements are somewhat biased to the surface of the material being tested. This method more sensitive to the material within the first several inches from the surface. **(SECTION 4.1.2.)

- **IN-PLACE DENSITY INTERFERENCES [RADIOACTIVE SOURCES]** – Other radioactive sources must **not be within 30 feet (10 meters)** of the gauge operation.

4.1.3.

- **IN-PLACE DENSITY INTERFERENCES [LARGE OBJECTS]** – large objects **must be at least 10 feet (3 meters) away.**

4.1.4.

*Use the gauge manufacturer's correction procedure when the gage will be closer than 24 inches (600 mm) to any vertical mass, or less than 12 inches (300 mm) from a vertical pavement edge. **(SECTION 4.1.5.)***

STANDARDIZATION:

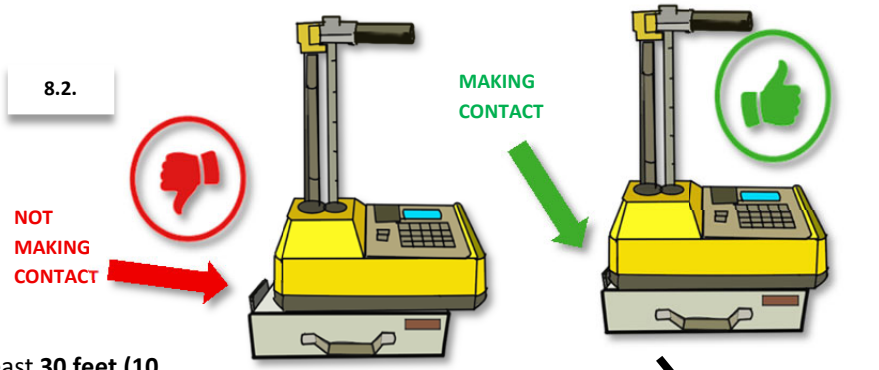
Nuclear gauge standardization, known as taking a "Standard Count," is performed to ensure the gauge's accuracy. This daily routine uses a standard block and is critical for obtaining reliable density and moisture measurements in tested materials.

- **Nuclear density/moisture gauges** are subject to **long-term aging** of the radioactive sources, detector, and electronic systems, which may **change** the relationship between **count rates and the material**. To offset this aging, gauges are **calibrated** as a ratio of the measurement count rate to a count rate made on a reference standard (or to an air gap count for the backscatter/air gap ratio method). The reference count rate should be roughly the same or greater than the range of measurement count rates acquired while using the gauge normally. **For information on calibration consult Annex A-WET DENSITY CALIBRATION AND VERIFICATION in AASHTO T355.**

8.1.

- **Standardization** of the gauge on the **reference standard / block is required** at the **start of each day.** Maintain a **permanent record** of all counts and associated data.

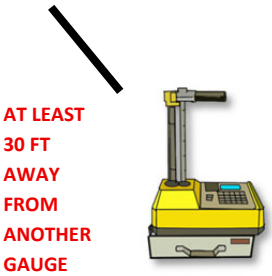
8.2.



- Perform the **standardization** at least **30 feet (10 meters)** from any **other gauge** or other radioactive sources. Also, the gauge should be **clear** of any **large masses or other large objects. Close proximity to these may affect the reference count rates. Take standard counts in the same environment as the actual measurement counts.**

8.2.

When gauge is seated on the reference block make sure the gauge is butted up against the metal plate on the block.



- Follow the **manufacturer's recommendations/ instructions** on how to **turn on** and **stabilize** the gauge. If the gauge is to be used either continuously or intermittently during the day, it is **best to leave it in the "power on" condition** to prevent having to repeat stabilization this provides more stable consistent results.

8.2.1

- While on the standardization/ reference block take at least **four repetitive readings** at the normal measurement period and **obtain** the **mean** (***Average)***. If available on the gauge, one measurement of four or more times the normal period is acceptable. **This is considered one standardization check.** ***Note: Most gauges have a built-in program that calculates four repetitive readings and analyzes the mean result against the previous 4 standard checks, mean values and will display whether it is satisfactory or not.***

8.2.2

If the gauge does not perform this step automatically, use the procedure recommended by the gauge manufacturer for determining compliance with the gauge calibration curves. Without specific recommendations from the gauge manufacturer use the following procedure:

- If the **mean of the 4 repetitive readings** is **outside the limits** set by the procedure's equation **repeat** the **standardization check**. If the **second check satisfies the equation the gauge is considered satisfactory but if it is still outside**, refer to the **annexes A & B**, **Sections A8 and B5** from the **procedure on how to check and verify the gauge**. If this verification shows that there is **no significant change** in the calibration curve**, establish a new reference standard count N_0**. If the verification check shows that **there is a significant difference** in the calibration curve, **repair and recalibrate** gauge.

8.2.3

$$N_s = N_o \pm 1.96\sqrt{(N_o/F)}$$

where:

N_s = value of current standardization count;

N_o = average of the past four values of Ns taken for prior usage; and

F = factory prescale factor (contact gauge manufacturer for the factor).

Summary: *The test site is selected and the method of taking the measurement is determined by the technician (or agency). The nuclear density gauge works by using a small source of gamma radiation (usually Cesium-137 or Americium-241) to send gamma rays into the compacted asphalt mixture. When the gamma rays interact with the material, some of the rays are scattered back to the detector, while others are absorbed by the material. The density of the material is then determined by the backscatter/air gap ratio method. See the procedure for more details.*

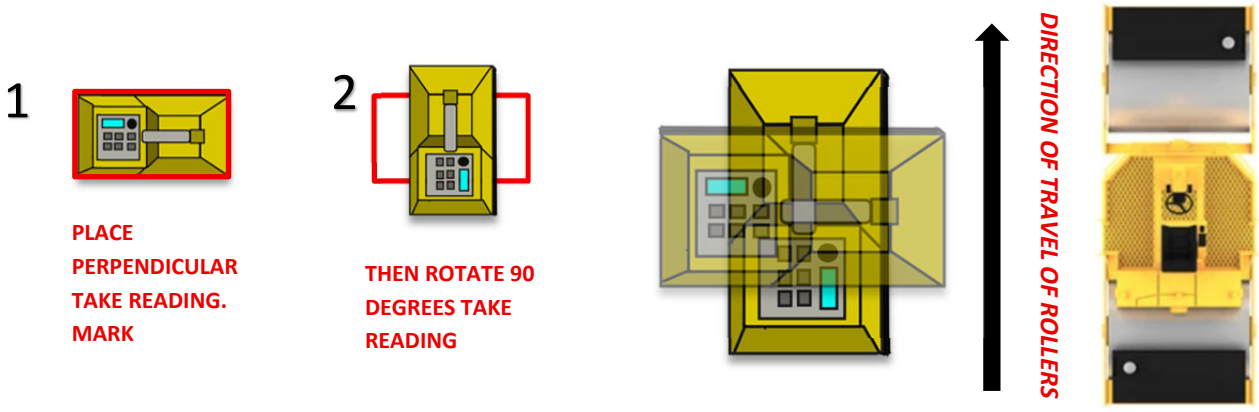
1. Select a relatively **flat and smooth test location**. Make sure the gauge is at least **10 feet (3 meters) away** from any **large object and 30 feet from any other radioactive sources**. **If closer than 24 inches to a vertical mass or less than 12 inches from a vertical pavement edge follow the manufacturer's guide for the correction procedure.** **9.1.**

2. The gauge must maintain **maximum contact** between its base and the test **surface.** If there are surface **voids** use filler material to **fill them in**. **Spread a small amount of filler over** the **voids** and distribute evenly. **Strike off** with a straight edge to remove excess material. **9.2.1.**

ALTERNATE METHOD 1 – 90 DEGREE ROTATION

3. Place the gauge on the test site **perpendicular** to the **direction of travel of the rollers**. Mark (using crayon or chalk) the **outline** of the foot print of the **gauge**. **9.3.1.1.**

4. Release the trigger on the handle to place **the source rod** in the **back scatter** position. **9.3.1.1.**



5. Take a **1-minute** test and **record** the **wet density** reading. **Record** to the **nearest 0.1 lb/ft^3 (or 1 kg/m^3).** 9.3.1.2.

6. Rotate the gauge **90 degrees** centered **over the original footprint** that has been outlined**. Mark the outline of the gauge in the new position.** 9.3.1.3.

7. Take a **1-minute** test and **record** the **NEW wet density** reading. **Record** to the **nearest 0.1 lb/ft^3 (or 1 kg/m^3).** 9.3.1.4.

8. If the **difference** between the **2 readings** is **greater** than **2.5 lb/ft^3** (**40 kg/m^3**) then **retest** in **BOTH directions**. 9.3.1.5.

9. If the difference of the retests is still greater than is **greater** than **2.5 lb/ft^3** (**40 kg/m^3**) **repeat the test at 180° & 270°.** 9.3.1.5.

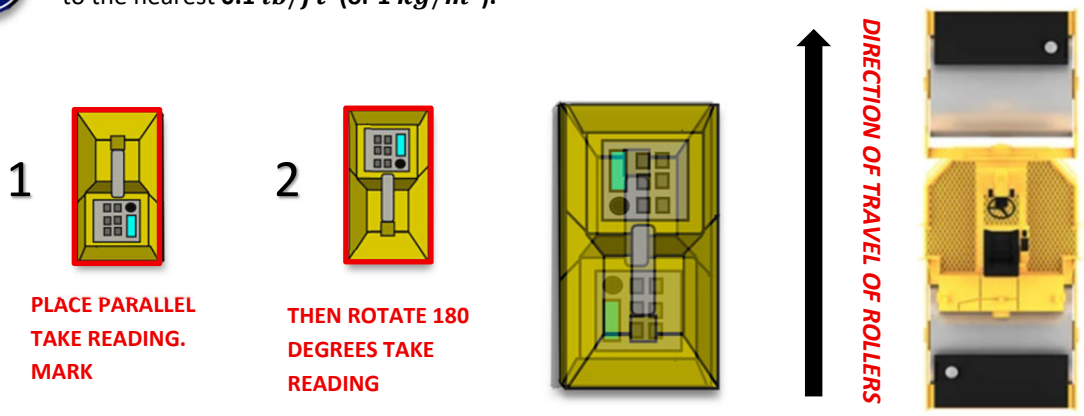
10. Report the average of the two individual 1-minute wet density readings. 9.3.1.6.

ALTERNATE METHOD 2 – 180 DEGREE ROTATION

3. Place the gauge on the test site **parallel** to the **direction of travel of the rollers**. Mark (using crayon or chalk) the **outline** of the foot print of the **gauge**. 9.3.2.1.

4. Release the trigger on the handle to place the **source rod** in the **back scatter** position. 9.3.2.1.

5. Take a **1-minute test** and record the **wet density** reading. Record to the nearest **0.1 lb/ft^3(or 1 kg/m^3).** 9.3.2.2.



