SOIL & AGGREGATE COMPACTION INSPECTOR PROGRAMMED INSTRUCTION MANUAL

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DEFINITION OF TERMS

& HANDOUTS

Compaction Study Sheet				
Asphalt				
Minimum Temperature 175º Take Temperature Every Hour	92%-96% of density design	1000' lot		
Subgrade				
6" Lift Thickness	Granular Material (<3" Particle Size)			
Pipe				
4" Lift Thickness	<60" Pipe 1 Lot Per 75' of Installation 60"-108" Pipe 1 Test per lift, 5 Test per Lot			
Sewer Line				
4" Lift Thickness	1 Lot per 500 linear feet **OR** one day's production (whichever is less)			
Structure Backfill				
4" Lift Thickness	1 Lot per structure, lot size determined by engineer			
MSE Walls				
6" Lift Thickness Select Granular Backfill	500' Lot	Sub-Lot 100' of single lift (at least one per lift)		
Base Course Material				
Test strip lift thickness 6" (other 12")	1 Lot per 2000 linear feet			
Embankment				
Random Material 35%-65% Hard Shale 35%-65% Rock >40% +3/4 Material Lot Size	6" Lift Thickness 12" Lift Thickness 12" Lift Thickness 12" Lift Thickness		>65% Hard Shale >65% Rock	24" Lift Thickness 36" Lift Thickness
Nuclear Gauge				
Standard Count ±2 Density ±4Moisture 4 tries to standardize	Neutron and Gamma Rays are most Damaging Neutron-Moisture Gamma-Density	Warm Up Gauge 20 min or Manufacturers' Standards		30FT from metal on a surface at of at least 110pcf
General				
Classify material by particle size		**Budget** project by material hardness		

* Data for all lines are given or correspond to an equation on the left side of the page

WEST VIRGINIA DIVISION OF HIGHWAYS

MATERIALS CONTROL, SOILS & TESTING DIVISION

LAB NUMBER

AUTHORIZATION NUMBER — GENERAL

PROJECT NUMBER — PROJECT

DISTRICT — INFORMATION

LOT NUMBER

ITEM NUMBER

Note: Data from CG, CH, OA, & DC always carry over from Left to Right until a new proctor is established.

FORM T-316
MP 207.07.20

GAUGE NUMBER		TEST NUMBER			1	2	3	4	5
MANUFACTURER'S STANDARDS			DATE		General Test Location / Identification				
DENSITY			STATION NUMBER	ft.					
MOISTURE			OFFSET	ft.					
GAUGE STANDARD COUNTS			DEPTH BELOW GRADE	ft.					
DENSITY			LIFT THICKNESS	in.					
MOISTURE			DEPTH OF SOURCE	in.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft³	1	**From Nuclear Gauge**				
		MA	MOISTURE	lb/ft³	1					
		DB	DRY DENSITY -3/4	lb/ft³	3	From Tables Using CG, CH, & DA				
MB = MA (100) / DB		**MB**	MOISTURE	%	4					
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams	2					
CC = CA - CB		**CB**	PAN	grams	2					
CF = CD - CE		**CC**	EXCAVATED MAT.	grams	2					
CG = CF (100) / CC		**CD**	PLUS 3/4 MAT. + PAN	grams	2					
		CE	PAN	grams	2					
PC = PA - PB		**CF**	PLUS 3/4 MAT.	grams	2					
PD = PC (0.066)		**CG**	PLUS 3/4 MAT.	%	2					
PE = PD (100) / 100 + MB		**CH**	SPECIFIC GRAVITY							
						RERUN		RERUN		RERUN		RERUN		RERUN
RERUN PROCTOR **PE (RERUN)** = PD (100) / 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	5									
		PB	MOLD	grams	5									
		PC	WEIGHT OF SOIL	grams	5									
		PD	WET DENSITY	lb/ft³	5									
		PE	DRY DENSITY	lb/ft³	5									
SC = SA - SB	STOVE DRIED MOISTURE	**SA**	WET WEIGHT + PAN	grams	This section is performed 6th, only used if a rerun proctor is performed (stove dried moisture is used to plot max density / optimum moisture					
SE = SD - SB		**SB**	PAN	grams						
SF = SC - SE		**SC**	WET WEIGHT	grams						
SG = SF (100) / SE		**SD**	DRY WEIGHT + PAN	grams						
		SE	DRY WEIGHT	grams						
DE = DB (100) / DC		**SF**	MOISTURE	grams						
		SG	MOISTURE	%						
$\bar{X} = \frac{\Sigma DE}{5}$	MOIST. EVAL	**OA**	OPTIMUM MOISTURE	%	6 if no Rerun needed / 7 if first proctor doesnt plot					
		OB	PLUS / MINUS TOLER.		+3/-4	+3/-4	+3/-4	+3/-4	+3/-4	
		OC	PASS / FAIL							
$QL = \frac{\bar{X} - T}{R}$	DEN EVAL	**DC**	MAXIMUM DENSITY	lb/ft³	6 if no Reun needed / 7 if first proctor doesnt plot					
		DE	RELATIVE DENSITY	%						
	LOT EVALUATION	$\bar{X}$	AVERAGE **DE**	%		INSPECTOR'S NAME:				
		T	TARGET	%	95	INSPECTOR'S SIGNATURE:				
		QL	QUALITY INDEX							
		DF	WITHIN TOLERANCE	%		PROJECT'S EVALUATION				
		DG	MIN. FOR 100% PAY	%	80	CHECKED BY:				
		DH	PASS / FAIL	YES	NO	DATE:				

*DF found in QL Tables

R= Highest DE- Lowest DE

Attachment 2 of MP 207.07.20 (Page 6-14)

Attachment 3 of MP 207.07.20 (Page 6-15)

DEFINITION OF TERMS

BASELINE: A reference line for project control usually located along one edge of the project. The baseline is usually abbreviated as: B

CENTERLINE: A reference line established for project location purposes. This line establishes the center of a specific part of the project such as centerline of roadway, centerline of pipe, etc. The centerline is abbreviated as: C

STATION NUMBER: For location purposes, the baseline and centerline are divided into increments referred to as stations. Stations are usually established on 50-foot intervals and are used to determine distance along the centerline or baseline. Station numbers normally start at the beginning of a baseline or centerline at station 0+00 and increase along the baseline or centerline. Each individual foot up to 99 feet is documented on the right side of the + sign. Increments of 100 feet are documented on the left side of the + sign.

For example: 50 feet is written as 0+50

150 feet is written as 1+50

2,250 feet is written as 22+50

OFFSET: Distance perpendicular (at 90 degrees) from the baseline or centerline. Offsets are followed by the notation “right or Left” to establish which side of the line the distance is measured from. In the direction that the stations progress along the baseline or centerline, everything located along the right side is referred to as “right of baseline” and everything located along the left side is referred to as “left of baseline”.

For example: 60 feet right is 60 feet right of the baseline or centerline.
15 feet left is 15 feet left of the baseline or centerline

BITUMINOUS CONCRETE: Commonly referred to as asphalt. A roadway paving material consisting of a mixture of asphaltic materials (bitumen) and fine and coarse aggregates. The wet density of bituminous concrete is measured during compaction testing.

