WACEL
SOIL FIELD SPECIAL INSPECTOR STUDY GUIDE

FEBRUARY 2025

Soil Field Special Inspector

Study Guide

Certification Objective:

The Soil Field Special Inspector certification assesses an engineering technician's ability to properly observe and perform field testing site preparation and grading operations for relatively straightforward projects. The certification covers project documentation and specifications, basic understanding of suitable materials for construction operations, required testing and operations, and an ability to read and understand project plans.

Certification Requirements:

Requirements to be certified as a Soil Field Special Inspector include:

- Complete the WACEL Certification Program Application signed by the technician and a WACEL-approved supervisor. Technicians that are not employed by a WACEL member firm must have their applications signed and sealed by a professional engineer who attests that the technician has the education and experience to perform as a Soil Field Special Inspector.
- Complete the Soil Field Special Inspector written exam within three hours and obtain an overall grade of 75%.
- Obtain a grade of 70% on the plan reading section of the written exam (20 questions).
- Pass the Soil Field Special Inspector proficiency exam within two hours.
- Provide a photo identification to the written and proficiency exam proctor prior to taking the test or email a copy of a photo identification to WACEL if the test is administered in-house.
- Sign and date the cover sheet of the written exam.
- Pass both the written and proficiency exam within 90 days of one another.
- Pay for the exams (either the technician's employer or the technician individually can provide payment).

Scope:

Soils Field Special Inspector is an entry-level geotechnical testing and construction observation certification that most engineering field technicians must obtain. The knowledge required is broad based and intended to prepare entry-level technicians to perform in the field with minimum on-site supervision.

Successful completion of this certification examination does not qualify the candidate as an experienced technician. At best, that individual should be considered to be an apprentice field technician who must broaden his or her experience under the tutelage of experienced technicians or field engineers.

The general scope of this certification includes:

1. Can visually describe basic soil types in general accordance with the USCS and is familiar with general properties.

2. Is familiar with certain ASTM laboratory tests used for classification and quality control purposes (grain size, Atterberg limits, moisture content, and proctor results).

3. Can obtain, identify, label, and transport representative samples.

4. Can understand and interpret basic earthwork specifications and geotechnical recommendations.

5. Understands the roles and responsibilities of project personnel (technician, geotechnical engineer, contractor, owner, and government agency).

6. Understands the principles of density testing.

7. Can perform, and evaluate compaction by the nuclear density gauge, sand cone, and drive-cylinder methods.

8. Can perform and understands the uses and limitations of one-point Proctor test and a "family of curves."

9. Can perform field moisture tests of soil samples using direct heat.

10. Is familiar with effects of and corrections for micaceous soils and testing in trenches using nuclear gauges.

11. Is familiar with the types, uses and suitability of various types of compaction equipment.

12. Can perform basic observations of topsoil stripping, the removal of unsuitable materials, and proofrolling.

13. Is familiar with field equipment calibration and leak testing of nuclear gauges.

14. Is familiar with excavation safety and applicable OSHA requirements.

15. Completed basic radiation safety training, has certification (for Nuclear Gauge users only), and is familiar with the operational requirements of ASTM D6938.

Although not part of this certification, technicians also need to be familiar with the employer's reporting requirements and formats for earthwork operations.

Due to the lack of concise references that address the wide range of skills that are covered by this certification, the contents of this Study Guide take on a special significance. The learning objectives outline much of the material soil technicians are expected to know. This same outline can serve as a syllabus for a basic soils training class. "Required References" listed in the study guide used during the written test must be clean copies. They cannot be unlined, highlighted or tabbed.

Examinations:

Written Exam:

The Soils Field Special Inspector Examination is a 75-question test (55 academic, 20 plan reading) based on the references listed below. Technicians have 3 hours to complete the open-book examination. No notes or working papers may be removed from the examination area. Examination candidates should bring the required references without markings, tabs or highlighting.

Practical (Performance) Exam:

There are two options for administering the Soil Field Inspector Practical exam. One is to request a WACEL-approved examiner to conduct the testing at an approved laboratory. The other is to rely on supervisory employees that are approved by WACEL to administer practical exams to their technicians. Tests administered by in-house representatives must be videotaped and submitted to WACEL for grading. Make individual videos for each proficiency test as opposed to one long video that tapes all of the tests at the same time.

A copy of the Soil Field Special Inspector Practical Exam is appended to this Study Guide and also can be obtained from the WACEL website (www.wacel.org) or by contacting WACEL (info@wacel.org) and requesting a copy. Detailed instructions are given on the cover page of the practical examination for administering the practical examination**. Technicians must complete the practical in two hours.**

Required References:

1. ASTM D75-19 "Standard Practice for Sampling Aggregate."

2. ASTM D1556-24 – "Standard Test Method for Density and Unit Weight of Soil by the Sand-Cone Method."

3. ASTM D2488-17e1 – "Standard Practice for Description and Identification of Soil (Visual – Manual Procedure)."

4. ASTM D2937-24- "Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method."

5. ASTM D4718-15 (2023) – "Standard Practice for Correction of Unit Weight and Water Content for Soil Containing Oversize Particles."

6. ASTM D4959-24 – "Standard Test Method for Water Content of Soil By Direct Heat Methods."

7. ASTM D6938-23 – "Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depths)."

8. VTM-12, One-Point Method. (VTM 12)

9. WACEL Study Guide for Soils Field Special Inspector, January 2025.

Background References:

1. ASTM D422-63 (2007) – “Standard Test Method for Particle Size Analysis of Soils.” (withdrawn 2016)

2. ASTM D698-(2021) – “Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3) (600 kN-m/m^3).”

3. ASTM D1557-(2021) – “Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3) (2,700 kN-m/m^3).”

4. ASTM D2487-17e1 – “Standard Practice for Classification of Soil for Engineering Purposes (USCS).”

5. ASTM D4318-17e1 – “Standard Test method for Liquid Limit, Plastic Limit, and Plasticity Index of Soil.”

6. Geotechnical Testing, Observation, and Documentation – Second Edition, Tim Davis (Author), published by ASCE.

Learning Objectives:

The following primary and supporting learning objectives were developed to assist candidate soil technicians and their employers to prepare individuals and create training programs for this entry-level certification, The learning objectives focus on what is important, what must be addressed in training and preparation programs, and form the basis for evaluation.