6. Rotate the gauge **180 degrees** centered **over the original footprint** that was been outlined. **Mark the outline of the new position.** 9.3.2.3.

7. Take a **1-minute** test and record the **NEW wet density** reading. Record to the nearest **0.1 lb/ft^3(or 1 kg/m^3).** 9.3.2.4.

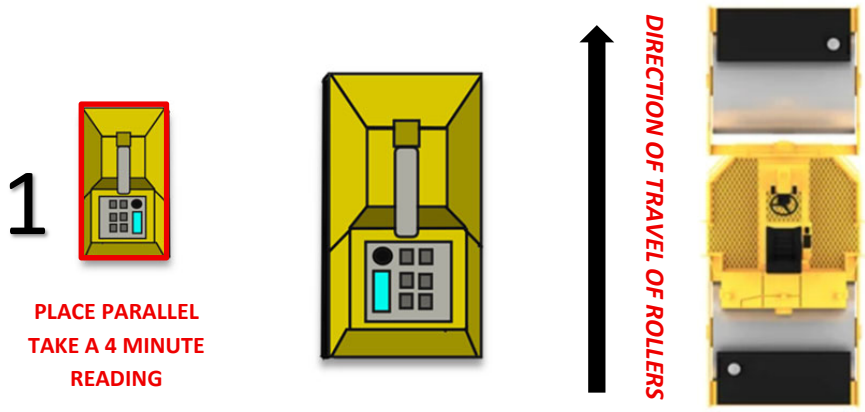
8. If the **difference** between the **2 readings** is **greater** than **2.5 lb/ft^3** (**40 kg/m^3**) then **retest** in **BOTH directions**. 9.3.2.5.

9. **Report the average** of the two individual **1-minute wet density readings**. 9.3.2.6.

ALTERNATE METHOD 3

3. Place the **gauge** on the test site **parallel** to the direction of travel of the rollers. Mark (using crayon or chalk) the **outline** of the foot print of the **gauge**. 9.3.3.1.

4. Take a **4-minute test** and record the **wet density**. Record to the nearest **0.1 lb/ft^3(or 1 kg/m^3).** 9.3.3.2.



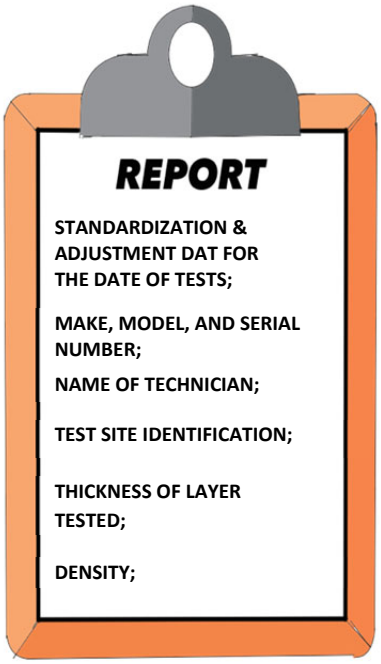
**Normally these results will be displayed on the gauge directly.*

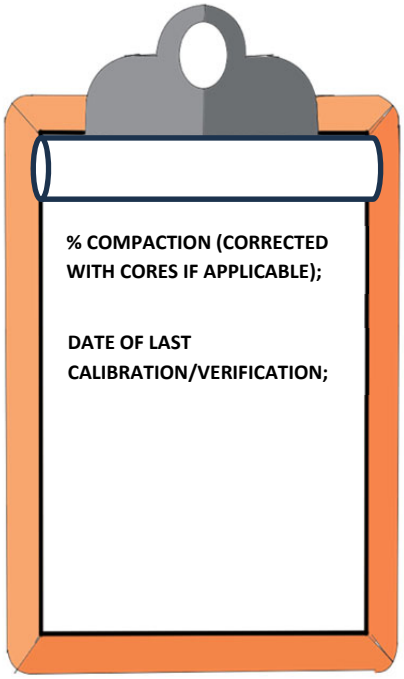
10.1.1.

To express the in-place density as a percentage of some other density **(PERCENT COMPACTION)**, for example, the laboratory densities determined **according to AASHTO T209**. This relation can be determined by **dividing the in-place density by the laboratory density and multiplying by 100.**

CALCULATION PERCENT COMPACTION:

% Compaction = $\frac{In\ Place\ Density}{Laboratory\ Density}$ **X 100**





The bulk specific gravity (G_{mb}) of the core is a physical measurement of the in-place asphalt mixture and can be compared with the nuclear density gauge readings. Comparing the core value to the corresponding gauge values, a correlation can be established. The correlation can then be used to adjust the gauge readings to the in-place density of the cores. The core correlation is gauge-specific and must be determined without traffic allowed on the pavement between nuclear density gauge readings and obtaining the core. When using multiple nuclear density gauges, correlate each gauge to the core locations prior to removal of the core.

CORRELATION WITH CORES:

WHAT IS BEST PRACTICE FOR CORRELATING GAUGES WITH PAVEMENT CORES?

ANSWER: Correlate on the first day's paving (within 24 hours) or from a test strip created prior to the start of production paving. **(SECTION X1.1.)**

THIS INFORMATION IS NON-MANDATORY. PLEASE REFER TO AGENCY POLICIES ON CORRELATION FACTORS (IF ANY) FOR NUCLEAR GAUGES

PROCEDURE:

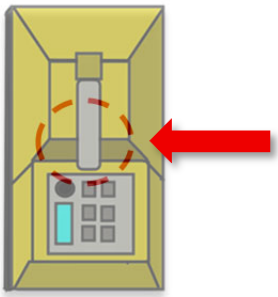
1. Establish the **number** and **location** of **cores required for correlation.** ***(See agency requirements)*** **X1.2.1.**

2. **Determine** the **IN-PLACE densities** for **each location** selected using the nuclear density gauge(s). **X1.2.2.**

3. Obtain a **core** (**center** of the **nuclear gauge footprint**) from each of the **selected locations according to AASHTO R67.** **X1.2.3.**

4. Determine the **bulk specific gravity (G_{mb})** of the cores according **to AASHTO T166** ***(see procedure for details on additional methods).*** **X1.2.4.**

5. Determine the bulk density of the cores by **multiplying the bulk specific gravity (G_{mb}) by 62.245 lb/ft^3 (997.1 kg/m^3),** and **report** the value to the **nearest 0.1 lb/ft^3(1 kg/m^3).** **X1.2.5.**



APPROXIMATE CORE LOCATION

CORRELATION FACTOR CALCULATION:

- Calculate the **difference between the core density and nuclear gauge density** at each test site. **Subtract the average nuclear gauge reading FROM** the **density results** from the **core** and **record to the nearest 0.1 lb/ft^3(1 kg/m^3).** X1.3.1.

- **Calculate the average difference and standard deviation** of the differences for the entire data set to the **nearest 0.1 lb/ft^3(1 kg/m^3).** X1.3.1.

- If the standard deviation of the **differences is equal to or less than 2.5 lb/ft^3(40 kg/m^3), apply the correlation factor *(average difference for the entire data set)*** to the nuclear density gauge reading. X1.3.2.

- If the standard deviation of the **differences is greater than 2.5 lb/ft^3(40 kg/m^3), eliminate the test site with the greatest variation** from the average difference from the data set. Then **repeat the process,** recalculating the average differences for the entire data set and the new standard deviation. X1.3.3.

- If the standard deviation of the modified data set still **exceeds 2.5 lb/ft^3(40 kg/m^3), additional test sites will be eliminated from the data set.** Then **repeat the process,** recalculating the average differences for the entire data set and the new standard deviation. **If the data set consists of less than five test sites, establish additional test sites.** X1.3.4.

RECORD THE DENSITIES FROM THE CORES AND THE (AVERAGE) DENSITIES FROM THE NUCLEAR GAUGE

TESTING LOCATIONS	CORE RESULTS (T166)	AVERAGE GAUGE READING (T355)
1	144.9 lb/ft^3	142.1 lb/ft^3
2	142.8 lb/ft^3	140.9 lb/ft^3
3	143.1 lb/ft^3	140.7 lb/ft^3
4	140.7 lb/ft^3	138.9 lb/ft^3
5	145.1 lb/ft^3	143.6 lb/ft^3
6	144.2 lb/ft^3	142.4 lb/ft^3
7	143.8 lb/ft^3	141.3 lb/ft^3
8	142.8 lb/ft^3	139.8 lb/ft^3
9	144.8 lb/ft^3	143.3 lb/ft^3
10	143.0 lb/ft^3	141.0 lb/ft^3

SUBTRACT THE AVERAGE GAUGE READING FROM THE DENSITY OF THE CORES AND RECORD THE DIFFERENCE FOR EACH TESTING LOCATION.

TESTING LOCATIONS	CORE RESULTS (T166)		AVERAGE GAUGE READING (T355)		DIFFERENCE
1	144.9 lb/ft^3	-	142.1 lb/ft^3	=	2.8 lb/ft^3
2	142.8 lb/ft^3	-	140.9 lb/ft^3	=	1.9 lb/ft^3
3	143.1 lb/ft^3	-	140.7 lb/ft^3	=	2.4 lb/ft^3
4	140.7 lb/ft^3	-	138.9 lb/ft^3	=	1.8 lb/ft^3
5	145.1 lb/ft^3	-	143.6 lb/ft^3	=	1.5 lb/ft^3
6	144.2 lb/ft^3	-	142.4 lb/ft^3	=	1.8 lb/ft^3
7	143.8 lb/ft^3	-	141.3 lb/ft^3	=	2.5 lb/ft^3
8	142.8 lb/ft^3	-	139.8 lb/ft^3	=	3.0 lb/ft^3
9	144.8 lb/ft^3	-	143.3 lb/ft^3	=	1.5 lb/ft^3
10	143.0 lb/ft^3	-	141.0 lb/ft^3	=	2.0 lb/ft^3

AVERAGE DIFFERENCE: 2.1 lb/ft^3

AVERAGE THE DIFFERENCES OF ALL THE DIFFERENCES OBTAINED FROM EACH TESTING LOCATION

NOTE X1 *– The correlation procedure must be repeated if there is a new job mix formula. Adjustments to the job mix formula beyond tolerances established in the contract documents will constitute a new job mix formula. A correlation factor established using this procedure is only valid for the particular gauge and in the mode and at the source rod depth used in the correlation procedure. If another gauge is brought onto the project, correlate it using the same procedure. Multiple gauges may be correlated from the same series of cores if done at the same time.* ***(SECTION X1.3.4.)***