AGGREGATE: Relatively inert granular mineral material such as sand, gravel, slag, crushed stone etc. Fine aggregate is material that will pass the No. 4 sieve. Coarse aggregate is material that will not pass the No. 4 sieve. Relatively inert granular mineral material such as sand, gravel, slag, crushed stone etc. Fine aggregate is material that will pass the No. 4 sieve. Coarse aggregate is material that will not pass the No. 4 sieve.

SOIL: Sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks, and which may or may not contain organic matter. Soils can be categorized by particle size.

Gravels- 3 inches to No. 4 sieve Sand- No.4 to No. 200 sieve

Silt and Clay- No. 200 sieve and smaller

ROCK: Natural solid mineral matter occurring in large masses or fragments.

BASE OR BASE COURSE: A layer of specified or selected material of planned thickness, constructed on the subgrade or subbase for the purpose of serving one or more functions such as distributing load, providing drainage, or minimizing frost action.

EMBANKMENT: A raised structure of soil, shale, rock or random material, constructed in layers to a predetermined elevation and cross-section.

FILL: Man-made deposits of natural soils and waste materials.

LIFT: The thickness of an individual layer of soil, aggregate or rock, that is being placed as fill or backfill. The lift thickness can be specified loose or compacted. Example: 8 inches loose or 6 inches compacted. Excessive lift thickness results in poor and non-uniform compaction and the potential for future settlement of the fill.

GRADE: The finished surface elevation of a specified layer.

SUBGRADE: The soil prepared and compacted to support a structure or pavement or pavement system.

PROCTOR: A test method used to determine the relationship between the moisture content and density of soils. The Proctor is named after the person who developed the test method, R. R. Proctor. Some types of Proctors are as follows:

Standard	ASTM D 698 OR AASHTO T-99
Modified	ASTM D 1557 OR AASHTO T-180
WVDOH 1-Point	MP 207.07.20

ROLLER PASS: A WVDOH method of determining the maximum density of a material. This method is applicable to treated and untreated aggregate base courses, select backfill, crushed aggregate backfill, granular backfill, and random material containing 40% or more (by weight) of particles that are retained on the ¾ inch sieve (plus ¾ inch material). The WVDOH procedure for the roller pass method is MP 700.00.24.

COMPACTION: The application of force or vibration to a material in an effort to densify the material.

DENISTY: Weight per unit volume. The standard unit for soil, aggregate and asphalt testing is pounds per cubic foot.

WET DENSITY: The total unit weight per unit volume including water.

DRY DENSITY: Weight per unit volume of a material after the moisture has been removed.

MAXIMUM DRY DENSITY: Maximum dry density of a material under optimum moisture conditions.

MOISTURE CONTENT: Moisture content or water content is the ratio expressed as a percentage of the weight of water in a given soil mass to the weight of solid particles.

OPTIMUM MOISTURE Optimum moisture content is the ideal moisture content that a particular material requires to achieve its maximum density.

SPECIFIC GRAVITY: Specific gravity is the ratio of the mass of a unit volume of a material at a stated temperature to the mass of the same volume of water at a stated temperature. Example: Limestone has a specific gravity of 2.7. Therefore, an equal volume is 2.7 times heavier than water.

LOT: Unit of measurement for the quantity of material being placed and tested. A lot of compaction tests consists of 5 tests.

SUBLOT: An equal 1/5 portion of a lot. For example, if a lot of bituminous concrete was 1000 feet x 12 feet, then each sublot would be 200 feet x 12 feet.

MATERIALS PROCEDURES: Abbreviated as MP. These are specific test methods that explain how to perform the individual tests. MP's were generated by the WVDOT (DOH) and are mostly derived from AASHTO specifications and re-written in step by step progression to ease interpretation.

OVERVIEW OF EMBANKMENT CONSTRUCTION

PREPARATION

NOTE: As a certified Compaction Inspector, you must be in possession of or have immediate access to the Standard Specifications, Supplemental Specifications, Project Plans, Special Provisions, Contractor's Quality Control Plan, etc. These documents govern the control of construction, testing, and inspection throughout the course of a project.

WHERE TO BEGIN?

Embankments are the biggest component of a Highway system.

Embankment construction can be broken down into three general phases of construction that a Compaction Inspector may be involved:

1. Clearing and Grubbing - Section 201, Standard Specifications
2. Excavation and Embankment - Section 207, Standard Specifications
3. Crushed Aggregate Base Course – Section 307, Standard Specifications

CLEARING & GRUBBING

Clearing and Grubbing - Section 201, Standard Specifications:

1. This work shall consist of clearing, grubbing, removing, and disposing of all vegetation and debris within the construction limits and other areas within the right of way.
2. This is also a good time to stockpile topsoil to be used for dressing slopes at the end of fill placement.
3. The Compaction Inspector will often verify that the area has been cleared sufficiently and is ready for fill placement.

SLOPES

Slopes - Section 207.3.1, Standard Specifications:

1. Slope lines shall conform to plans.
2. Slopes lines may only be altered by the Engineer.
3. The typical slope line for soil is 2:1.
4. Slope lines for rock may vary depending upon rock lithology and hardness.

EXCAVATION

Rock Excavation - Section 207.3.3, Standard Specifications:

1. Slopes steeper than 1:1 shall utilize presplitting techniques.
2. Control particle size of rock with drill pattern for production drilling.

EMBANKMENT CONSTRUCTION

Placing Embankment – Section 207.7.3.1, Standard Specifications:

1. No embankment shall be placed on frozen ground.
2. During the process of excavation and embankment construction, the roadway shall be maintained in such a condition that it will be well drained at all times.
3. Depositing and compacting embankment in layers shall be started at the lowest point of the fill below grade.
4. Each layer shall be placed horizontally across the entire length and width of the fill
5. Each layer shall be compacted prior to the placement of the next layer.

LIFT THICKNESS

Section 207.7.3.2, Standard Specifications:

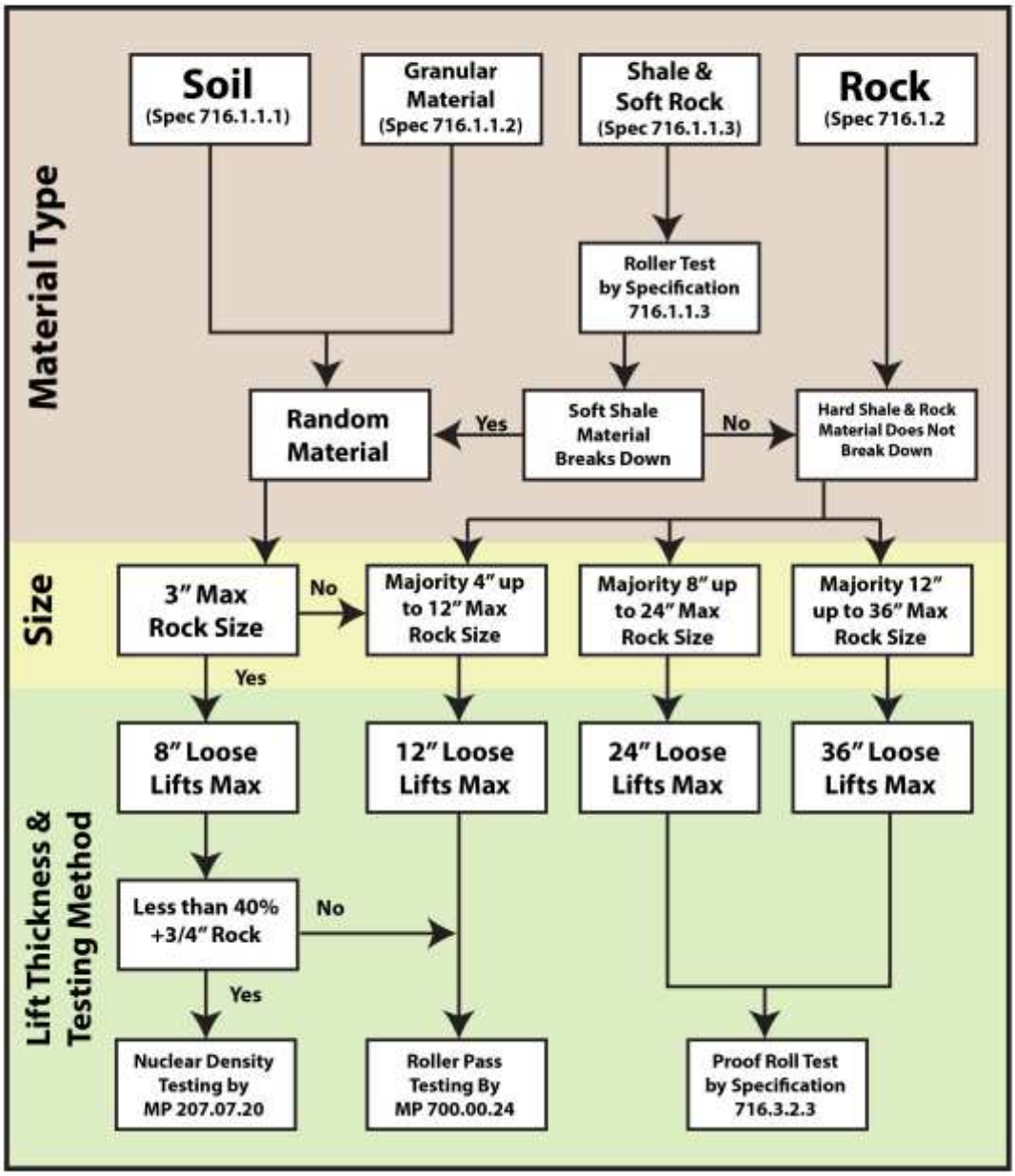
1. The contractor shall record material type and lift thickness for all types of embankments.
2. The lift thickness will be determined by material type and rock hardness (207.7.3.2.3, 2017 Standard Specs).
3. The lift thickness can also be determined by using Table C of MP 717.04.21.
4. The lift thickness shall be as thin as the excavated material will permit.
5. The largest rock size permitted in any lift is 36 inches.

FILL BENCHES

Benches

Section 207.4, Standard Specifications – Benches to be constructed either above or below the profile grade shall conform to the dimensions shown on the plans or as directed by the engineer.

Table C – Guide for Quality Control of Embankment Material



EMBANKMENTS

Embankment Materials are the most important components of a Highway system. The materials can be broken down into three different categories:

1. Select Embankment
2. Embankment Fill
3. Sub-Grade & Base

SELECT EMBANKMENT

Select Embankment- Section 207.7.3.2.3, Standard Specifications:

Rock lifts that are designated as Select Embankment shall contain no more than 15% of other suitable embankment material by visual inspection. The dominant rock size shall be 6 inches and greater.

Select Embankment- Section 211.6, Standard Specifications:

Shall be placed in accordance with the plans or as designated by the engineer.

Select Embankment- Section 704.5, Standard Specifications:

Select Embankment may be designated as Special Rock Fill in the plans. Special Rock Fill shall be limestone or sandstone having no more than 30% loss after 5 cycles of the sodium sulfate soundness test.

TYPES OF TESTING LOTS

MP 207.07.20 (PG. 6-4 PI MANUAL)

- “F” Lot – Embankment
- “S” Lot – Subgrade
- “B” Lot – Base
- “P” Lot – Pipe and Structure Backfill

Embankment Material – “F” LOTS

Standard Specifications Section 716:

1. Section 716.1.1 - Random Material
2. Section 716.1.1.1 - Soil
3. Section 716.1.1.2 - Granular Material
4. Section 716.1.1.3 - Soft Shale
5. Section 716.1.2 - Rock
6. Section 716.1.3 - Hard Shale

SUBGRADE. - "S" LOTS

Standard Specifications Section 207.9:

1. The subgrade shall be 6 inches compacted thickness for all embankment and excavation sections.
2. The subgrade material shall consist of granular material.
3. The subgrade shall be free of particles larger than 3 inches.
4. The subgrade shall be uniformly compacted to the requirements of section 716.

BASE -"B" LOTS

Standard Specifications Section 307:

1. Base material shall be placed according to the compacted thickness on the plans.
2. The base material shall consist of granular material conforming to the requirements of section 704.6
3. The aggregate class of base material will be designated in the plans. (Typically, class 1).
4. The base material shall be uniformly compacted to the requirements of section 717

RANDOM MATERIAL

Random Material 716.1.1-Random Material: Random material shall be considered as a mixture of any or all of soil, granular material, or soft shale as described which are permitted by the Engineer to be used in embankment. These are materials that can be incorporated in a 6 inch (150 mm) compacted layer.

Softshale 7.16.1.1.3-Soft shale shall be considered as any of the shales, weak sandstone, weak limestone, claystones or siltstones that break down under three complete coverages with a 1.5 ton per linear foot steel drum roller

Rock 716.1.2-Rock: Rock is defined as sandstone, limestone, or concrete that cannot be incorporated in a 6 inch (150 mm) compacted lift and shall be medium hard or harder.

Hardshale 716.1.3-Hard Shale: Material that meets the description of shale in 716.1.1.3 except that is does not break down under the hardness test shall be considered as hard shale and placed as specified in 207.7.3.2.2 when used as embankment material.

2 Primary Soft Rocks

1)Shale – Can be sandy or silty; Thin 1/8” Laminations (Layers)

2)Claystone- Can be sandy or silty; Chunky

Soil

716.1.1.1-Soil: Soil material shall be considered as layers or deposits of disintegrated rock, lying on or near the surface of the earth, which has resulted from natural processes, such as weathering, decay or chemical action or a combination of these processes. Material shall be considered as soil when more than 25 percent by weight of the grains or particles pass the No. 200 (75 µm) sieve.