Introduction and “Why We Test Soils”:

1. Appreciates that soil or rock serve as the foundation for just about every building, road, or structure that is built.

    a. Understands that different soil types can have dramatically different characteristics that impact how and where they are best used.

    b. Knows that proper handling and testing of soils can significantly reduce the potential for failures or deficient work.

    c. Realizes the key role that field soils technicians serve in the testing and observations of soils on a project to help produce a quality project.

Basic Concepts and Soil Characteristics:

2. Appreciates the basic soil types defined by the Uniform Soil Classification System (USCS), some of their construction-related characteristics, and how they may be used in typical construction activities.

    a. Understand the approximate particle sizes that define boulders, cobbles, gravel, sands, and silt/clay.

b. Knows the difference between well-graded and poorly-graded soils.

c. Knows what soil types are generally best for drainage.

d. Knows what soil types are generally best for limiting water movement.

e. Understands the terms pervious and permeable as well as plasticity and shrink/swell potential.

f. Understand the major variable that influences how soil reacts during construction to include particle size, plasticity, moisture content, and compaction.

g. Knows what soil types are generally best for engineered (structural) fill and for paved areas.

Technician Responsibilities:

3. Understands the roles and responsibilities of project personnel (technician, project manager, geotechnical engineer, contractor, owner, and government agency).

    a. Understands when actual site conditions require the involvement of the geotechnical engineer of record.

    b. Understands the role of a project's geotechnical engineer and geotechnical report.

    c. Knows that the general contractor's designated representative must be notified immediately of deficient test results.

    d. Understands that a field technician's primary functions are involved with confirming, observing, testing, recording, and reporting.

Select Laboratory Testing:

4. Is familiar with relevant ASTM laboratory tests used for classification and quality control purposes (grain size, Atterberg limits, moisture content, and Proctor tests).

    a. Knows the purposes of obtaining Atterberg limits.

    b. Understands the meaning of the Atterberg terms (LL, PL, PI).

    c. Has general knowledge of the various "Proctor" procedures.

    d. Knows how particle sizes are determined.

Sampling:

5. Can obtain, label, and transport representative samples.

    a. Knows how to obtain and properly label soil samples.

    b. Has a basic understanding of how to obtain a representative sample.

Specifications and Geotechnical Recommendations:

6. Can fully understand and interpret basic earthwork specifications and geotechnical recommendations.

    a. Knows what to do if unanticipated materials are encountered.

    b. Can determine what materials are unsuitable for use and which on-site materials may be used.

    c. Can properly identify other, proper construction quality control information from project specifications.

Field Observations, Compaction, and Oversize Corrections:

7. Understands the principles of density testing, including weight/volume and moisture/density relationships.

    a. Knows how to interpret and apply Proctor data.

    b. Can compute and evaluate moisture content data, optimum moisture contents (OMC), and moisture effects on compaction.

    c. Can compute the dry density of a soil sample given the wet density and the moisture content.

    d. Knows the proper use of the equipment and supporting documentation necessary for each system.

    e. Given nuclear gauge readings, sand cone field data, or drive cylinder results, can compute percent compaction and moisture content.

    f. Can adjust compaction and moisture content data based on oversized material using the appropriate formulae or nomograph. Emphasis will be on +4 corrections for material retained on a No. 4 sieve using the nomograph.

    g. Knows how to address and evaluate failing compaction test results and who must be provided this information.

    h. Can compare computed results with specifications to confirm acceptability using the formula.

i. Is aware of the probable or specified testing frequency for compacted fill.

j. Understands the advantages and limitations of using either nuclear gauge equipment, the sand cone, or the drive cylinder.

Moisture Corrections:

8. Is familiar with effects of and corrections for certain soils (i.e., moisture corrections) and testing in trenches using nuclear gauges.

    a. Understands the different times that moisture content corrections may be required when using portable nuclear gauges.

    b. Has a basic knowledge of how these situations produce distorted results.

Proper Compaction Equipment:

9. Is familiar with the types, uses and suitability of various types of compaction equipment.

    a. Type for soil type. Coarse grained soils compact better with smooth drum compactors; fine grained soils with sheepsfoot rollers.

    b. Size vs. lift thickness vs. passes.

Topsoil Stripping & Proofrolling:

10. Can perform basic observations of topsoil stripping, the removal of unsuitable materials, and proofrolling.

    a. Can identify what is generally classified as topsoil.

    b. Knows the limitations if topsoil is used as structural fill.

    c. Understands the purposes and limitations of proofrolling.

Calibration:

11. Is familiar with field equipment calibration/verification and leak testing of gauges.

    a. Understands the importance of only using clean, serviceable, and calibrated equipment.

    b. Knows the range and interval of tests and checks that apply to portable nuclear gauges to include standardization, calibration, and leak tests.

    c. Knows the calibration intervals for scales, sand cone components, proctor molds, etc.

Site Plan Reading:

12. Is familiar with and able to read earthwork site plans.

a. Able to read contour lines – existing grades and proposed grades.

b. Able to determine when cut or fill operations are necessary, based on grades/contour lines.

c. Knows how to become directionally oriented based on the North Arrow shown on the plans.

d. Able to read and decipher information shown on a profile, including (but not limited to) existing grade lines, proposed grade lines and invert elevations.

e. Familiar with symbols and common abbreviations used on plans.

f. Can determine distances based on station numbers.