SUBTRACT THE RESULTS OF THE DIFFERENCE COLUMN FROM THE AVERAGE DIFFERENCE FOR THE ENTIRE DATA SET. RECORD YOUR RESULTS

TESTING LOCATIONS	CORE RESULTS (T166)	AVERAGE GAUGE READING (T355)	DIFFERENCE		DIFFERENCE FROM AVERAGE DIFFERENCE (X)
1	144.9 lb/ft^3	142.1 lb/ft^3	2.1 - 2.8 lb/ft^3	=	-0.7
2	142.8 lb/ft^3	140.9 lb/ft^3	2.1 - 1.9 lb/ft^3	=	+0.2
3	143.1 lb/ft^3	140.7 lb/ft^3	2.1 - 2.4 lb/ft^3	=	-0.3
4	140.7 lb/ft^3	138.9 lb/ft^3	2.1 - 1.8 lb/ft^3	=	+0.3
5	145.1 lb/ft^3	143.6 lb/ft^3	2.1 - 1.5 lb/ft^3	=	+0.6
6	144.2 lb/ft^3	142.4 lb/ft^3	2.1 - 1.8 lb/ft^3	=	+0.3
7	143.8 lb/ft^3	141.3 lb/ft^3	2.1 - 2.5 lb/ft^3	=	-0.4
8	142.8 lb/ft^3	139.8 lb/ft^3	2.1 - 3.0 lb/ft^3	=	+0.9
9	144.8 lb/ft^3	143.3 lb/ft^3	2.1 - 1.5 lb/ft^3	=	-0.6
10	143.0 lb/ft^3	141.0 lb/ft^3	2.1 - 2.0 lb/ft^3	=	-0.1

AVERAGE DIFFERENCE: 2.1 lb/ft^3

TESTING LOCATIONS	CORE RESULTS (T166)	AVERAGE GAUGE READING (T355)	DIFFERENCE	DIFFERENCE FROM AVERAGE DIFFERENCE (X)		DIFFERENCE FROM AVERAGE DIFFERENCE SQUARED (X^2)
1	144.9 lb/ft^3	142.1 lb/ft^3	2.8 lb/ft^3	-0.7	$(-0.7)^2$ =	0.49
2	142.8 lb/ft^3	140.9 lb/ft^3	1.9 lb/ft^3	+0.2	$(+0.2)^2$ =	0.04
3	143.1 lb/ft^3	140.7 lb/ft^3	2.4 lb/ft^3	-0.3	$(-0.3)^2$ =	0.09
4	140.7 lb/ft^3	138.9 lb/ft^3	1.8 lb/ft^3	+0.3	$(+0.3)^2$ =	0.09
5	145.1 lb/ft^3	143.6 lb/ft^3	1.5 lb/ft^3	+0.6	$(+0.6)^2$ =	0.36
6	144.2 lb/ft^3	142.4 lb/ft^3	1.8 lb/ft^3	+0.3	$(+0.3)^2$ =	0.09
7	143.8 lb/ft^3	141.3 lb/ft^3	2.5 lb/ft^3	-0.4	$(-0.4)^2$ =	0.16
8	142.8 lb/ft^3	139.8 lb/ft^3	3.0 lb/ft^3	+0.9	$(+0.9)^2$ =	0.81
9	144.8 lb/ft^3	143.3 lb/ft^3	1.5 lb/ft^3	-0.6	$(-0.6)^2$ =	0.36
10	143.0 lb/ft^3	141.0 lb/ft^3	2.0 lb/ft^3	-0.1	$(-0.1)^2$ =	0.01

TAKE THE VALUE FROM THE X COLUMN AND SQUARE EACH ONE. SUM ALL THESE RESULTS UP

AVERAGE DIFFERENCE: 2.1 lb/ft^3

SUM OF DIFFERENCE FROM AVERAGE DIFFERENCE: Σx^2 = 2.5

THIS WILL BE YOUR TOP VALUE IN THE STANDARD DEVIATION CALCULATION

STANDARD DEVIATION:

$$\sqrt{\frac{\Sigma x^2}{(n-1)}}$$

SUM OF DIFFERENCE FROM AVERAGE DIFFERENCE: Σx^2 = 2.5

NUMBER OF DATA SETS: $(n\text{-}1)$ = 10 – 1 = 9

THE NUMBER OF DATA SETS ARE 10 THEN SUBTRACT 1 FROM THIS NUMBER

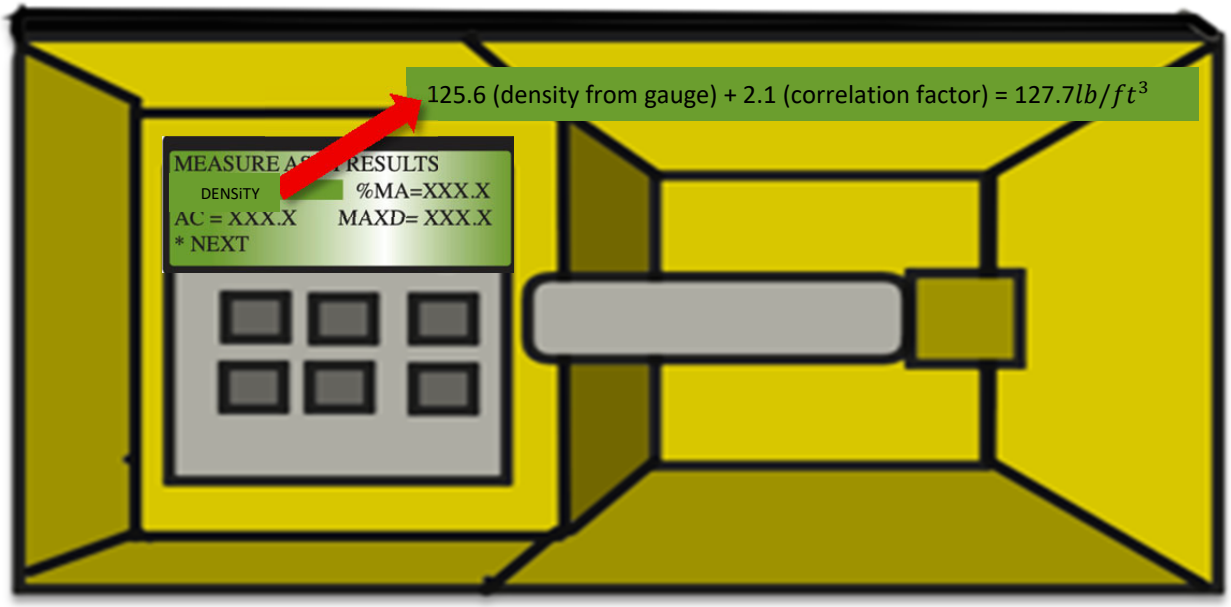
$\boldsymbol{\Sigma}$ = Sum;
$\boldsymbol{x}$ = difference from the average difference;
$\boldsymbol{n-1}$ = number of data sets minus 1;

PLUG IN YOUR NUMBERS AND CALCULATE. VERIFY THAT THE STANDARD DEVIATION IS EQUAL TO OR LESS THAN 2.5 lb/ft^3(40 kg/m^3). IF SO, APPLY THE CORRELATION FACTOR *(AVERAGE DIFFERENCE FOR THE ENTIRE DATA SET)* TO THE NUCLEAR DENSITY GAUGE READING.

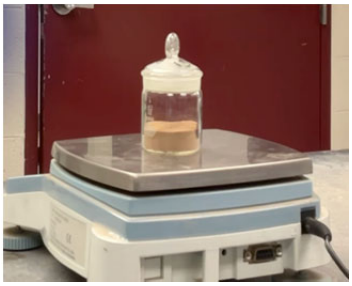
STANDARD DEVIATION:

$\sqrt{\frac{2.5}{9}}$ = 0.53

THE RESULT FROM THIS EXAMPLE IS 0.53 THIS IS LESS THAN 2.5 SO THE CORRELATION FACTOR WOULD BE THE (AVERAGE DIFFERENCE) + 2.1 lb/ft^3. THIS NUMBER SHOULD THEN BE ADDED TO THE IN-PLACE DENSITIES TAKEN WITH THE NUCLEAR GAUGE



AASHTO T265:
STANDARD METHOD OF TEST FOR LABORATORY DETERMINATION OF MOISTURE CONTENT OF SOILS



SCOPE:

This method covers the laboratory determination of the moisture content of soils.

1.1.

EQUIPMENT:

- **DRYING OVEN –** Thermostatically controlled capable of being heated continuously at a **temperature of 230 ± 9°F (110 ± 5°C).** Ovens for heating and drying will be capable **of operation at the temperatures require, between 77°F to 248°F (25°C to 120°C), within ± 9°F (± 5°C),** as corrected, if necessary, by standardization. More than one oven may be used, provided each is used within its proper operating temperature range.

4.

SEE PROCEDURE FOR ADDITIONAL DETAILS & DIMENSIONS. NOT ALL EQUIP INFO IS COVERED IN THIS MANUAL

- **THERMOMETER (OVEN VERIFICATION) –** must meet the requirements of AASHTO M339 with a temperature **range** of at **least 32°F to 266°F (0°C to 130°C), and an accuracy of ± 2.25°F (± 1.25°C).**

- **BALANCE –** must have sufficient capacity, conform to the requirements of **AASHTO M231,** and be **readable to the nearest 0.1 % of the sample mass, or better.**

- **CONTAINERS – suitable containers** must be made of material resistant to corrosion and will **not change in mass or disintegrate** on repeated heating and cooling. Containers must have **close-fitting lids** to prevent loss & absorption of moisture in test samples. **One container** is needed for **each moisture content determination**.

SAMPLE:

Generally, the material amount needed for a representative sample will be located in the test method being used. Moisture content (the ratio of the mass of water to the mass of dry soil) directly affects almost every engineering property of soil — strength, density, and compaction behavior. This procedure is referenced in all soils procedures that requires a moisture content determination.

- The **minimum representative test sample** amount is generally indicated in the **test method**. If **no amount** is **specified**; the minimum mass of the sample will be **found in the table** in this procedure ***(AASHTO T265 SEC 5.1.).***

5.1.

Maximum Particle Size	Minimum Mass of Sample, g
0.425-mm (No. 40) sieve	10
4.75-mm (No. 4) sieve	100
12.5-mm (1/2 in.)	300
25.0-mm (1 in.)	500
50-mm (2 in.)	1000

PROCEDURE:

1. **Weigh** a clean, dry **container** with its **lid** and record this weight. **Record the weight of the container and lid to the nearest 0.1% (or better).** 6.1.

2. Place the **moisture content sample** in the container and place the **lid on immediately** then **weigh. Record the weight to the nearest 0.1% (or better).** 6.1.

3. When ready to place in the oven, **remove the lid** and place everything (container, lid, sample) in an oven at **230 ± 9°F (110 ± 5°C). Leave in the oven for a minimum of 15 hours OR** until the sample reaches **Constant Mass (the sample is dried until the mass loses LESS than 0.1% after 1 hour of additional drying).** 6.1.

4. ***(AFTER THE SAMPLE HAS ACHIEVED CONSTANT MASS)*** **Remove the sample from the oven and immediately re**place the lid on the container and allow to **cool to room temperature.** 6.1.