Residual Soil

Residual Soil is a mineral that has weathered or disintegrated in place from primary bedrock. Residual soils are soils that develop from their underlying parent rocks and have the same general chemistry as those rocks

Colluvium

Colluvium is loose Earth material that has accumulated at the base of a hill, through the action of gravity, avalanche debris, and sheets of detritus by soil creep or frost action

Alluvium

Alluvium is a deposit of sand, silt, etc. formed by flowing water and usually deposited in the valleys of large rivers

Soil Classification

(Classified by Particle Size)

Clay	Silt	Sand	Topsoil
Lean Clay		Fine Grain	Peat
Fat Clay		Medium Grain	Loam
		Coarse Grain	

Soil Combinations

Clay	Silt	Sand
Sandy Clay	Clayey Silt	Clayey Sand
Silty Clay	Sandy Silt	Silty Sand

CLAY CHARACTERISTICS

- Very Fine Grained (0.004mm to 0.001mm)
- Cohesive
- Moisture Sensitive (+3 / -4 of Optimum Moisture)
- Easy to Compact at Optimum Moisture (Can use Vibratory or Static Weight)
- Shrink/Swell potential (Especially with finer particle sizes)

SAND CHARACTERISTICS

- Coarse Grained (Minus No. 4 to No. 200 Sieves)
- Non-Cohesive
- Moderately Moisture Sensitive (Needs some Moisture, but not a lot)
- Easy to Compact with a little Moisture (Best to Compact with Vibration)
- Good Friction Resistance
- High Bearing Capacity if Contained

SILT CHARACTERISTICS

- Fine Grained (00.074mm to 0.005mm)
- Lowe Cohesive to Non-Cohesive
- Moisture Sensitive (Water Rises to Surface Under Pressure)
- Difficult to Compact (Prone to Pumping and Rutting at Optimum Moisture, Best to Compact with Static Weight)
- Low Bearing Capacity
- If possible, Silt should be wasted or used to dress slopes!

THEORY OF COMPACTION

CHAPTER 1

COMPACTION CONCEPTS - AN OVERVIEW

Compaction is very important when soil is used as an engineering material; that is, when the structure itself is constructed of soil. Earth dams and highway embankments are typical examples of earth structures. If soils are dumped or otherwise placed at random in a fill, the result will be an embankment with low stability and high settlement.

The embankment and base materials provide the foundation for the pavement. The performance of the pavement depends on the quality of materials and construction techniques used to place the underlying materials. The placement of materials in an embankment, subgrade, base, or pipe and structure backfill, involves several factors which influence the quality of the final product. The goal is to provide materials that possess the engineering propertiesrequired by the design.

Construction personnel must be experienced and knowledgeable in the placement of materials and recognize and resolve problems as they are encountered. Each type of material has unique properties which must be addressed in design and construction. Failure to correctly place materials can have devastating effects. The problems can range from rutting of the pavementto excessive settlement and other instabilities such as landslides. Settlement always occurs to some degree but must be minimized and uniform over a largearea. Differential settlement can be very detrimental to the performance of the roadway.

Earthwork construction consists of placing lifts of material. Sound engineering decisions must be made before each lift is covered. The performance of the roadway depends on the daily decisions and workmanship as the construction progresses. Errors are difficult to correct and poor construction can lead to failures and large financial expenditures.

COMPACTION

Compaction is the densification of soils by the application of mechanical energy. It may also involve modification of water content and blending of soils. Coarse-grained soils are efficiently compacted by vibration. In the field, hand- operated vibrating plates and motorized vibratory rollers of various sizes are quite efficient for compacting shallow deposits of sand and gravel soils. Rubber-tired equipment can also be used efficiently to compact sands. In certain situations, large free-falling weights are used to dynamically compact loose granular deposits and fills.

Fine-grained and cohesive soils may be compacted in the laboratory by falling weights and hammers, by special "kneading" compactors, and even statically. In the field, common compaction equipment includes hand-operated tampers, sheepsfoot rollers, rubber-tired rollers, vibratory rollers, and other types of heavy compaction equipment.

The objective of compaction is to improve the engineering properties of the soil mass. By compaction:

- Detrimental settlements can be reduced or prevented.
- Soil strength can be increased, and slope stability improved.
- Bearing capacity of pavement subgrades can be improved; and
- Undesirable volume changes, for example, caused by frost action, swelling, and shrinkage, may be controlled.

THEORY OF COMPACTION

Soils form the foundation for most highway structures. The final structure, whether it is a pavement or a bridge structure, can only be as durable as the foundation upon which it rests. Compaction of the soil is necessary to assure that the soil or soil aggregate structure will perform and support its intended design loads. Material that is densely compacted will support more load than uncompacted material.

The fundamentals of compaction of cohesive soils were developed by R. R. Proctor in the early 1930s. Proctor published a series of articles in Engineering News-Record (Proctor 1933) on the principles of compaction, and in his honor, the standard laboratory compaction test he developed is called the Proctor test.

Proctor noted that compaction is a function of four variables: (a) dry density, γ_d; (b) water content, w; (c) compactive effort; and (d) soil type. Compactive effort is a measure of the mechanical energy applied to a soil mass. In the field, compactive effort is the number of passes of "coverages" of the roller of a certain type and weight on a given volume of soil. In the laboratory impact compaction test, a hammer is dropped several times on a soil sample in a mold. The mass of the hammer, height of drop, number of drops, number of layers of soil, and the volume of the mold are specified.

The "percent compaction" is a comparison between the compaction achieved in the field (in place density) and the maximum compaction possible for that soil type when compaction is performed under a set of controlled conditions. These controlled conditions exist in the laboratory. AASHTO T-99 and T-180 are used to determine

the maximum possible density that can be expected for that specific soil type using normal construction compacting efforts.

Maximum density of a soil or soil-aggregate is also dependent on the optimum moisture content of the soil being tested. Since it is possible that several types of soil will be used on a particular construction project, it is necessary for a laboratory to test and develop the different moisture-density relationships for each soil or soil aggregate that will be encountered. A soil or soil aggregate mixture which is not compacted to the required density may subside or undergo excessive settlement due to its own mass or traffic loadings, causing failure of the highway structure. It is critical that these tests and procedures, which determine the maximum density and the optimum moisture content, be performed properly.

The process of compaction for cohesive soils can best be illustrated by the Proctor test. Several samples of the same soil, but at different water contents, are compacted according to the standard Proctor test specifications given earlier. The total or wet density and the actual water content of each compacted sample are measured. Then the dry density for each sample can be calculated from

Wet Density: $$D_{wet} = \frac{Total\ Mass\ of\ wet\ Sample,\ W_s}{Total\ Volume\ of\ Sample,\ V_t}$$

Dry Density: $$D_{dry} = \frac{Wet\ Density,\ D_{wet}}{Total\ Volume\ of\ Sample,\ V_t}$$

When the dry densities of each sample are determined and plotted versus the water contents for each sample, a curve called a compaction curve for standard Proctor compaction is obtained (See Figure 4.1) Each data point on the curve represents a single compaction test, and usually four or five individual tests are required to completely determine the compaction curve. This curve is unique for a given soil type, method of compaction, and (constant) compactive effort. The peak point of the curve determines the maximum dry density γ_d max at a water content known as the optimum water content W_{opt} [also called the optimum moisture content (OMC)].