ASTMs Covered in Performance Evaluation:

13. Water content by direct heating (ASTM 4959-24).

    a. Knows that determining the water content of a soil by direct heating in the field is a common expedient during construction.

    b. Is aware that the heat source can take many forms so long as open flames are not applied to a specimen.

    c. Knows that a calibrated scale or balanced allowing 0.1 grams readability is generally required.

    d. Can determine the minimum mass of the moist specimen based on the sieve size retaining more than 10 percent of the sample in accordance with the table in ASTM D4959.

    e. Knows to determine and record the mass of the clean, dry specimen container both before and after the moist specimen is added.

    f. Understands the need to heat the specimen while stirring to obtain even heat distribution and taking care to avoid localized overheating.

    g. Knows that specimen is heated initially until it appears dry and is typically allowed to cool. The mass is then determined and recorded.

    h. Is aware that the heating, cooling, and weighing is repeated until the change between two consecutive mass determinations would have an insignificant effect on the calculated water content.

    i. Can correctly calculate the water content of the specimen by dividing the mass of the water in the moist specimen by the mass of the dry soil. This is multiplied by 100 to express the result as a percentage.

14. Nuclear Density Gauge (ASTM D6938-23).

    a. Is aware of the standardization requirements for portable nuclear gauges to include checks before each day's use.

    b. Knows the requirements for the preparations needed for each test site location. These preparations include smoothness and corrective actions if gaps are greater than standards.

    c. Knows the gauge should be at least 6 inches from any vertical projection when being used in the direct transmission mode.

    d. Is aware of the correct use of drive pins as well as the proper and safe insertion of test probes.

    e. Knows that after the test probe is lowered into the hole that the gauge should be gently pulled back so that the probe is in direct contact with the side of the hole.

15. Density and unit weight of soil in place by sand-cone method (ASTM D1556-24).

    a. Is aware that the sand-cone method can be for the determination of the in-place density and unit weight of intact or *in situ* soils, provided certain soil conditions are met.

    b. Knows that the typical sand-cone apparatus is limited to soil with maximum particle size of approximately 1½ inch.

    c. Is knowledgeable of the time intervals and atmospheric conditions that would require the bulk-density of the sand to be redone.

    d. Can properly select and prepare test locations that are representative, flat, level, and free of vibrations.

    e. Knows how to estimate the proper depth and size of test holes.

    f. Can properly go through the procedural steps to determine the volume of the test hole and the mass of the wet soil removed from the hole.

    g. Determines the water content of the soil removed from the hole to the nearest 1 percent.

    h. Can properly complete the calculations to determine the volume of the test hole, the moist mass of the material from the test hole, the dry mass of the material from the test hole, and the dry density of the tested material.

16. Density of soil in place by drive-cylinder method (ASTM D2937-24).

    a. Knows what types of soils are suitable for this test method and what types are not.

    b. Is aware of the maximum particle size limitations for both in-place density testing and field compacted soils.

c. Is knowledgeable of the approximate depth the top of the cylinder should be driven to relative to the original ground surface.

d. Knows the trimming, cleaning, and patching steps that may be required before the mass of the drive cylinder and soil sample is determined.

e. Can generally describe the conditions that would result in a specimen being discarded.

f. Knows how to determine the wet density ($\boldsymbol{\rho}_{wet}$) and the moisture content (w) of the test specimen.

g. Can calculate the in-place dry density ($\boldsymbol{\rho}_{dry}$)

17. One-Point Proctor.

a. Can perform and understands the uses and limitations of the one-point proctor test and a “family of curves.”

b. Understands when it is appropriate to accomplish a one-point proctor test.

c. Understands that one-point proctor tests are typically conducted to give field technicians a relatively rapid “confirmation” of a provided proctor test or an interim control value for a new borrow source.

d. Understands the limitations of the results of a one-point Proctor test.

e. Realizes that contractors must be informed that one-point results must be validated by properly conducted laboratory testing of a representative sample.

f. Can properly accomplish a one-point Proctor test in accordance with VTM-12.

g. Given wet density and moisture content test results, can determine the maximum dry density and the optimum moisture content of a soil sample using the specified family of curves.

Attachments:

1. Performance evaluation checklists for ASTM D4959, VTM-12 (AASHTO T272), ASTM D1556, ASTM D2937, and ASTM D6938.

2. Data gathering forms for D4959, VTM-12, D1556, and D2937.

3. VTM-12, March 2019.

WACEL SOIL FIELD SPECIAL INSPECTOR PRACTICAL EVALUATION
(REVISIONS, FEBRUARY 2025)

INSTRUCTIONS

On the following pages are the proficiency checklists used by the WACEL Practical Examiner to record candidate technicians' skills in the processing and testing of soils in the field using identified test procedures. Candidate technicians are strongly encouraged to use these checklists to properly prepare for the proficiency exam. All of the included test procedures are incorporated. There is, however, one option for the technician being evaluated. **Technicians being evaluated need to only accomplish one of the non-nuclear-gauge density methods (e.g. either sand cone or drive cylinder). There is a two (2) hour time limit to complete the practical examination.**

Following the checklists are WACEL data gathering worksheets that can be used by the candidate technicians during the performance evaluation. On approval of the practical examiner, similar worksheets prepared by the technician's employer can be authorized for use.

The checklist for the one-point proctor test merits some explanation.

a. There is no ASTM method used to conduct a one-point proctor test. There is an AASHTO test method, AASHTO T272. To avoid potential confusion with AASHTO T272, WACEL elected to use the Virginia Test Method-12, VTM-12, for instructional purposes.

b. VTM-12 is simpler and more straightforward in its approach, and includes a simple monograph for density corrections if the oversize component is based on a No. 4 sieve. Density/moisture content curves are also based on the wet density of the sample, which makes this procedure more adaptable for field use. A copy of VTM-12 is attached.

c. Users should be aware that many state DOTs have different adaptation of AASHTO T272 to include slightly different procedures and different moisture/density curves.