5. **Weigh** the **container** including the lid and the **dried sample**. **Record the weight to the nearest 0.1% (or better).** 6.1.

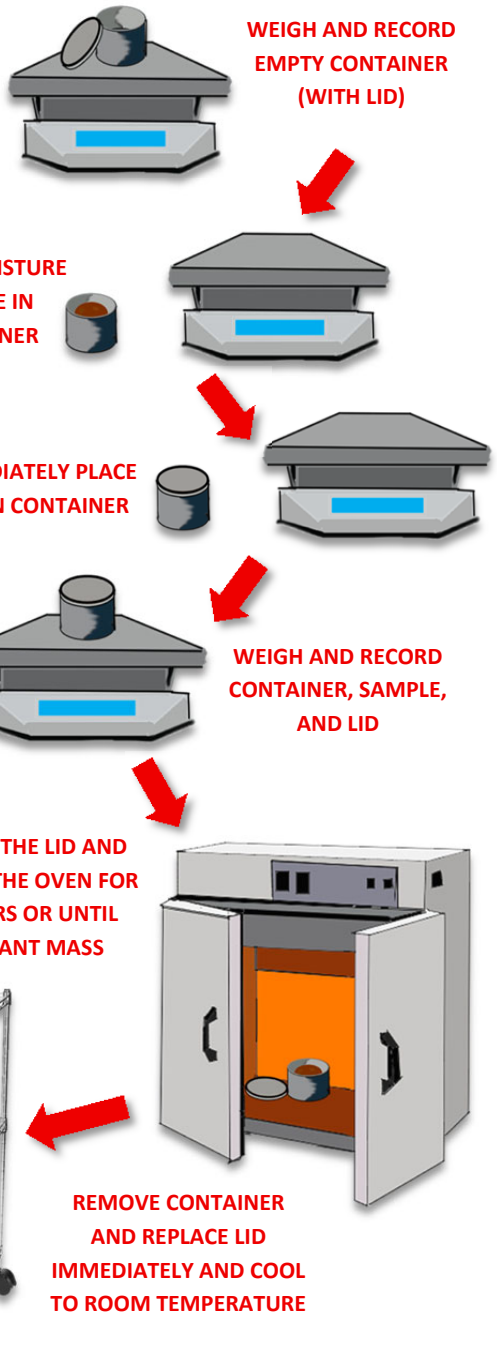
NOTE 2 *– When there is doubt about the adequacy of overnight drying (minimum 15 hours) drying should continue until constant mass is achieved.* ***(SECTION 6.1.)***

NOTE 2- Remove dried samples from the oven before placing wet samples in the oven. ***(SECTION 6.1)***

NOTE 3 *– Oven drying at* **230 ± 9°F (110 ± 5°C)** *does not result in reliable moisture content values for soil containing gypsum or other minerals having loosely bound water form hydration or for soil containing significant amounts of organic material. Reliable moisture content values for these soils can be obtained by drying in an oven at approximately* **140 °F (60 °C)** *or by vacuum desiccation at a pressure of approximately 10 mmHg and at a temperature not lower than* **73 °F (23°C)** ***(SECTION 6.1.)***

CAN A CONTAINER WITHOUT A LID BE USED?

ANSWER: *It can be used if the sample is weighed immediately after being taken, and provided the dried sample is weighed immediately after being removed from the oven or after cooling in a desiccator.* ***(SECTION 6.1. NOTE 4)***



CALCULATION OF MOISTURE CONTENT:

$$W = \left[\frac{(w_1 - w_2)}{(w_2 - w_c)}\right] \text{ X } 100$$

W = Moisture content in percent.
W_1 = Mass of the container and sample in grams.
W_2 = Mass of the container and oven-dried sample in grams.
W_c = Mass of the container in grams.

HOW TO CALCULATE % CHANGE IN MASS WHEN DETERMINING CONSTANT MASS:

$$\text{\% CHANGE} = \frac{(M_p - M_n)}{(M_p)} \text{ X } 100$$

M_p = previous mass measurement;
M_n = next mass measurement;

Remember: *different material types may dry quicker than other types.*

EXAMPLE:

W_c = ***60.08 grams***

W_1 (becomes the first M_p) = ***75.85 grams***

AFTER SAMPLE WAS DRIED FOR 1 HOUR:

M_n (becomes the new M_p if constant mass has not been achieved) = ***72.91 grams***;

$\frac{(75.85 - 72.91)}{(75.85)}$ X 100 = 3.9% **NOT LESS THAN 0.1% KEEP DRYING!**

AFTER SAMPLE WAS DRIED FOR AN ADDITIONAL 1 HOUR:

$M_n(W_2)$ = ***72.85 grams;***

$\frac{(72.91 - 72.85)}{(72.91)}$ X 100 = 0.08% **LESS THAN 0.1% THIS WILL BE RECORDED AS YOUR W_2!**

W_c = ***60.08 grams***

W_1 = ***75.85 grams***

W_2 = ***72.85 grams***

$$\left[\frac{(75.85 - 72.85)}{(72.85 - 60.08)}\right] \text{ X } 100 = 23.49\ \%$$

ANSWER:

W = 23.49 %

AASHTO T255:

STANDARD METHOD OF TEST FOR TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING.

This test method determines the total moisture content in aggregates, including those used in asphalt and concrete mixtures. This test has many applications. An example of the significance for this test is that both batch and drum asphalt plants, aggregate is weighed before mixing. If moisture is not measured and adjusted for, the plant may add too much water (by weight), resulting in under-dosing of asphalt binder and other ingredients.

SCOPE:

This test method covers the determination of the percentage of evaporable moisture in a sample of aggregate by drying both surface moisture and moisture in the pores of the aggregate. Some aggregate may contain water that is chemically combined with the minerals in the aggregate. Such water is not evaporable and is not included in the percentage determined by this test method.

1.1.

EQUIPMENT:

- **SOURCE OF HEAT –** oven(s) for heating and drying must be capable of operation at the temperatures required, **between 212°F to 248°F (100°C to 120°C), within ± 9°F (± 5°C),** as corrected, if necessary, by standardization. **Other suitable sources of heat may be used, such as an electric or gas hot plate, electric heat lamps, or a ventilated microwave oven.**

5.

- **THERMOMETER (OVEN VERIFICATION) –** must meet the requirements of AASHTO M339 with a temperature **range** of at **least 194°F to 266°F (90°C to 130°C), and an accuracy of ± 2.25°F (± 1.25°C).**

SEE PROCEDURE FOR ADDITIONAL DETAILS & DIMENSIONS. NOT ALL EQUIP INFO IS COVERED IN THIS MANUAL

- **BALANCE –** must have sufficient capacity, conform to the requirements of **AASHTO M231,** and be **readable to the nearest 0.1 % of the sample mass**, **or better**.

- **CONTAINERS (FOR CONSTANT MASS) –** Made of **material** not **effected by heat** and **volume enough** to **contain** the sample **without spilling** and a **size** where **the sample depth** will not **exceed one-fifth** of the **least lateral dimension**.

- **CONTAINERS (FOR TRANSPORT/ OBTAINING) –** That can **adequately protect** the **sample against loss of moisture**.

- **STIRRER**

SAMPLE:

The sample for moisture content of aggregates is a small, representative portion of the material taken to determine how much water it contains. Refer to the table in this procedure for the required amount of material needed.

6.1

- Sampling will, generally, be according to **AASHTO R90 except the sample size may conform to Table 1** in the procedure.

6.2.

- Obtain the representative aggregate sample. The sample must have a mass that is **at least minimum amount** that is outlined in the table and is representative of the moisture content in the supply being tested.

6.2.

- **Protect** the sample from a **loss of moisture before** determining the mass of the sample.

Nominal Maximum Size of Aggregate, mm (in.)[a]	Mass of Normal Weight Aggregate Sample, Min., kg[b]
4.75 (0.187) (No. 4)	0.5
9.5 (3/8)	1.5
12.5 (1/2)	2
19.0 (3/4)	3
25.0 (1)	4
37.5 (1 1/2)	6
50 (2)	8
63 (2 1/2)	10
75 (3)	13
90 (3 1/2)	16
100 (4)	25
150 (6)	50

[a] Based on sieves meeting ASTM E11.
[b] Determine the minimum sample mass for lightweight aggregate by multiplying the value listed by the dry–loose unit mass of the aggregate in kg/m³ (determined using T 19M/T 19) and dividing by 1600.

SUMMARY: *Obtain a representative sample of aggregate and ensure that it is protected from moisture loss. Weigh the wet sample. Dry the sample in the oven until constant weight is achieved. Weigh the dry sample. Compute total moisture content.*

PROCEDURE:

1. **Weigh and record** the **mass** of the moisture sample to the nearest **0.1% or to the nearest 0.1 grams. Obtain weight of container empty to subtract from total mass of sample and container. Record the mass of the sample.** **7.1.**

EXAMPLE OF CONTAINER TO PROTECT SAMPLE FROM LOSS OF MOISTURE FROM THE FIELD

2. **Dry** the sample thoroughly in the **sample container** by means of the selected **source of heating (ex: oven, hotplate, microwave)**. **Avoid loss of particles.** **7.2.**

Rapid heating may make particles explode losing material. IF NOT heating by means of the oven stir constantly to avoid over localized heating. ***(SECTION 7.2.)***

3. **Use an oven** when it is determined that **excessive heat** will **alter the character** of the **aggregate, or** where **more precise measurement is required.** **7.2.**

Contant Mass: *Sample is dry when further heating causes less than 0.1% additional loss in mass.* ***(SECTION 7.4.).***

4. **Remove** the **moisture sample** from the selected source of heating (**ex: oven, hotplate, microwave)** and **reweigh** and **record the mass** to the **nearest 0.1 % or** to the **nearest 0.1 grams. Calculate** the change in mass of the **sample and verify that it has lost less than 0.1% from the previously recorded weight.** If not **repeat the process until constant mass has been attained.** **7.2.**

5. Once **dried weigh and record the mass of the dried sample to the nearest 0.1% or nearest 0.1 grams after it has cooled** to the point where it won't damage the balance. **7.4.**

TOTAL EVAPORABLE MOISTURE CONTENT CALCULATION

$$P = \frac{100*(W-D)}{D}$$

P = total evaporable moisture content of sample (percent);
W = mass of original sample (grams);
D = mass of dried sample (grams)

HOW TO CALCULATE % CHANGE IN MASS WHEN DETERMINING CONSTANT MASS:

% CHANGE = $\frac{(M_p - M_n)}{(M_p)}$ X 100

M_p = previous mass measurement;
M_n = next mass measurement;

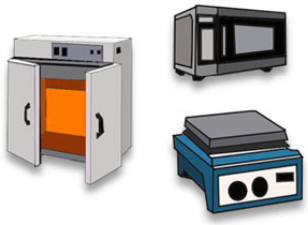
Remember: *different material types may dry quicker than other types.*

WHAT IS THE SURFACE MOISTURE CONTENT?