Note the maximum dry density is only a maximum for a specific compactive effort and method of compaction. This does not necessarily reflect the maximum dry density that can be obtained in the field. Increasing the compactive effort tends to increase the maximum dry density, as expected, but it also decreases the optimum water content.

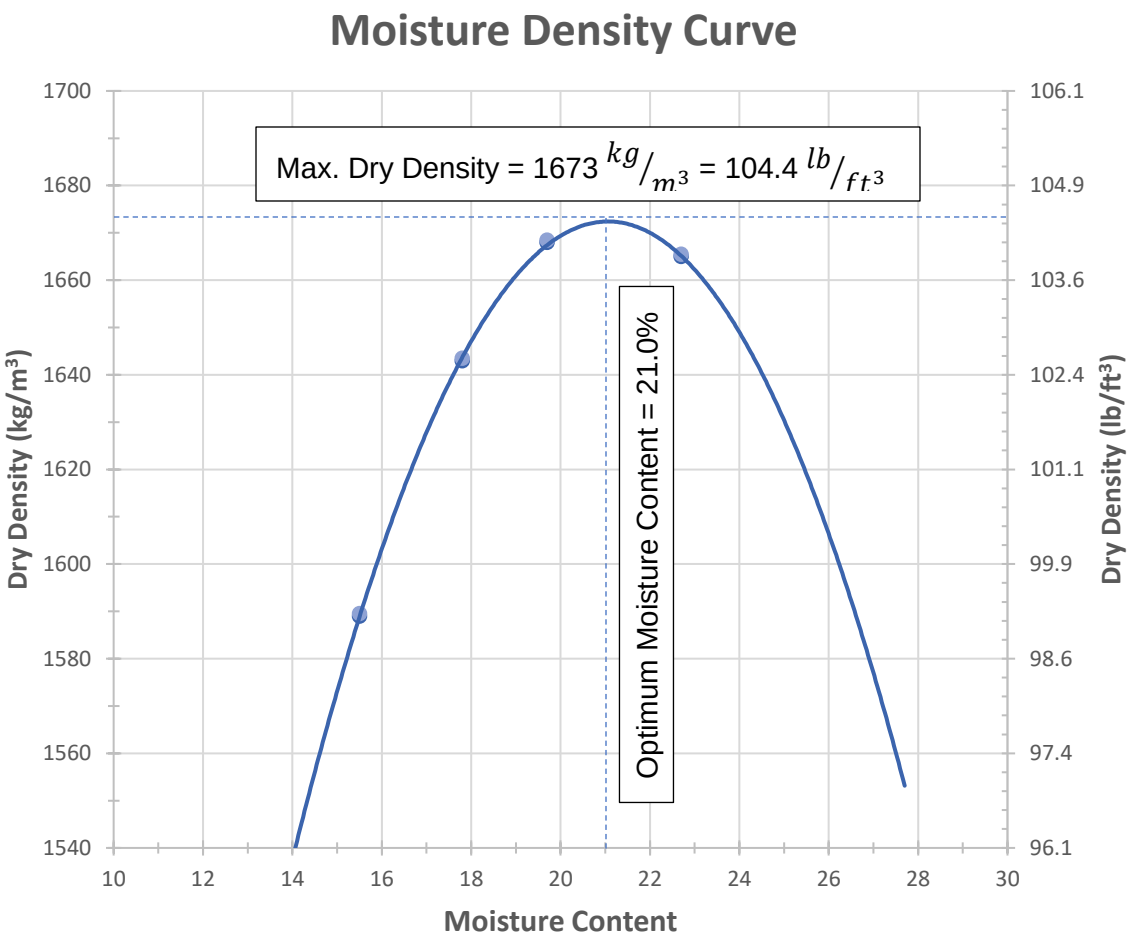


Figure 4.1 Example Moisture-Density Curve

As the water content increases, the particles develop larger and larger water films around them, which tend to "lubricate" the particles and make them easier to be moved about and reoriented into a denser configuration. However, eventually a water content is reached at which the density does not increase any further. At this point, water starts to replace soil particles in the mold, and because the density of water is much less than the density of the mineral grains, the dry density curve starts to fall off.

EMBANKMENTS

Usually, materials that are to be used to construct the embankment are selected by the contractor and approved by the engineer. Many agencies have general requirements in their standard specifications for the soil types that are acceptable for embankment construction. These requirements or any special provision for the project should be strictly adhered to so that only suitable materials are used.

Suitable materials, if properly placed and compacted, will make satisfactory embankments. Water content in the natural state has no bearing on suitability. However, materials with excessive moisture will require drying before compaction, or they must be replaced with materials having proper water content. During excavation, if materials are uncovered that have an excessive water content, construction personnel should refer to the contract specifications. If there is still a question about whether to use the wet soils, the engineer should be consulted.

COMPACTION OPERATIONS

General

Compaction of a soil layer is probably the most important aspect of proper embankment construction. A uniform, densely compacted embankment will provide a satisfactory platform upon which to place the base courses and pavement. The word "uniform" is important in that uniform conditions during construction of the embankment will result in uniform behavior of the pavement, assuming that foundation conditions do not enter the picture. The benefits of good compaction are substantial, and the consequences of poor compaction are severe. Compaction increases bearing capacity, slope stability, and resistance to frost action. It also decreases permeability and future settlement. Inadequate compaction may result in general and differential subsidence, which causes depressions and potential for premature failure of the pavement.

Heaving or Pumping

Heaving or pumping is an elastic-type deformation of the soil. When loaded, the material deforms and as the load is removed, the material springs back to its original position. The construction equipment looks as if it is riding on a wave as it travels over the fill. The soil will deflect, and a wave will be created ahead of the wheel, but once the equipment moves on, the area looks the same, although there may be some cracking of the surface. Heaving occurs when there is excess moisture in the soil that does not have time to drain as the load is applied. The load is then borne jointly by the soil and the pore water pressure. This gives a temporary elasticity to the soil, thus creating the heaving or pumping effect.

Note that, when in this condition, the strength of the soil is substantially reduced. Repeated loadings will continue to create cumulative pore pressures and may ultimately result in shear failure or rutting. Continued compaction operations can only worsen the situation.

Rutting

Rutting is a surface shear or bearing failure. As the equipment moves across the embankment, the loads imposed exceed the shear strength of the soil, the wheels sink, and rutting occurs. Rutting destroys the previous compaction and makes it impossible to place the next lift to a uniform thickness. This is particularly critical at the top of subgrade.

Compaction Equipment

There are many types and sizes of compaction equipment. The equipment ranges from large rollers such as pneumatic tired, vibratory, tamping foot etc. to small walk behind or handheld compactors. In any case, the equipment should be of the proper type and size to provide the compactive effort required for the material being placed. For example, a vibratory roller is well suited for a granular type of material. Vibrations move the finer particles into void spaces. For cohesive soils, a tamping foot (sheep's foot) roller is ideal. The tamping feet provide a kneading action which compacts the material.

The efficiency of compaction equipment often depends on such things as ballast, roller speed, vibration amplitude and frequency, etc. Checking the equipment should be part of the construction activities. The compaction equipment selected should be determined by the type of soils encountered.