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED FEBRUARY 2025)

Name (Technician): ____ Date(s): _________________

Office / Location: ____ Final Rating (P or F): ______________

Name of Examiner: ____

Instructions: An approved WACEL Practical Examiner shall observe the testing technician perform the following tests, rate the performance appropriately and score the overall performance as either pass or fail. A failure of any individual test will result as a failure of the practical exam. The examiner shall sign as witnessing each individual test method and shall sign the final page. Completed forms must be returned to WACEL.

ASTM D4959-24 Water (Moisture) Content of Soil by Direct Heating	**Pass**	**Fail**	**N/A**
1. Sample protected from moisture loss (sealed container, shielded from direct sunlight).			
2. Determine and record the mass of a clean, dry container to 0.1 g.			
3. Sample size conforms to the following: Nom./Max. Size (Largest sieve retaining >10%) — Minimum Mass of Moist Specimen No. 10 — 200-300 g No. 4 — 300-500 g 3/4" — 500-1000 g			
4. Representative portion of the sample placed into the container and the mass of the soil and container immediately determined and recorded.			
5. Heat applied to container, stirring frequently to minimize localized overheating.			
6. Continue heating until sample appears dry.			
7. Container removed from heat and allowed to cool until it can be safely handled.			
8. Determine and record the new mass of the container and sample.			
9. Container and sample returned to heat source and stirred.			
10. Care taken when stirring, and in general when handling the container, not to lose any material.			
11. Container removed from heat and allowed to cool until it can be handled.			
12. Determine and record the mass of the container and sample.			
13. Heating and weighing process repeated until constant mass (0.1% or less change) achieved.			
14. Moisture content calculated. $w = (mass_{water} / mass_{dry\ solids}) \times 100$ $= [(M_1-M_2)/(M_2-M_c)] \times 100$ $= M_w/M_s \times 100$ Where: w = water content in % M_1 = mass of container and wet specimen, g M_2 = mass of container and dry specimen, g M_c = mass of container, g M_s = mass of solid particles, g M_w = mass of water, g.			
Signature of examiner observing and overall results:			

See optional data sheet for recording information

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED FEBRUARY 2025)

One-Point Proctor VTM-12 (Using T99 and T272)	**Pass**	**Fail**	**N/A**
1. Sample collected and weighed.			
2. Material sieved over #4 sieve.			
3. The +#4 material collected from sieve and weighed.			
4. Use -#4 material as is or dry to 4% less than assumed OMC.			
5. Compact -#4 material in 4" mold in 3 equal lifts and using 25 blows/layer.			
6. Remove Collar. Excess material should be observed.			
7. Excess screeded off using a straight edge.			
8. Mold cleaned, weighed, and wet density determined. D_w = net weight of soil / calibrated volume of mold (approximately 0.0333 ft^3)			
9. Soil removed from mold and split vertically through the center.			
10. 300-500 g of material removed from cut face(s).			
11. Moisture content of this sample determined in accordance with either D4959 or D4944.			
12. Plot the 1-point data for the -#4 material on the family of curves. (Family of curves and nomograph attached.)			
13. Closest curve selected and the MDD and OMC looked up in table.			
IF THERE IS > 10% OVERSIZE MATERIAL (+#4), CONTINUE TO GET CORRECTED VALUE. OTHERWISE STOP HERE. (Only continue with #14-20 if an oversize correction is necessary.)			
14. Using nomograph, line drawn from D_d to 2.65 (or actual SG if known) on Specific Gravity axis.			
15. Line 3/(1 + 2.0/100) (2.0% is assumed $\mathcal{W}$ of oversize)			
16. Dry weight of all -#4 material calculated. Dry Weight of -#4 = (*Line 1 – Line 3*) / (1+ <u>*Line 11*</u>) 100 note: write MC% from *Line 11* as decimal			
17. Calculate % of +#4 material. % +#4 *Line 15 / (Line 15 + Line 16)*			
18. % +#4 material marked at top of nomograph and line drawn down to intersection of previous line.			
19. At the point of intersection, line drawn horizontally back to the density axis and the corrected density determined.			
20. Corrected OMC calculated. $OMC_{corrected}$ = (% -#4 x MC of -#4) + (% +#4 x 2%) Where %+#4 and %-#4 are written as decimals and the MCs% are written as whole numbers. 2.0% $\mathcal{W}$ for coarse fraction assumed.			
Signature of examiner observing and overall results :			

See optional data sheet for recording information

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED FEBRUARY 2025)

ASTM D1556-24 Density and Unit Weight of Soil in Place by Sand Cone	**Pass**	**Fail**	**N/A**
1. The technician understands that the sand must be "calibrated" (bulk-density) and that the volume of funnel and base plate (or mass of sand required to fill the funnel) must be known/determined.			
2. Apparatus in working condition and is a set.			
3. Flat and level testing surface prepared.			
4. Outline of base plate marked (or secured, if necessary) to prevent movement.			
5. Depth of hole is approximately the same depth as the lift(s) being tested.			
6. Hole dug ensuring that:			
• Sides of hole slope slightly inward.			
• Bottom is reasonably flat or concave.			
• The hole is free of pockets, overhangs, and protrusions.			
• Care is taken to avoid the loss of material.			
• Material is protected to prevent loss of moisture until water content sample is taken.			
7. Any material cleaned from flange of base plate.			
8. Mass of apparatus (sand, jar, & funnel) determined.			
9. Sand Cone inverted, and funnel placed in base plate, in same position as calibration (marks matched).			
10. Vibration from personnel and equipment avoided (or minimized).			
11. Valve opened until sand ceases to flow.			
12. Valve closed and mass of apparatus (remaining sand, jar, & funnel) determined.			
13. If oversized material is encountered, mass of oversized material determined and corrected for.			
14. Determine mass of moist material removed from hole.			
15. Material thoroughly mixed and representative moisture content specimen taken (if not entire sample).			
16. Moisture content determined (preferably by D4959).			
17. Proper calculations:			
$\mathbf{V = (M_1 - M_2) / \rho_1}$ Where: V = Volume M_1 = Mass of sand to fill test hole, funnel, & plate M_2 = Mass of sand to fill funnel & plate ρ_1 = Bulk-density of sand $\mathbf{\rho_m = M_3 / V}$ Where: ρ_m = Wet density M_3 = Mass of moist material from hole V = Volume $\rho_d = \rho_m / (1 + w/100)$ or $\mathbf{M_4 = 100\, M_3 / (w + 100)}$ Where: ρ_d = Dry density w = Moisture content as decimal Where: M_4 = mass of dry material			
Signature of examiner observing and overall results:			

See optional data sheet for recording information

Only this density-determining procedure or the drive-cylinder method, D2937, needs to be accomplished.