Surface moisture content is equal to the difference between the total evaporable moisture content and the absorption with all values based on the mass of a dry sample. Absorption may be determined in accordance with AASHTO T85, or AASHTO T84.

EXAMPLE:

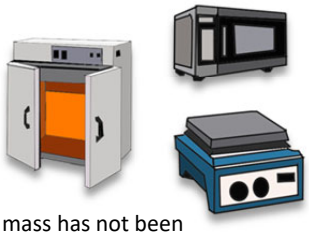
Mass of original sample W (becomes the first M_p)***:*** ***688.1 grams.***



AFTER SAMPLE WAS DRIED USING THE SELECTED HEAT SOURCE FOR A DETERMINED AMOUNT OF TIME:

M_n (becomes the new M_p if constant mass has not been achieved) = ***675.5 grams***;

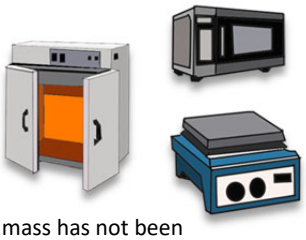
$\frac{(688.1 - 675.5)}{(688.1)}$ X 100 = 1.8% **NOT LESS THAN 0.1% KEEP DRYING!**



AFTER SAMPLE WAS DRIED USING THE SELECTED HEAT SOURCE FOR A DETERMINED AMOUNT OF TIME:

M_n (becomes the new M_p if constant mass has not been achieved) = ***669.2 grams***;

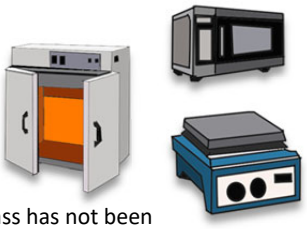
$\frac{(675.5 - 669.2)}{(675.5)}$ X 100 = 0.9% **NOT LESS THAN 0.1% KEEP DRYING!**



AFTER SAMPLE WAS DRIED USING THE SELECTED HEAT SOURCE FOR A DETERMINED AMOUNT OF TIME:

M_n (becomes the new M_p if constant mass has not been achieved) = ***663.9 grams***;

$\frac{(669.2 - 663.9)}{(669.2)}$ X 100 = 0.8% **NOT LESS THAN 0.1% KEEP DRYING!**



AFTER SAMPLE WAS DRIED USING THE SELECTED HEAT SOURCE FOR A DETERMINED AMOUNT OF TIME:

M_n (becomes the new M_p if constant mass has not been achieved) = ***663.5 grams***;

$\frac{(663.9 - 663.5)}{(663.9)}$ X 100 = 0.06% **LESS THAN 0.1% THIS WILL BE RECORDED AS YOUR *D*!**

Mass of dried sample (D): 663.5 grams.

ANSWER:

$\frac{100*(688.1-663.5)}{663.5}$ = 3.754523522 = 3.7%

PRACTICE QUESTIONS:

1. When performing AASHTO T255 what does the technician determine the mass of the dried sample to?

    a. 0.01%
    b. 0.001%
    c. 0.1%

2. When performing AASHTO T265 weigh a clean, dry container WITHOUT its lid and record this weight.

    a. True
    b. False

3. When determining in place density of asphalt mixtures according to AASHTO T355 take a ____ test and record the new wet density reading.

    a. 1 Minute
    b. 10 Seconds
    c. 5 Minutes

4. When standardizing a nuclear gauge how far does another gauge (or other radioactive source) have to be?

    a. 10 feet
    b. 20 feet
    c. 30 feet

5. When standardizing a nuclear gauge while on the reference block take at least ____ repetitive readings and obtain the mean.

    a. 3
    b. 4
    c. 2

ANSWERS:

1. c
2. b
3. a
4. c
5. b

INFORMATIONAL ONLY

(WILL NOT BE TESTED ON)

FIELD SOILS DESCRIPTION & IDENTIFICATION OF SOILS

Soils identification in the field is primarily accomplished by a mixture of standardized methods and agency procedures. It is difficult to accurately classify material due to the impracticality of performing sieving and the Atterberg test while in the field but a preliminary identification can be performed. Once a sample is brought back to the lab a thorough soils classification can be performed. The following steps for field identification will be a combination of internal ADOT procedures and ASTM D2488: Standard Practice for Description and Identification of Soils (Visual- Manual Procedures). Not all sections in ASTM D2488 will be discussed. Please refer to the procedure for additional information.

Obtain a representative sample of the stratum being tested. Ensure there is enough material to perform all tests.

Remove any material 3" or larger from the sample to be tested. Best practice is to still note the estimated percentage of cobbles and boulders that were removed (see ASTM D2488 for definitions).

Estimate and note the percentage, of the gravel, sand, and fines by 5% increments. The visually estimated percentages must **equal 100%.** If it is estimated that any of the components (gravel, sand, fines) of material is less than 5% then do not include that component in estimating to the 100%. Best practice is to note this amount as TRACE on any report.

Describe the moisture condition *of the sample:*

TABLE 4: Criteria for Describing Moisture Condition

Description	Criteria
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, usually soil is below water table

Describe the color of the material that is obtained. If the sample contains layers or patches of varying colors, this shall be noted and all representative colors shall be described. The color shall be described for moist samples. If the color represents a dry condition, this shall be stated in the report.

Describe the consistency of the material:

TABLE 6: Criteria for Describing Consistency

Description	Criteria
Very Soft	Thumb will penetrate soil more than 1 inch.
Soft	Thumb will penetrate soil about 1 inch.
Firm	Thumb will indent soil about 1/4 inch.
Hard	Thumb will not indent soil but will indent with thumbnail.
Very Hard	Thumbnail will not indent soil.

Describe the odor if organic or unusual. Soils containing a significant amount of organic material usually have a distinctive odor of decaying vegetation.

Visually identify (just an estimate) whether the soils are:

Fine grained (more than 50% or more of fines) Follow the procedures for identifying fine-grained soils
Coarse grained (more than 50% coarse grained soil) Follow the procedures for identifying coarse-grained soils

GRAVEL*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) sieve with the following subdivisions:*
coarse*—passes a 3-in. (75-mm) sieve and is retained on a 3⁄4-in. (19-mm) sieve.*
fine*—passes a 3⁄4-in. (19-mm) sieve and is retained on a No. 4 (4.75-mm) sieve.*

SAND*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-µm) sieve with the following subdivisions:*
coarse*—passes a No. 4 (4.75-mm) sieve and is retained on a No. 10 (2.00-mm) sieve.*
medium*—passes a No. 10 (2.00-mm) sieve and is retained on a No. 40 (425-µm) sieve.*

***SILT**—soil passing a No. 200 (75-µm) sieve that is non-plastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4, or the plot of plasticity index versus liquid limit falls below the "A" line.*

***CLAY**—soil passing a No. 200 (75-µm) sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents, and that exhibits considerable strength when air-dried. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line.*

Not all descriptions, criteria, and methods are discussed in this section. Please refer to ASTM D2488 for additional information on how to perform this procedure.

Fine Grained:

Remove particles larger than the No. 40 sieve (medium sand and larger) until a specimen equivalent to about a handful of material is available. Retain the larger material to assess its qualities.

Dry Strength:

Select enough material to mold into a ball about 1/2 in. in diameter. Mold the material until it has the consistency of putty, adding water if necessary. Then allow the test specimens to air dry or dry by artificial means, with a temperature not to exceed 140°F (60°C).

If the test specimen contains natural dry lumps, those that are about 1⁄2 in. (12 mm) in diameter may be used in place of the molded balls.

Test the strength of the dry balls or lumps by crushing between the fingers. Note the strength as none, low, medium, high, or very high in accordance with the criteria in the table.

Perform this procedure on at least 3 molded or natural dry lumps.

Crush test sample between fingers

TABLE 9: Criteria for Describing Dry Strength

Description	Criteria
None	The dry specimen crumbles into powder with just pressure of handling.
Low	The dry specimen crumbles into powder with some finger pressure.
Medium	The dry specimen breaks into pieces or crumbles with considerable finger pressure.
High	The dry specimen cannot be broken with finger pressure. Specimen will break into pieces between thumb and a hard surface.
Very High	The dry specimen cannot be broken between the thumb and a hard surface.

Dilatancy:
From the specimen, select enough material to mold into a ball about 1⁄2 in. (12 mm) in diameter. Mold the material, adding water, if necessary, until it has a soft, but not a sticky consistency.
Smooth the soil ball in the palm of one hand making the sample flatter to better fit in the palm. Shake horizontally, striking the side of the hand vigorously against the other hand several times. Note the reaction of water appearing on the surface of the soil. Squeeze the sample by closing the hand or pinching the soil between the fingers, and note the reaction as none, slow, or rapid in accordance with the criteria in the table. The reaction is the speed with which water appears while shaking, and disappears while squeezing.

Hit free hand against hand that is holding the sample

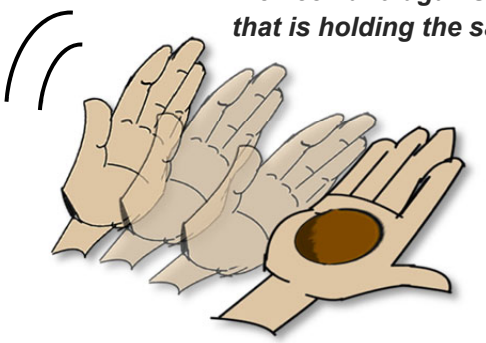


TABLE 10: Criteria for Describing Dilatancy

Description	Criteria
None	No visible change in the specimen.
Slow	Water appears slowly on the surface of the specimen during shaking and does not disappear or disappears slowly upon squeezing.
Rapid	Water appears quickly on the surface of the specimen during shaking and disappears quickly upon squeezing.

Plasticity:
From the specimen, select enough material to mold
into a ball about 1⁄2 in. (12 mm) in diameter. Add water to the material, if necessary, until it has a soft, but not sticky,
test specimen is shaped into an ellipsoidal mass and rolled by
hand on a smooth surface or between the palms into a thread
about 1⁄8 in. (3 mm) in diameter (normally is done after the Dilatancy test).
If the sample is too wet to roll easily, it should be spread into a thin layer and allowed to lose some water by evaporation.
Fold the sample threads and reroll repeatedly until the thread crumbles at a diameter of about 1⁄8 in. (3 mm).
The thread will crumble at a diameter of 1⁄8 in. (3mm) when the soil is near the plastic limit.
Note the pressure required to roll the thread near the plastic limit. Also, note the strength of the thread. After the thread crumbles, the pieces should be lumped together and kneaded until the lump crumbles.