Pneumatic-tired compactors achieve compaction by the interaction of (a) wheel load, (b) tire size, (c) tire ply, (d) inflation pressure, and (e) the kneading action of the rubber tires as they pass over the lift. Pneumatic-tired rollers should be ballasted to meet at least the minimum wheel load.

Vibratory drum compactors develop their compactive effort by load and vibrations. Five machine features must be known in order to rate vibratory rollers: (a) unsprung drum weight, (b) rated dynamic force, (c) frequency at which the rated dynamic force is developed, (d) amplitude of the drum vibration, and (e) drum width. The dynamic force is proportional to the square of the frequency. A reduction in the frequency will significantly reduce the compactive force.

Compaction of granular soils is mostly due to the dynamic force created by a rotating eccentric weight. Vibratory compactors dramatically lose their effectiveness when the

vibration is shut off because the compaction is due solely to the weight of the machine.

When sheepsfoot rollers are used, the feet must penetrate the loose lift. If they ride on top, the machine is too light, and the ballast must be increased. With succeeding passes, the feet should "walk out" of the layer. The number of passes required for the feet to walk out of the layer will be used to control compaction of subsequent layers. If the feet do not walk out, the machine is too heavy and is shearing the soils, or the soil is too wet.

MATERIALS

Materials to be compacted must be of a satisfactory quality and possess the necessary properties for the particular use. Poor quality materials may not perform properly or require extensive time and expense to improve.

In many cases embankment materials are excavated on the project. The quality of these materials may vary, and it is the designer's responsibility to adequately evaluate the material properties and address their use in design. The disposition of poor materials should be addressed in the design and not left to construction personnel to handle without specific guidelines.

Poor quality materials may be improved. This might include reducing the moisture content by aeration, adding a stabilizer such as lime or cement, mixing with higher strength materials, etc.

If off-site borrow sources are used, the material must be of satisfactory quality.

The following tables and figures provide general descriptions, properties and classification of various soils and soil components. Table 4.1 defines soil components and their properties. Table 4.2 and Figure 4.2 define the AASHTO classification system of soils and soil-aggregate mixtures. Table 4.3 and Figure 4.3 define the Unified Soil Classification System (USCS). Table 4.4 provides a comparison and cross referencing of the AASHTO and uses methods.

Table 4.1 Soil Components and Significant Properties				
	Soil Component	**Symbol**	**Grain Size Range and Description**	**Significant Properties**
Coarse Grained Components	Boulder	None	Rounded to angular, bulky, hard, rock particle, average dia. Smaller than 300 mm /12 in.)	Boulders and cobbles are very stable components, use for fills, ballast, and to stabilize slopes (riprap). Because of size and weight, their occurrence in natural deposits tends to improve the stability of foundation. Angularity of particles increase stability.
	Cobble	None	Rounded to angular, bulky, hard, rock particle, average dia. Smaller than 300 mm (12 in.) but larger than 76 mm (3 in.)	
	Gravel	G	Round to angular, bulky, hard, rock particle, passing 76 mm (3 in.) sieve retained on 4.75 mm (#4) sieve	Gravel and sand have essentially the same engineering properties differing mainly in degree. The 4.75mm sieve is arbitrary division and does not correspond to significant change in properties. They are easy to compact, little affected by moisture, not subject to frost action. Gravels are generally more pervious and stable, resistant to erosion and piping than are sands. The well- graded sands and gravels are generally less pervious and more stable than those which are poorly graded and uniform in gradation. Irregularity of particles increases the stability slightly. Finer, uniform sands approach the characteristics of silts, i.e. decreases in permeability and reduction in stability with increase in moisture.
	Coarse		76 mm to 19 mm (3 in. To 0.75 in.)	
	Fine		19 mm to 4.75 mm (0.75 to #4 Sieve)	
	Sands	S	Rounded to angular, bulky, hard, rock particle, passing 4.75 mm (#4) sieve, retained on 0.075 mm 1#200) sieve	
	Coarse		4.75 mm to 2.0 mm (#4 to #10) Sieve	
	Medium		2.0 mm to 0.425 mm (#10 to #40) Sieve	
	Fine		0.425 mm to 0.075 mm (#40 to #200) Sieve	

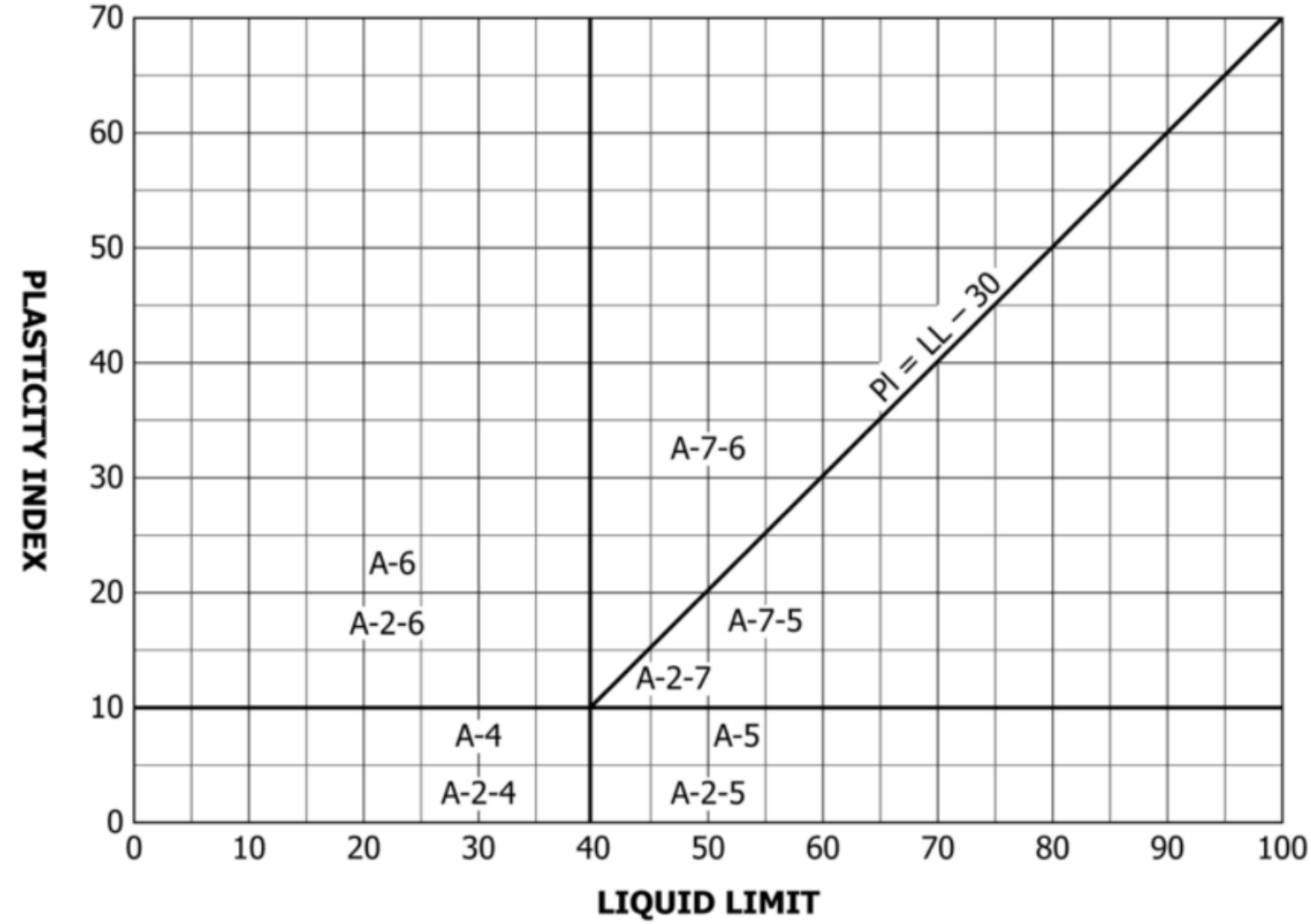
Table 4.1 Soil Components and Significant Properties				
	Soil Component	**Symbol**	**Grain Size Range and Description**	**Significant Properties**
Fine Grained Components	Silt	M	Particles smaller than 0.075 mm (#200) sieve identified by behavior: that is, slightly or non-plastic regardless of moisture and exhibits little or no strength when air dried.	Silt is inherently unstable, particularly when moisture is increased, with a tendency to become quick when saturated. It is relatively impervious, difficult to compact highly susceptible to frost heave, easily erodible and subject to piping and boiling. Bulky grains reduce compressibility; flaky grains, i.e., mica, atoms, increase compressibility, produce an 'elastic' silt. The distinguishing characteristic of clay is cohesion or cohesive strength, which increases with decreases in moisture. The permeability of clay is very low, it is difficult to compact when wet and impossible to drain by ordinary means, when compacted s resistant to erosion and piping, is not susceptible to frost heave, is subject to expansion and shrinkage with changes in moisture. The properties are influenced not only by size and shape, flat, plate-like particles, but also by their mineral composition, i.e., the type of clay mineral, and chemical environment or base exchange capacity. In general, the montmorillonite clay mineral has greatest illite and kaolinite the least adverse effect on the properties.
	Clay	C	Particles smaller than 0.075 mm (#200) sieve identified by behavior: that is, it can be made to exhibit plastic properties within certain range of moisture and exhibits considerable strength when air dried.	