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED FEBRUARY 2025)

ASTM D2937-24, Density of Soil in Place by the Drive-Cylinder Method	Pass	Fail	N/A
1. The technician understands that the use of this test method is limited to certain soil types and with the bulk of the material having particle sizes less than 3/16 inch (4.75mm).			
2. Apparatus is in working condition and appears acceptable.			
3. Weight the cylinder and record its calibrated volume.			
4. Brush all loose particles from the surface prepared by a shovel or auger for near surface sampling.			
5. Drive cylinder until it is approximately ½ inch (13mm) below the original ground surface.			
6. Remove the drive head and extract the cylinder using a shovel.			
7. Trim the ends of the sample flush ends of the cylinder.			
8. Discard the sample if incomplete, contains foreign material, or cylinder is deformed.			
9. Calculate the wet density (ρ_{wet}) of the soil in the cylinder. $\rho_{wet} = (M_1 - M_2)/V$ Where: M_1 = Mass of cylinder and wet soil sample, g; M_2 = Mass of cylinder, g; V = Volume of cylinder, cm^3			
10. Obtain a representative soil sample (not less than 100g) and compute water content (w) by an approved ASTM method.			
11. Calculate in-place dry density (ρ_d) of the sample in g/cm^3 $(\rho_d) = \dfrac{\rho_{wet}}{(1 + (w/100)}$			
Signature of examiner observing and results:			

Only this density-determining procedure or the sand cone method, D1556, needs to be accomplished.

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED FEBRUARY 2025)

ASTM D6938-23 Nuclear Density Gauge (Direct Transmission)	**Pass**	**Fail**	**N/A**
1. Gauge standardized at start of day's use.			
2. Testing location selected and surface prepared.			
3. Surface allows total contact with bottom of gauge, voids filled as necessary (no void > 1/8").			
4. Hole-forming device driven through guide to a depth at least 2" deeper than the testing depth.			
5. Hole-forming device removed, and corners of guide marked.			
6. Any necessary repairs made to surface.			
7. Gauge carefully aligned on surface, placing the source rod over the hole (aligned from scoring marks).			
8. Source rod inserted into the hole to the testing depth.			
9. Gauge seated firmly by rotating back and forth.			
10. Gauge gently pulled such that the source rod is in contact with the side of the hole nearest detectors.			
11. Perform and record at least one reading for the normal measurement period.			
Signature of examiner observing and overall results:			

Overall Performance Evaluation

☐ **Pass** ☐ **Requires Retest**

I attest that the tests results reported above are accurate and testing was conducted and proctored in accordance with WACEL requirements.

____

PRINTED NAME OF WACEL EXAMINER

____

SIGNATURE

____

DATE

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED FEBRUARY 2025)

Field Moisture of Soil by Direct Heat
(ASTM D4959)

Date: ____________________ Technician: ___________________

DATA FORM FOR MOISTURE CONTENT OF SOIL

TEST NUMBER:		1	2	3
1.	Weight of container and wet soil, g			
2.	Weight of dry soil and container, g			
3.	Weight of water, g (1-2)			
4.	Weight of container, g			
5.	Weight of dry soil, g (2-4)			
6.	Percent moisture (3/5) x 100			

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(VTM-12/AASHTO T272)
(REVISED FEBRUARY 2025)

ONE-POINT PROCTOR WORK SHEET

Technician: ______________________

Date:

Sample No:			
Description / USCS:			
Sample Location:			
I. Gravel (+4) Material % Determination			
a. Wt. of Total Sample + Container (lbs.)			
b. Wt. of Container (lbs.)			
c. Net Wt. of Total Sample (a-b) (lbs.)			
d. Wt. of Gravel (+4) Material + Container (lbs.)			
e. Wt. of Container (lbs.)			
f. Net Wt. of Gravel (+4) Material (d-e) (lbs.)			
g. % Gravel (+4) (f/c x 100)			
II. Moisture Content Determination			
h. Wt. of Wet Soil + Container g			
i. Wt. of Dry Soil + Container g			
j. Wt. of Container g			
k. Net Wt. of Dry Soil (i-j) g			
l. Wt. of Moisture (h-i) g			
m. % Moisture Content of Soil (l/k x 100)			
III. Proctor Determination			
n. Wt. of Wet Soil + Mold (lbs.)			
o. Wt. of Mold (lbs.)			
p. Net wt. of Wet Soil (n-o) (lbs.)			
q. Wet Density (p x 30) (lb./ft^3)			
r. Moisture Content of Soil (%) (m)			
s. Max. Dry Density fr. Family of Curves (lb./ft^3)			
t. Opt. Moisture Content (%) fr. Family of Curves (%)			
IV. +4 Correction			
u. % Gravel (+4) (g)			
v. Corrected Max. Dry Density (lb./ft^3)			
w. Corrected Opt. Moist. Content (%)			

Note 1: The “30” in line q represents the nominal volume of the mold, $1/30^{th}$ of a cubic foot.