Form and roll. Repeat

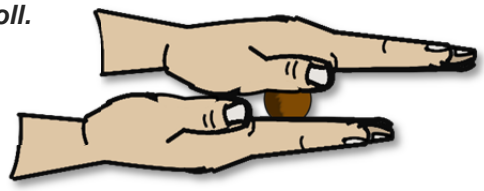
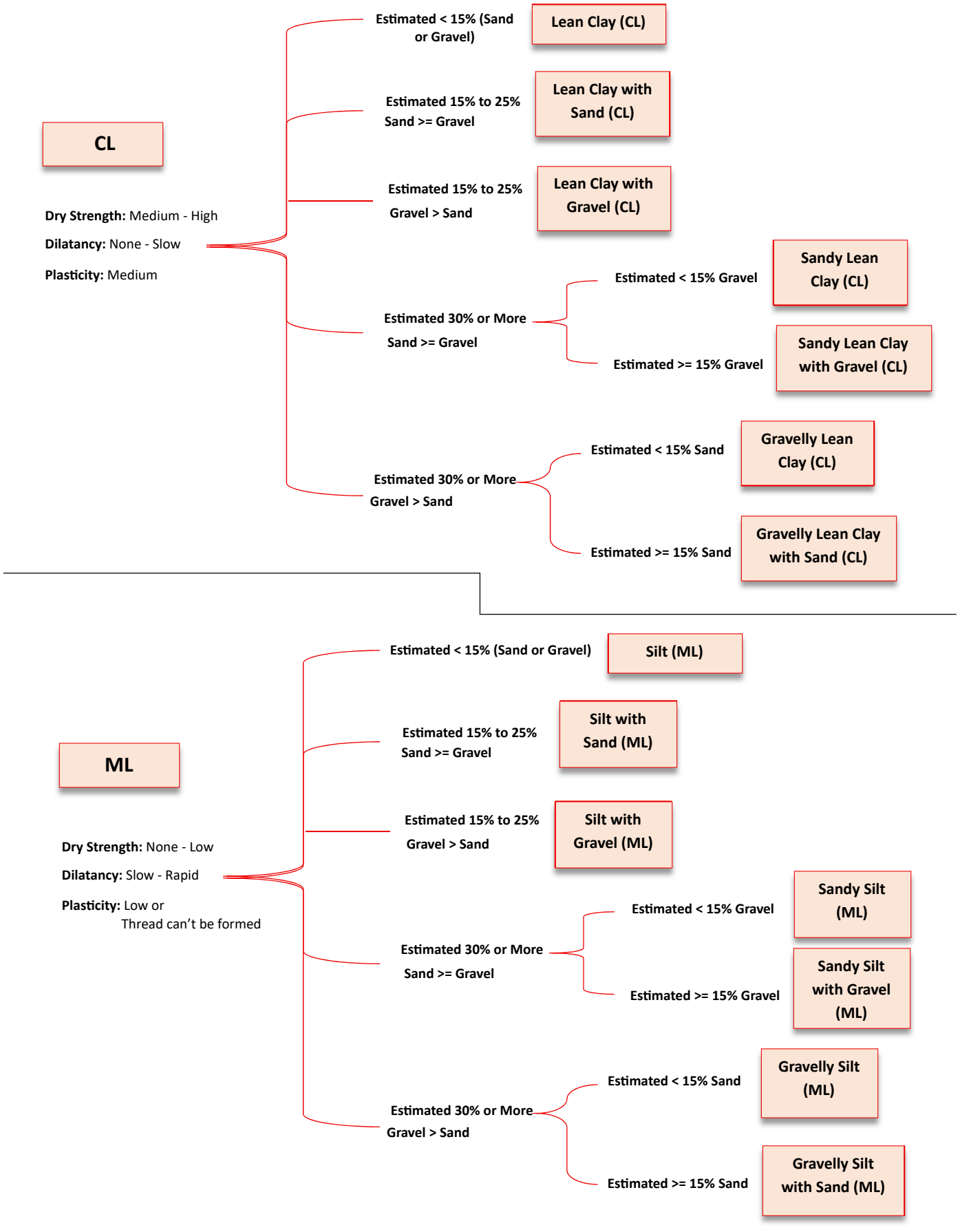


TABLE 12: Criteria for Describing Plasticity

Description	Criteria
Non-plastic	A 1/8-inch thread cannot be rolled at any water content.
Low	The thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.


CL
Dry Strength: Medium - High
Dilatancy: None - Slow
Plasticity: Medium
Estimated < 15% (Sand or Gravel)
Lean Clay (CL)
Estimated 15% to 25% Sand >= Gravel
Lean Clay with Sand (CL)
Estimated 15% to 25% Gravel > Sand
Lean Clay with Gravel (CL)
Estimated 30% or More Sand >= Gravel
Estimated < 15% Gravel
Sandy Lean Clay (CL)
Estimated >= 15% Gravel
Sandy Lean Clay with Gravel (CL)
Estimated 30% or More Gravel > Sand
Estimated < 15% Sand
Gravelly Lean Clay (CL)
Estimated >= 15% Sand
Gravelly Lean Clay with Sand (CL)
ML
Dry Strength: None - Low
Dilatancy: Slow - Rapid
Plasticity: Low or Thread can't be formed
Estimated < 15% (Sand or Gravel)
Silt (ML)
Estimated 15% to 25% Sand >= Gravel
Silt with Sand (ML)
Estimated 15% to 25% Gravel > Sand
Silt with Gravel (ML)
Estimated 30% or More Sand >= Gravel
Estimated < 15% Gravel
Sandy Silt (ML)
Estimated >= 15% Gravel
Sandy Silt with Gravel (ML)
Estimated 30% or More Gravel > Sand
Estimated < 15% Sand
Gravelly Silt (ML)
Estimated >= 15% Sand
Gravelly Silt with Sand (ML)

CH

Dry Strength: High – Very High

Dilatancy: None

Plasticity: High

- Estimated < 15% (Sand or Gravel) → **Fat Clay (CH)**
- Estimated 15% to 25% Sand >= Gravel → **Fat Clay with Sand (CH)**
- Estimated 15% to 25% Gravel > Sand → **Fat Clay with Gravel (CH)**
- Estimated 30% or More Sand >= Gravel
  - Estimated < 15% Gravel → **Sandy Fat Clay (CH)**
  - Estimated >= 15% Gravel → **Sandy Fat Clay with Gravel (CH)**
- Estimated 30% or More Gravel > Sand
  - Estimated < 15% Sand → **Gravelly Fat Clay (CH)**
  - Estimated >= 15% Sand → **Gravelly Fat Clay with Sand (CH)**

MH

Dry Strength: Low – Medium

Dilatancy: None - Slow

Plasticity: Low - Medium

Refer to the procedure on how to identify organic soils.

- Estimated < 15% (Sand or Gravel) → **Elastic Silt (MH)**
- Estimated 15% to 25% Sand >= Gravel → **Elastic Silt with Sand (MH)**
- Estimated 15% to 25% Gravel > Sand → **Elastic Silt with Gravel (MH)**
- Estimated 30% or More Sand >= Gravel
  - Estimated < 15% Gravel → **Sandy Elastic Silt (MH)**
  - Estimated >= 15% Gravel → **Sandy Elastic Silt with Gravel (MH)**
- Estimated 30% or More Gravel > Sand
  - Estimated < 15% Sand → **Gravelly Elastic Silt (MH)**
  - Estimated >= 15% Sand → **Gravelly Elastic Silt with Sand (MH)**

Coarse Grained:

Sample contains more than 50% coarse grained soils.

Describe the angularity of the sand, gravel, cobbles, and boulders, as angular, subangular, subrounded, or rounded according to the table:

TABLE 2: Criteria for Describing Angularity of Coarse-Grained Particles

Description	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Particles are similar to angular description but have rounded edges.
Subrounded	Particles have nearly plane sides but have well rounded corners and edges.
Rounded	Particles have smoothly curved sides and no edges.

Estimate and note the percentage, of the gravel, sand, and fines by 5% increments. The visually estimated percentages must **equal 100%.** If it is estimated that any of the components (gravel, sand, fines) of material is less than 5% then do not include that component in estimating to the 100%. Best practice is to note this amount as TRACE on any report.

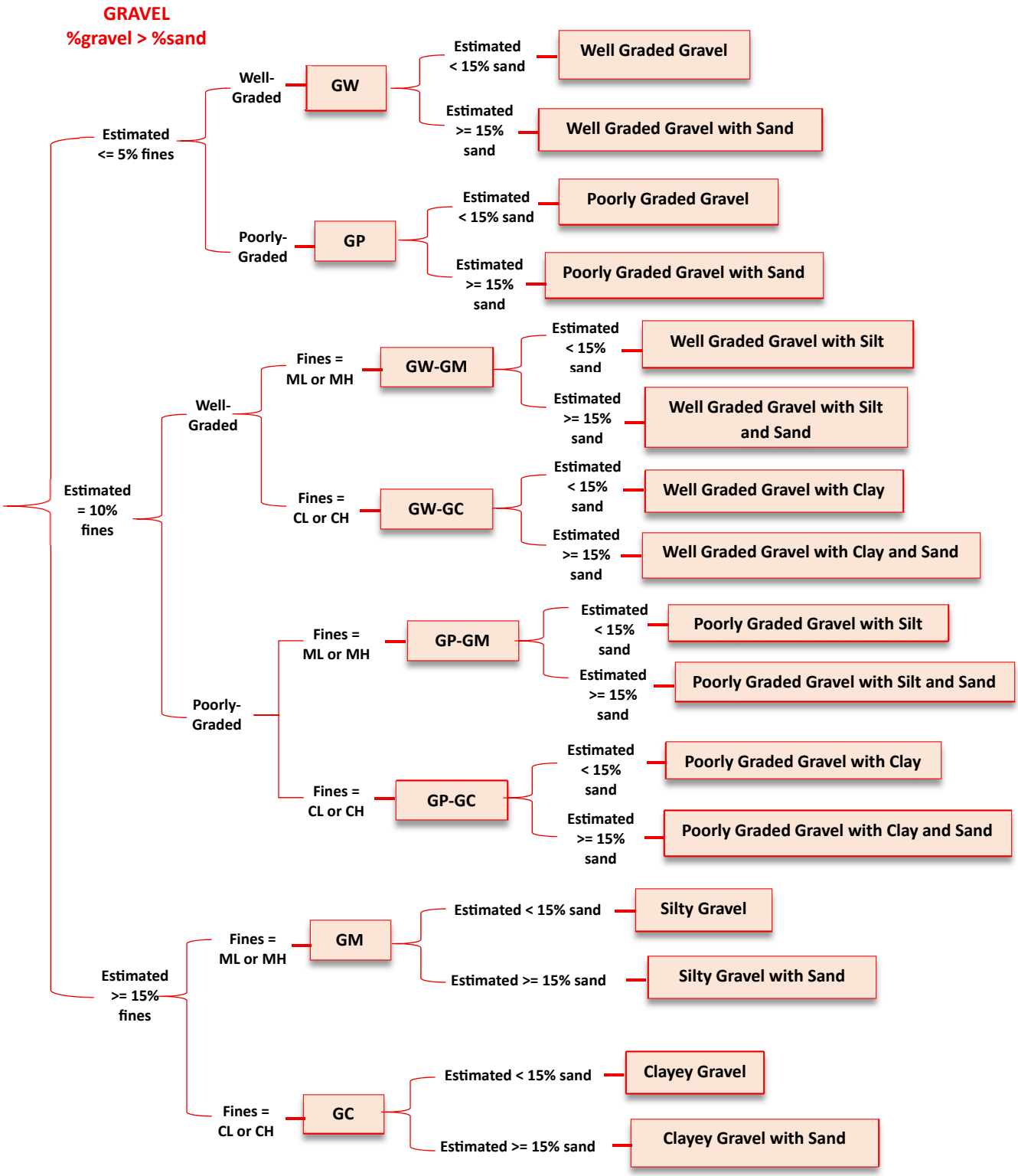
Jar Method (Determining relative percentage of coarse and fine material):
The relative percentage of coarse- and fine-grained material may be estimated by thoroughly shaking a mixture of soil and water in a test tube or jar, and then allowing the mixture to settle. The coarse particles will fall to the bottom and successively finer particles will be deposited with increasing time; the sand sizes will fall out of suspension in 20 to 30 s. The relative proportions can be estimated from the relative volume of each size separate. This method should be correlated to particle-size laboratory determinations.