Table 4.1 Soil Components and Significant Properties				
	Soil Component	**Symbol**	**Grain Size Range and Description**	**Significant Properties**
Organic Matter	Organic Matter	O	Organic matter in various sizes and stages of decomposition	Organic matter present even in moderate amounts increases the compressibility and reduces the stability of the fine-grained components. It may decay causing voids or by chemical alteration change the properties of the soil, hence organic soils are not desirable for engineering uses.

TABLE 2 Classification of Soils and Soil-Aggregate Mixtures

General Classification	Granular Materials 35 % or Less Passing 75 µm (No. 200)							Silt-Clay Materials More Than 35 % Passing 75 µm (No. 200)			
Group Classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5, A-7-6
Sieve analysis, % passing:											
2.00 mm (No. 10)	50 max	...	...	...	...	...	...	...	...	...	...
425 µm (No. 40)	30 max	50 max	51 min	...	...	...	...	...	...	...	...
75 µm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 425 µm (No. 40):											
Liquid Limit	...		...	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity Index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min[A]
Usual types of significant constituent materials	Stone Fragments, Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General rating as subgrade	Excellent to Good							Fair to Poor			

[A]Plasticity index of A-7-5 subgroup is equal to or less than *LL* minus 30. Plasticity index of A-7-6 subgroup is greater than *LL* minus 30 (see Fig. 1).



A-2 soils contain less than 35 % passing the 75-μm (No. 200) sieve.

FIG. 1 Liquid Limit and Plasticity Index Ranges for Silt-Clay Materials

TABLE 1 Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
COARSE-GRAINED SOILS	Gravels (More than 50 % of coarse fraction retained on No. 4 sieve)	Clean Gravels (Less than 5 % fines[C])	$Cu \geq 4.0$ and $1 \leq Cc \leq 3.0$[D]	GW	Well-graded gravel[E]
			$Cu < 4.0$ and/or $[Cc < 1$ or $Cc > 3.0]$[D]	GP	Poorly graded gravel[E]
		Gravels with Fines (More than 12 % fines[C])	Fines classify as ML or MH	GM	Silty gravel[E,F,G]
			Fines classify as CL or CH	GC	Clayey gravel[E,F,G]
More than 50 % retained on No. 200 sieve	Sands (50 % or more of coarse fraction passes No. 4 sieve)	Clean Sands (Less than 5 % fines[H])	$Cu \geq 6.0$ and $1.0 \leq Cc \leq 3.0$[D]	SW	Well-graded sand[I]
			$Cu < 6.0$ and/or $[Cc < 1.0$ or $Cc > 3.0]$[D]	SP	Poorly graded sand[I]
		Sands with Fines (More than 12 % fines[H])	Fines classify as ML or MH	SM	Silty sand[F,G,I]
			Fines classify as CL or CH	SC	Clayey sand[F,G,I]
FINE-GRAINED SOILS	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OL	Organic clay[K,L,M,N] / Organic silt[K,L,M,O]
50 % or more passes the No. 200 sieve	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OH	Organic clay[K,L,M,P] / Organic silt[K,L,M,Q]
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