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED FEBRUARY 2025)

FIELD DENSITY TEST
(SAND CONE) (ASTM D1556)

Date: ___________________ Tech. ___________________________

TEST NUMBER:	1	2	3	4
TEST LOCATION:				
DEPTH BELOW GRADE OR ELEVATION:				
WET DENSITY:				
(A) Sand Density (lb/ft^3 or g/cm^3) (provided)				
(B) Wt. of Sand in Funnel and base plate (separate procedure or provided)				
(C) Wt. of Sand + Apparatus (before)				
(D) Wt. of Pan/Container				
(E) Wt. of Sand + Apparatus (after)				
(F) Wt. of Sand in Hole + Funnel **(C-E)**				
(G) Wt. of Sand in Hole **(F-B)**				
(H) Volume of Hole (G/A) (nearest 0.0001 ft^3)				
(I) Wt. of Pan/Container + Wet Soil				
(J) Wt. of Wet Soil **(I-D)**				
(K) Wet Density (ft^3) **(J/H)**				
MOISTURE CONTENT:				
(L) Wt. of Container + Wet Soil (note 1)				
(M) Wt. of Container + Dry Soil				
(N) Wt. of Water **(L-M)**				
(O) Wt. of Container				
(P) Wt. of Dry Soil **(M-O)**				
(Q) Percent (%) Moisture **(N/P X100)** (note 2)				
DRY DENSITY:				
(R) Dry Density (lb/ft^3) **K/(1+Q/100)** (closest 0.1 lb/ft^3)				
LABORATORY DATA:				
(S) Corrected Proctor Maximum Dry Density				
(T) Corrected Optimum Moisture Content				
RESULTS:				
(U) Percent (%) Compaction (R**/S)** X 100				

Note 1: Minimum of 200-300 g of moist soils.
Note 2: Take a jar sample for lab analysis if required by project manager.

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED FEBRUARY 2025)

DRIVE CYLINDER WORKSHEET (ASTM D2937)

Date: ___________________ Tech. __________________________

TEST NUMBER:	**1**	**2**	**3**
a. Elevation / Depth			
b. “Calibrated” Volume of Drive Cylinder (DC), cm^3			
c. Weight of Wet Soil and DC, g			
d. Weight of Drive Cylinder, g			
e. Weight of Wet Soil, g (c-d)			
f. Water Content of Soil, $\mathcal{W}$% (other method)			
g. Wet Density of Soil, $\boldsymbol{\rho}_{wet}$, g/cmM^3 (e/b)			
h. Dry Density of Soil, g/cm^3 g $\boldsymbol{\rho}_{dry} = \boldsymbol{\rho}_{wet}$ / (1 + (w/100))			

WACEL SOIL FIELD INSPECTOR PRACTICAL EVALUATION
(REVISED FEBRUARY 2025)

RESULTS WORK SHEET			
Attempt No:	1	2	3
One Point Proctor			
1. Moisture Content			
2. +4 Material Percentage			
3. -4 Material Percentage			
4. Wet Density (WD)			
5. Dry Density (DD)			
6. Family of Curves Letter			
7. Maximum Dry Density (MDD)			
8. Optimum Moisture Content (OMC)			
9. Corrected Maximum Dry Density			
10. Corrected Optimum Moisture Content			
Sand Cone			
11. Volume of Hole			
12. Moisture Content			
13. Wet Density			
14. Dry Density			
Nuke Gauge			
15. Wet Density			
16. Dry Density			
17. Moisture Content			
Percent Compaction			
18. Sand Cone			
19. Nuke Gauge			
20. Pass or Fail			

Virginia Test Method – 12

Use of One-Point Proctor Density – (Soils Lab)

March 4, 2019

AASHTO T 272 (Method A of T 99) shall be followed, except as modified below:

5. Apparatus

Add the following to Section 4.1:

a. "Speedy" moisture tester (AASHTO T 217) or drying apparatus (ASTM D4959).

7. Procedure

7.1 The representative sample must fall within the minimum and maximum curve range shown on Figure 1. If the point plotted within or on the family of curves (Figure 1) does not fall within the minimum and maximum curve range, compact another specimen, using the same material, at an adjusted moisture content that will place the one-point within this range. The maximum density determination will be more accurate the closer the moisture content is to the optimum moisture content.

7.4 Take a sample for moisture content determination by "Speedy" moisture tester in accordance with AASHTO T 217, or the manufacturer's directions labeled on the instrument. Moisture content can be also determined using a hot plate, gas stove, or burner in accordance with ASTM D4959 if "Speedy" tester is not available. Record the moisture content.

7.5 Delete.

8. Maximum Density and Optimum Moisture Content Determination

8.1 Delete.

8.2 Delete.

8.3 Family of Curves:

8.3.1 Results for wet density of the soil in pounds per cubic foot and moisture content shall be plotted on Typical Moisture Density Curves Set "C" (Figure 1).

8.3.2 Plot the wet density and moisture content results above on Figure 1. If this point falls on one of the curves, go to the upper right hand corner of the graph and use the Maximum Dry Density and Optimum Moisture Content that correspond to that curve.

8.3.3 When this point falls within the family but not directly on a curve, use the nearest existing curve in the family of curves.

8.3.4 When oversized particles have been removed, it is necessary to use the following procedures from VTM-1 to determine the corrected Maximum Dry Density and Optimum Moisture Content.

A. Correction for +No. 4 (4.75 mm) in the sample, if there is 10% or greater material retained on the No. 4 (4.75 mm) sieve.

The correction to be used for the +No. 4 (4.75 mm) material is determined by the following procedures:

(1) Record the percent of +No. 4 (4.75 mm) material from density hole.

(2) The theoretical maximum density, "D" of mixtures containing coarse aggregate larger than a No. 4 (4.75 mm) sieve will be determined by the formula:

Where:

$$D = \frac{D_f \, x \, Dc}{Pc \, D_f + P_f \, Dc}$$

D_f = Maximum dry laboratory density of minus No. 4 (4.75 mm)material (by AASHTO Designation: T 99), in lb/ft^3 (kg/m^3)

Dc = Maximum density of Plus No. 4 material {62.4 lb/ft^3 (1000 kg/m^3) x bulk specific gravity by AASHTO Designation: T85 or as estimated by the engineer} in lb/ft^3 (kg/m^3).