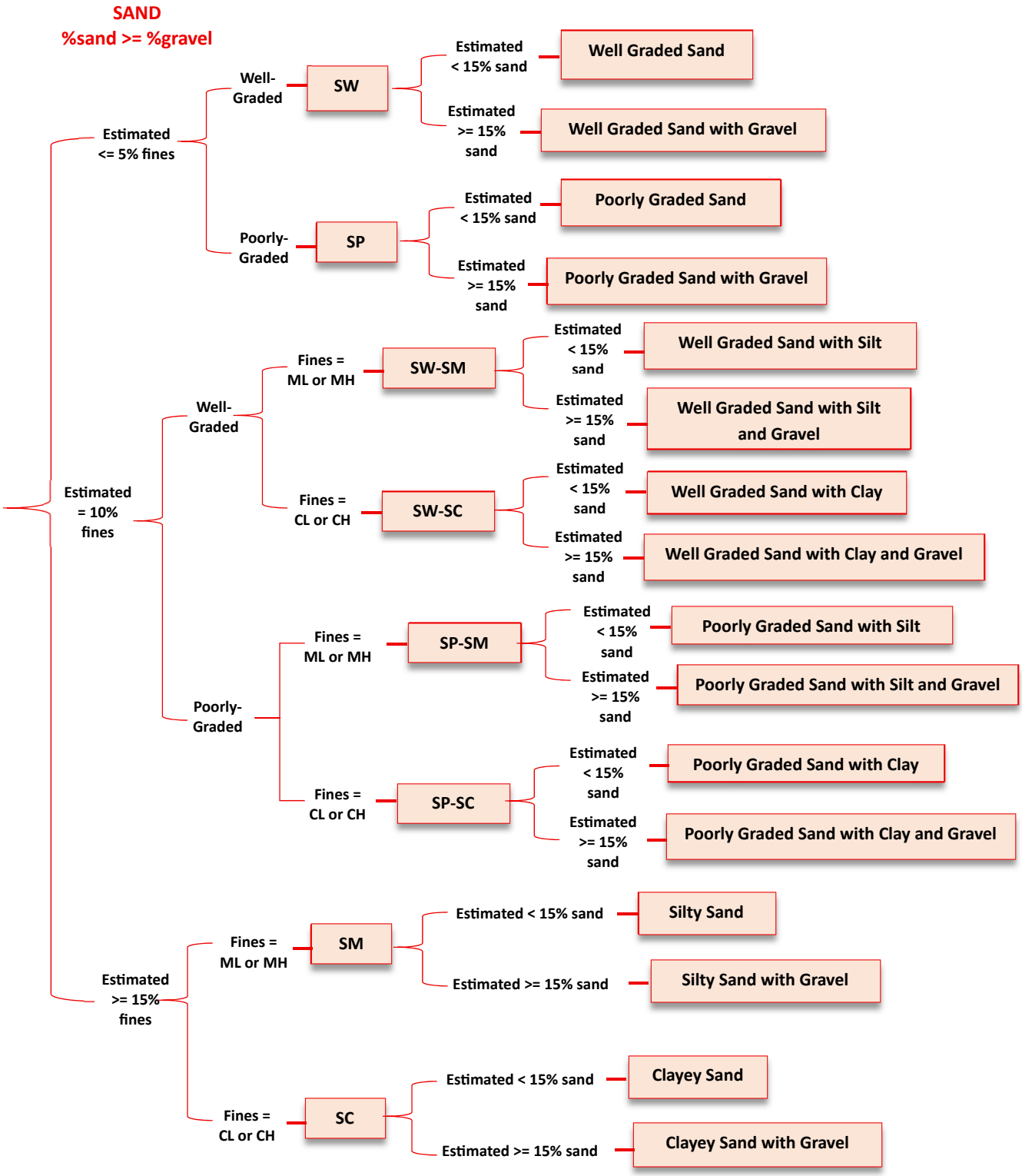
Visual & Hand Texturing Method:
Mentally visualize the gravel size particles placed in a container. Then, do the same with the sand size particles and the fines. Then, mentally compare the number of containers to estimate the percentage of plus No. 4 sieve size and minus No. 4 sieve size present.

For additional information obtain some of the soil and moistened it. Work between the thumb and fingers to form a ribbon. Sand and clay percentages are then estimated.
-Sand imparts a gritty feel to soil.
-When moist, silt has a floury feel and does not ribbon when pressed between the thumb and forefinger
-Moist clay is sticky and will ribbon readily when pressed between the thumb and forefinger.

Well Graded- *if it has a wide range of particle sizes and substantial amounts of the intermediate particle sizes.*

Poorly Graded *- if it consists predominantly of one size (uniformly graded), or it has a wide range of sizes with some intermediate sizes obviously missing (gap or skip graded).*


GRAVEL
%gravel > %sand
Estimated <= 5% fines
Well-Graded
GW
Estimated < 15% sand
Well Graded Gravel
Estimated >= 15% sand
Well Graded Gravel with Sand
Poorly-Graded
GP
Estimated < 15% sand
Poorly Graded Gravel
Estimated >= 15% sand
Poorly Graded Gravel with Sand
Estimated = 10% fines
Well-Graded
Fines = ML or MH
GW-GM
Estimated < 15% sand
Well Graded Gravel with Silt
Estimated >= 15% sand
Well Graded Gravel with Silt and Sand
Fines = CL or CH
GW-GC
Estimated < 15% sand
Well Graded Gravel with Clay
Estimated >= 15% sand
Well Graded Gravel with Clay and Sand
Poorly-Graded
Fines = ML or MH
GP-GM
Estimated < 15% sand
Poorly Graded Gravel with Silt
Estimated >= 15% sand
Poorly Graded Gravel with Silt and Sand
Fines = CL or CH
GP-GC
Estimated < 15% sand
Poorly Graded Gravel with Clay
Estimated >= 15% sand
Poorly Graded Gravel with Clay and Sand
Estimated >= 15% fines
Fines = ML or MH
GM
Estimated < 15% sand
Silty Gravel
Estimated >= 15% sand
Silty Gravel with Sand
Fines = CL or CH
GC
Estimated < 15% sand
Clayey Gravel
Estimated >= 15% sand
Clayey Gravel with Sand


SAND
%sand >= %gravel
Estimated <= 5% fines
Well-Graded
SW
Estimated < 15% sand
Well Graded Sand
Estimated >= 15% sand
Well Graded Sand with Gravel
Poorly-Graded
SP
Estimated < 15% sand
Poorly Graded Sand
Estimated >= 15% sand
Poorly Graded Sand with Gravel
Estimated = 10% fines
Well-Graded
Fines = ML or MH
SW-SM
Estimated < 15% sand
Well Graded Sand with Silt
Estimated >= 15% sand
Well Graded Sand with Silt and Gravel
Fines = CL or CH
SW-SC
Estimated < 15% sand
Well Graded Sand with Clay
Estimated >= 15% sand
Well Graded Sand with Clay and Gravel
Poorly-Graded
Fines = ML or MH
SP-SM
Estimated < 15% sand
Poorly Graded Sand with Silt
Estimated >= 15% sand
Poorly Graded Sand with Silt and Gravel
Fines = CL or CH
SP-SC
Estimated < 15% sand
Poorly Graded Sand with Clay
Estimated >= 15% sand
Poorly Graded Sand with Clay and Gravel
Estimated >= 15% fines
Fines = ML or MH
SM
Estimated < 15% sand
Silty Sand
Estimated >= 15% sand
Silty Sand with Gravel
Fines = CL or CH
SC
Estimated < 15% sand
Clayey Sand
Estimated >= 15% sand
Clayey Sand with Gravel

PRACTICE ROCK CORRECTION CALCULATIONS

Correction of Maximum Dry Density and Optimum Moisture for Oversized Particles

AASHTO T99 Annex A

Use the information below to calculate your answers

Determine the corr **SEE VIDEO** ctor T99 Method A.

(DF) Lab Proctor Method A: 110.6 lb./ft³ @ 18.3% moisture
(MM) Wet weight Fine Particles: 6.234lbs.
(MM) Wet weight Coarse Particles: 1.112lbs.
(Gsb) Bulk Specific Gravity Coarse: 2.650
(MC) Moisture Content Coarse: 2.1%
(MC) Moisture Content Fine: 16.8%

When Calculating **MDC & MDF** the percent moisture needs to be converted to a decimal; divide the Moisture Content by 100. 2.1% divided by 100 = .021

MDC	Calculate the Dry Mass of the Coarse Material. **MDC** = $\frac{MM}{(1+MC)}$ **MM** = weight of coarse particles. **MC** = moisture content of oversized particles (convert to decimal)	
MDF	Calculate the Dry Mass of the Fine Material. **MDF** = $\frac{MM}{(1+MC)}$ **MM** = weight of fine material **MC** = moisture content of fine particles (convert to decimal)	
PC	Calculate the Percentage of Dry Oversized (Coarse) Particles. **PC** = $\frac{(100*MDC)}{(MDF+MDC)}$ **to the whole percent %**	
PF	Calculate the Percentage of Dry Fine Particles. . **PF = 100-PC** **To the whole percent %**	
MCT	Corrected Moisture Content (0.1%) **MCT** = $\frac{(MCF*PF)+(MCC*PC)}{100}$ **MCF** = Optimum moisture content of lab proctor. **PF** = Percent of fine particles **PC** = Percent coarse particles **MCC** = Moisture content of the oversized particles;	
DD	Corrected Dry Density (lb/ft3); **DD** = $\frac{(100*DF*k)}{(DF*PC+k*PF)}$ **DF** = maximum dry density of the fine particles (lab proctor) **K** = Gsb x 62.4 **PC** = percent of oversized particles **PF** = percent of fine particles	

Correction of Maximum Dry Density and Optimum Moisture for Oversized Particles

AASHTO T99 Annex A

Use the information below to calculate your answers

Determine the corrected maximum dry density and moisture content of the Lab Proctor T99 Method A.