Pc = Percent plus No. 4 (4.75 mm) material, expressed as a decimal, and

P_f = Percent minus No. 4 (4.75 mm) material, expressed as a decimal.

(3) The optimum moisture content for the total soil will be determined by the formula:

Where:

$$W_t = (P_c \, W_c + P_f \, W_f) \, 100$$

W_t = Optimum moisture content for total soil,

Wc = Optimum moisture content, expressed as a decimal, for material retained on No. 4 sieve (4.75 mm) (estimated between 1% and 3%),

W_f = Optimum moisture content, expressed as a decimal, for material passing No. 4 (4.75 mm) sieve.

Pc = Percent, expressed as a decimal, of material retained on a No. 4 (4.75 mm) sieve, and

P_f = Percent, expressed as a decimal, of material passing a No. 4 (4.75 mm) sieve.

Alternatively, the corrected maximum dry density can be determined herein with the aid of the nomograph (Figure 2).

B. Percent Compaction

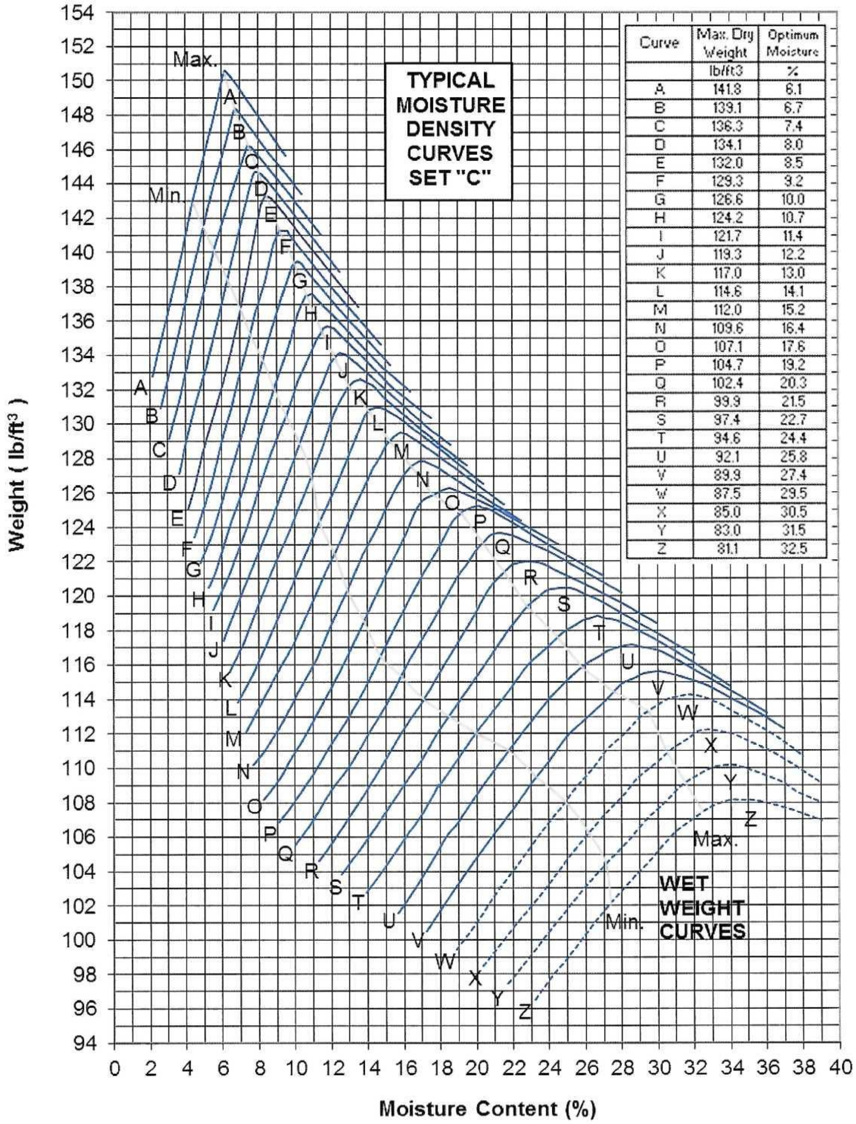
$$\text{Percent Compaction} = \frac{\text{Field Dry Density}}{\text{Maximum Dry Density}} \times 100$$

General Notes:

1 The density required in the work will be a variable percentage of the theoretical maximum density, "D", depending upon variations in the percentage of plus No. 4 (4.75 mm) material in the mixture and upon the position of the material in the work, and will be specified in the applicable section of the specifications.
2 The specific gravity of +4 material can be found in soil survey reports and contractor borrow material submittals for soils and Approved List No. 5 (http://www.virginiadot.org/business/resources/Materials/Approved_Lists.pdf) for aggregates. If this information is not available, the specific gravity can be assumed as directed by the District Material Engineer.

8.3.5 Perform a full moisture/density relationship if the one-point determination does not fall within the family of curves or cannot meet the minimum and maximum curve range.