(DF) Lab Proctor Method A: 117.5 lb/ft³ @ 12.5% moisture
(MM) Wet weight Fine Particles: 6.574lbs.
(MM) Wet weight Coarse Particles: 2.324lbs.
(Gsb) Bulk Specific Gravity Coarse: 2.653
(MC) Moisture Content Coarse: 2.1%
(MC) Moisture Content Fine: 11.8%

When Calculating **MDC & MDF** the percent moisture needs to be converted to a decimal; divide the Moisture Content by 100. 2.1% divided by 100 = .021

MDC	Calculate the Dry Mass of the Coarse Material. **MDC** = $\frac{MM}{(1+MC)}$ **MM** = weight of coarse particles. **MC** = moisture content of oversized particles (convert to decimal)	$\frac{2.1}{100}$ = 0.021 → $\frac{2.324}{1.021}$ **2.276 *LB***
MDF	Calculate the Dry Mass of the Fine Material. **MDF** = $\frac{MM}{(1+MC)}$ **MM** = weight of fine material **MC** = moisture content of fine particles (convert to decimal)	$\frac{11.8}{100}$ = 0.118 → $\frac{6.574}{1.118}$ **5.880 *LB***
PC	Calculate the Percentage of Dry Oversized (Coarse) Particles. **PC** = $\frac{(100*MDC)}{(MDF+MDC)}$ **to the whole percent %**	$\frac{227.6}{8.156}$ **28%**
PF	Calculate the Percentage of Dry Fine Particles. . **PF = 100-PC** **To the whole percent %**	**72%**
MCT	Corrected Moisture Content (0.1%) **MCT** = $\frac{(MCF*PF)+(MCC*PC)}{100}$ **MCF** = Optimum moisture content of lab proctor. **PF** = Percent of fine particles **PC** = Percent coarse particles **MCC** = Moisture content of the oversized particles;	$\frac{(12.5\ X\ 72) + (2.1\ X\ 28)}{100}$ **9.6%**
DD	Corrected Dry Density (lb/ft3); **DD** = $\frac{(100*DF*k)}{(DF*PC+k*PF)}$ **DF** = maximum dry density of the fine particles (lab proctor) **K** = Gsb x 62.4 = 165.5 **PC** = percent of oversized particles **PF** = percent of fine particles	$\frac{(100\ X\ 117.5\ X\ 165.5)}{(117.5\ X\ 28) + (165.5\ X\ 72)}$ **127.9 *LB/FT3***

Correction of Maximum Dry Density and Optimum Moisture for Oversized Particles

AASHTO T99 Annex A

Use the information below to calculate your answers

Determine the corrected maximum dry density and moisture content of the Lab Proctor T99 Method A.

(DF) Lab Proctor Method A: 123.2 lb/ft³ @ 11.5% moisture
(MM) Wet weight Fine Particles: 7.341lbs.
(MM) Wet weight Coarse Particles: 4.235lbs.
(Gsb) Bulk Specific Gravity Coarse: 2.600
(MC) Moisture Content Coarse: 2.0%
(MC) Moisture Content Fine: 8.5%

When Calculating **MDC & MDF** the percent moisture needs to be converted to a decimal; divide the Moisture Content by 100. 2.0% divided by 100 = .020

MDC	Calculate the Dry Mass of the Coarse Material. **MDC** = $\frac{MM}{(1+MC)}$ **MM** = weight of coarse particles. **MC** = moisture content of oversized particles (convert to decimal)	$\frac{2.0}{100}$ = 0.020 → $\frac{4.235}{1.020}$ **4.152 *LB***
MDF	Calculate the Dry Mass of the Fine Material. **MDF** = $\frac{MM}{(1+MC)}$ **MM** = weight of fine material **MC** = moisture content of fine particles (convert to decimal)	$\frac{8.5}{100}$ = 0.085 → $\frac{7.341}{1.085}$ **6.766 *LB***
PC	Calculate the Percentage of Dry Oversized (Coarse) Particles. **PC** = $\frac{(100*MDC)}{(MDF+MDC)}$ **to the whole percent %**	$\frac{415.2}{10.918}$ **38%**
PF	Calculate the Percentage of Dry Fine Particles. . **PF = 100-PC** **To the whole percent %**	**62%**
MCT	Corrected Moisture Content (0.1%) **MCT** = $\frac{(MCF*PF)+(MCC*PC)}{100}$ **MCF** = Optimum moisture content of lab proctor. **PF** = Percent of fine particles **PC** = Percent coarse particles **MCC** = Moisture content of the oversized particles;	$\frac{(11.5\ X\ 62) + (2.0\ X\ 38)}{100}$ **7.9%**
DD	Corrected Dry Density (lb/ft3); **DD** = $\frac{(100*DF*k)}{(DF*PC+k*PF)}$ **DF** = maximum dry density of the fine particles (lab proctor) **K** = Gsb x 62.4 = 162.2 **PC** = percent of oversized particles **PF** = percent of fine particles	$\frac{(100\ X\ 123.2\ X\ 162.2)}{(123.2\ X\ 38) + (162.2\ X\ 62)}$ **135.6 LB/FT3**

Correction of Maximum Dry Density and Optimum Moisture for Oversized Particles

AASHTO T99 Annex A

Use the information below to calculate your answers

Determine the corrected maximum dry density and moisture content of the Lab Proctor T99 Method A.

(DF) Lab Proctor Method A: 114.6 lb/ft³ @ 14.6% moisture
(MM) Wet weight Fine Particles: 5.987 lbs.
(MM) Wet weight Coarse Particles: 2.145 lbs.
(Gsb) Bulk Specific Gravity Coarse: 2.623
(MC) Moisture Content Coarse: 2.2%
(MC) Moisture Content Fine: 13.4%

When Calculating **MDC & MDF** the percent moisture needs to be converted to a decimal; divide the Moisture Content by 100. 2.2% divided by 100 = .022

MDC	Calculate the Dry Mass of the Coarse Material. **MDC** = $\frac{MM}{(1+MC)}$ $\frac{2.2}{100}$ = 0.022 → $\frac{2.145}{1.022}$ **MM** = weight of coarse particles. **MC** = moisture content of oversized particles (convert to decimal)	**2.099 *LB***
MDF	Calculate the Dry Mass of the Fine Material. **MDF** = $\frac{MM}{(1+MC)}$ $\frac{13.4}{100}$ = 0.134 → $\frac{5.987}{1.134}$ **MM** = weight of fine material **MC** = moisture content of fine particles (convert to decimal)	**5.280 *LB***
PC	Calculate the Percentage of Dry Oversized (Coarse) Particles. **PC** = $\frac{(100*MDC)}{(MDF+MDC)}$ **to the whole percent %** $\frac{209.9}{7.379}$	**28%**
PF	Calculate the Percentage of Dry Fine Particles. . **PF = 100-PC** **To the whole percent %**	**72%**
MCT	Corrected Moisture Content (0.1%) **MCT** = $\frac{(MCF*PF)+(MCC*PC)}{100}$ **MCF** = Optimum moisture content of lab proctor. **PF** = Percent of fine particles $\frac{(14.6\ X\ 72) + (2.2\ X\ 28)}{100}$ **PC** = Percent coarse particles **MCC** = Moisture content of the oversized particles;	**11.1%**
DD	Corrected Dry Density (lb/ft3); **DD** = $\frac{(100*DF*k)}{(DF*PC+k*PF)}$ **DF** = maximum dry density of the fine particles (lab proctor) **K** = Gsb x 62.4 = 163.7 **PC** = percent of oversized particles $\frac{(100\ X\ 114.6\ X\ 163.7)}{(114.6\ X\ 28) + (163.7\ X\ 72)}$ **PF** = percent of fine particles	**125.1 LB/FT3**

Correction of Maximum Dry Density and Optimum Moisture for Oversized Particles

AASHTO T99 Annex A

Use the information below to calculate your answers

Determine the corrected maximum dry density and moisture content of the Lab Proctor T99 Method A.

(DF) Lab Proctor Method A: 119.3 lb/ft³ @ 12.7% moisture
(MM) Wet weight Fine Particles: 5.682lbs.
(MM) Wet weight Coarse Particles: 1.245lbs.
(Gsb) Bulk Specific Gravity Coarse: 2.600
(MC) Moisture Content Coarse: 2.0%
(MC) Moisture Content Fine: 8.5%

When Calculating **MDC & MDF** the percent moisture needs to be converted to a decimal; divide the Moisture Content by 100. 2.0% divided by 100 = .020

MDC	Calculate the Dry Mass of the Coarse Material. **MDC** = $\frac{MM}{(1+MC)}$ $\frac{2.0}{100}$ = 0.020 → $\frac{1.245}{1.020}$ **MM** = weight of coarse particles. **MC** = moisture content of oversized particles (convert to decimal)	**1.221 *LB***
MDF	Calculate the Dry Mass of the Fine Material. **MDF** = $\frac{MM}{(1+MC)}$ $\frac{8.5}{100}$ = 0.085 → $\frac{5.682}{1.085}$ **MM** = weight of fine material **MC** = moisture content of fine particles (convert to decimal)	**5.237 *LB***
PC	Calculate the Percentage of Dry Oversized (Coarse) Particles. **PC** = $\frac{(100*MDC)}{(MDF+MDC)}$ **to the whole percent %** $\frac{122.1}{6.458}$	**19%**
PF	Calculate the Percentage of Dry Fine Particles. . **PF = 100-PC** **To the whole percent %**	**81%**
MCT	Corrected Moisture Content (0.1%) **MCT** = $\frac{(MCF*PF)+(MCC*PC)}{100}$ **MCF** = Optimum moisture content of lab proctor. **PF** = Percent of fine particles $\frac{(12.7\ X\ 81) + (2.0\ X\ 19)}{100}$ **PC** = Percent coarse particles **MCC** = Moisture content of the oversized particles;	**10.7%**
DD	Corrected Dry Density (lb/ft3); **DD** = $\frac{(100*DF*k)}{(DF*PC+k*PF)}$ **DF** = maximum dry density of the fine particles (lab proctor) **K** = Gsb x 62.4 = 162.2 **PC** = percent of oversized particles $\frac{(100\ X\ 119.3\ X\ 162.2)}{(119.3\ X\ 19) + (162.2\ X\ 81)}$ **PF** = percent of fine particles	**125.6 LB/FT3**