ONE-POINT PROCTOR

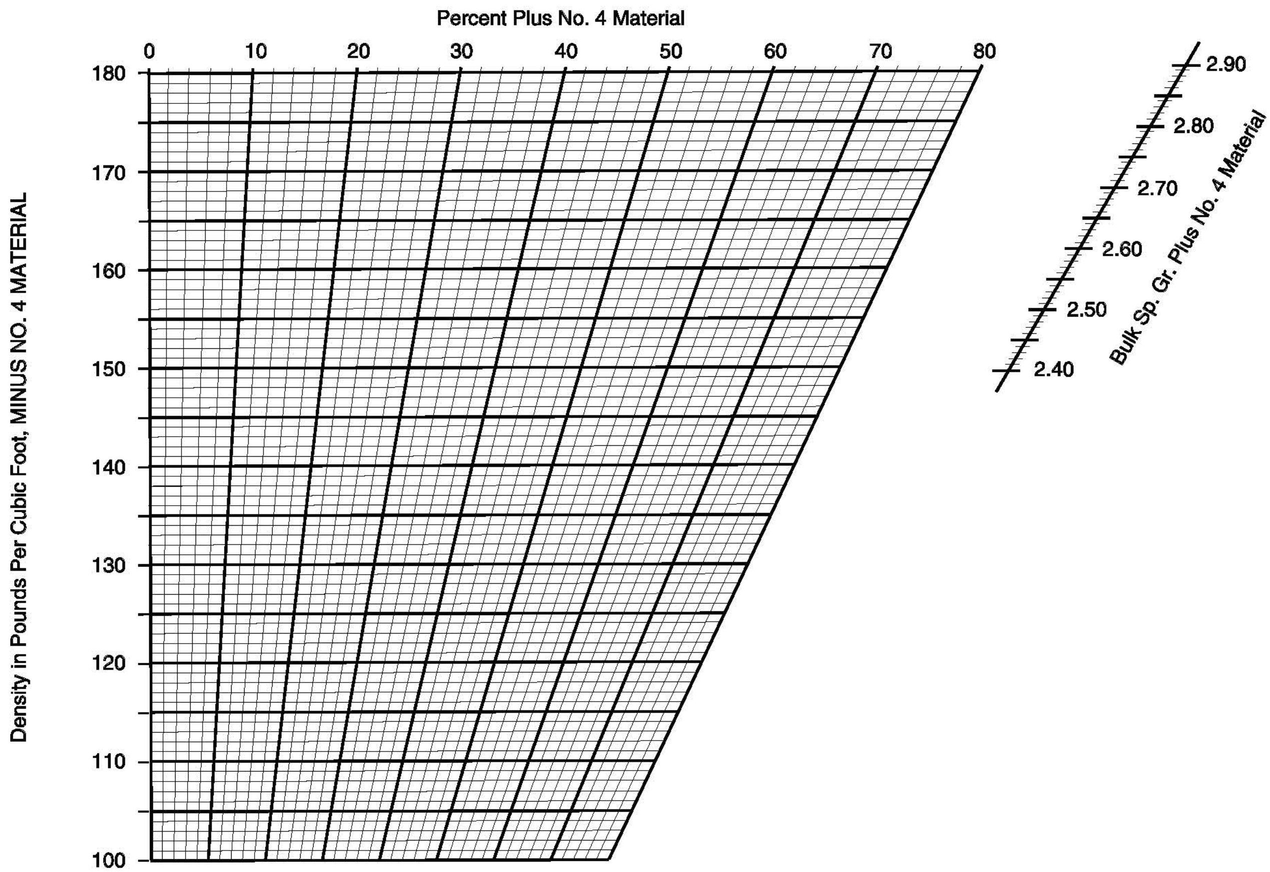


Curve	Max. Dry Weight	Optimum Moisture
	lb/ft3	%
A	141.8	6.1
B	139.1	6.7
C	136.3	7.4
D	134.1	8.0
E	132.0	8.5
F	129.3	9.2
G	126.6	10.0
H	124.2	10.7
I	121.7	11.4
J	119.3	12.2
K	117.0	13.0
L	114.6	14.1
M	112.0	15.2
N	109.6	16.4
O	107.1	17.6
P	104.7	19.2
Q	102.4	20.3
R	99.9	21.5
S	97.4	22.7
T	94.6	24.4
U	92.1	25.8
V	89.9	27.4
W	87.5	29.5
X	85.0	30.5
Y	83.0	31.5
Z	81.1	32.5

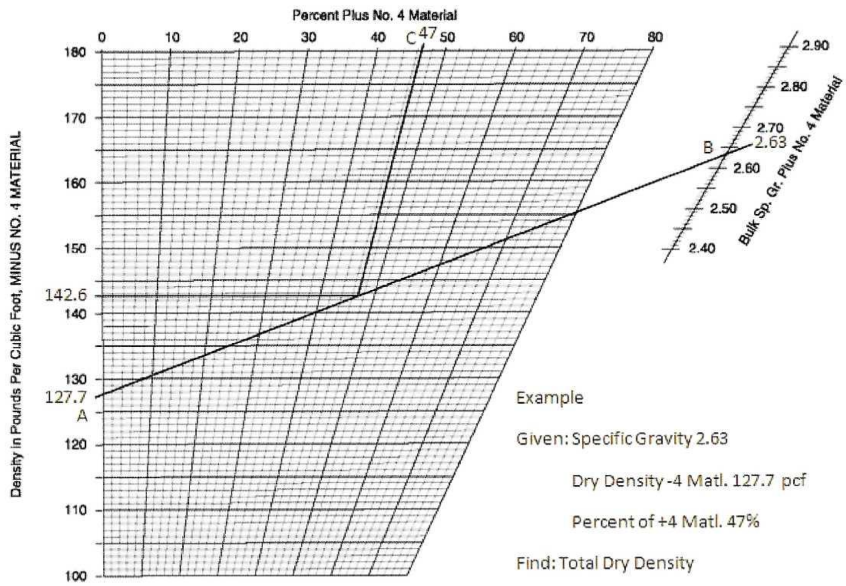
Figure 1

NOMOGRAPH FOR DETERMINING TOTAL DENSITIES OF SOILS

VTM-1



NOMOGRAPH FOR DETERMINING TOTAL DENSITIES OF SOILS



Example

Given: Specific Gravity 2.63

Dry Density -4 Matl. 127.7 pcf

Percent of +4 Matl. 47%

Find: Total Dry Density

1. Plot A, B and C
2. Using a straight edge draw a line from A to B
3. From C draw a line at the same slant as the nomograph lines to intersect line AB
4. Draw a straight line from the point of intersection to the left edge of the nomograph
5. Total Dry Density =142.6 pcf

Figure 2b