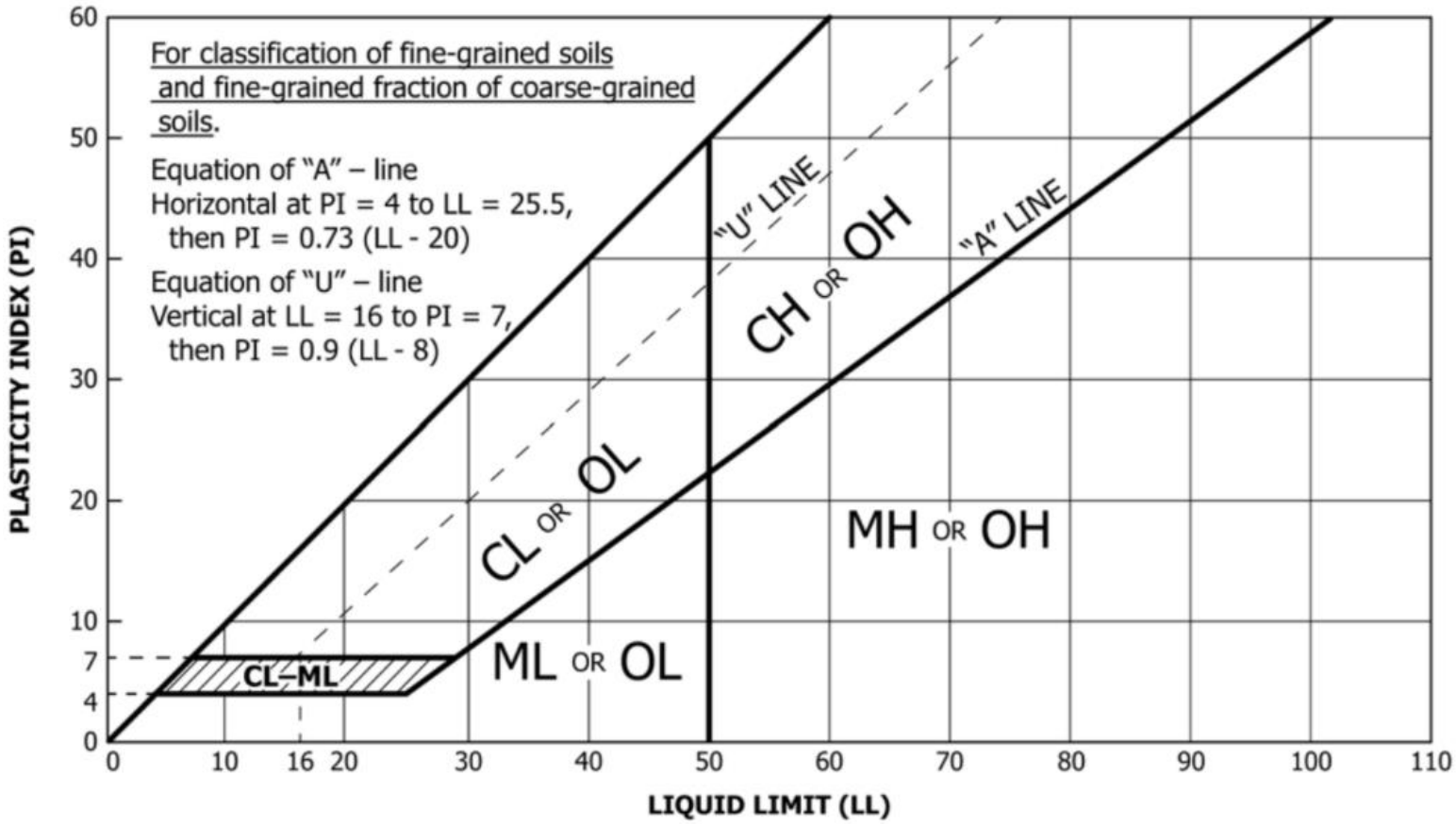


FIG. 4 Plasticity Chart

TABLE 4.4
COMPARISON OF AASHTO & uses SOILS CLASSIFICATION SYSTEMS

SOIL GROUP IN AASHTO SYSTEM	COMPARABLE SOIL GROUPS IN UNIFIED SYSTEM			SOIL GROUP IN uses SYSTEM	COMPARABLE SOIL GROUPS IN AASHTO SYSTEM		
	MOST LIKELY	POSSIBLE	POSSIBLE BUT NOT LIKELY		MOST LIKELY	POSSIBLE	POSSIBLE BUT NOT LIKELY
A-1-a	GW,GP	SW,SP	GM,SM	GW	A-1-a	-----	A-2-4 A-2-5 A-2-6 A-2-7
A-1-b	SW,SP GM,SM	GP	-----	GP	A-1-a	A-1-b	A-3, A-2-4 A-2-5 A-2-6 A-2-7
A-3	SP	-----	SW, GP	GM	A-1-b A-2-4 A-2-5 A-2-7	A-2-6	A-4, A-1-a A-5, A-7-5 A-6, A-7-6
A-2-4	GM,SM	GC,SC	GW,GP SW,SP	GC	A-2-6 A-2-7	A-2-4 A-6	A-4 A-7-5 A-7-6
A-2-5	GM,SM	-----	GW,GP SW,SP	SW	A-1-b	A-1-a	A-3, A-2-4 A-2-5 A-2-6 A-2-7
A-2-6	GC,SC	GM,SM	GW,GP SW,SP	SP	A-3 A-1-b	A-1-a	A-2-4 A-2-5 A-2-6 A-2-7
A-2-7	GM,GC SM,SC	--	GW,GP SW, SP	SM	A-1-b A-2-4 A-2-5 A-2-7	A-4 A-5 A-2-6	A-6 A-1-a A-7-5 A-7-6
A-4	ML, OL	CL,SM SC	GM,GC	SC	A-2-6 A-2-7	A-4 A-6 A-2-4 A-7-6	A-7-5
A-5	OH,MH ML,OL	----	SM,GM	ML	A-4 A-5	A-6 A-7-5	---
A-6	CL	ML, OL SC	GC,GM SM	CL	A-6 A-7-6	A-4	---
A-7-5	OH,MH	ML, OL CH	GM,SM GC,SC	OL	A-4 A-5	A-6 A-7-5 A-7-6	---
A-7-6	CH,CL	ML, OL SC	OH, MH GC,GM SM	MH	A-5 A-7-5	---	A-7-6
				CH	A-7-6	A-7-5	---
				OH	A-5 A-7-5	---	A-7-6
				PT	----	----	-----

COMPACTION CONTROL

Compaction is more than just operating a piece of equipment. There is a tendency to assume that, as long as compaction equipment is being used, the necessary degree of compaction is being achieved. This is quite often the case with embankment materials, especially materials that are not tested. Uniform compaction is just as important as adequate compaction. The operator should develop a roller pattern so that all of the material in a lift receives the same compactive effort.

The reaction of the compaction equipment to changes in the material can aid the roller operator. For example, when compacting cohesive soils with a tamping foot roller, the feet will initially sink into the material. As the material is compacted, the feet will sink in less (walk out) and continue until there are very small feet impressions. The roller operator should observe the effects and incorporate the observations in his/her rolling technique.

The equipment must be operated properly. Roller speed is particularly important with vibratory rollers. If the roller speed is too fast, the vibrations are too far apart to effectively compact. A granular material, such as a base, should be seated with one or two initial passes with the vibrator off to avoid displacing the material.

The entire lift should receive the same number of roller passes. Compaction problems occur when there is more than one type of material in the same lift. The materials may require different compactive efforts. Some materials may be over compacted while others may be under compacted.

For a base material, a gradation requirement is generally specified. Once the material is compacted to the point that the maximum density has been achieved, further compaction may start to break down the particles and the gradation will no longer be according to specifications. On the other hand, materials such as shales often break down to a soil material when exposed to air and water. Breaking these materials down during construction prevents excessive consolidation.

LIFT THICKNESS

The lift thickness depends on the type of material and particle size. Materials must be placed in lifts thin enough to ensure that adequate compaction can be achieved. Soils and aggregates are generally placed in thin lifts, from say 4 to 8 inches, while bedrock materials are placed in thicker lifts depending on the size of the particles and material type. Compaction testing is generally restricted to the finer materials (soils and aggregates). The lift thickness should be uniform throughout the lift. If the lift thickness is variable, some material may be under compacted and some over compacted.

Embankment lift thicknesses are often difficult to control. Lift thickness should be controlled by the dominant particle size rather than the largest pieces. For example, when a small quantity of large durable pieces are mixed with fine material (soil), the roller rides on top of the large pieces, especially when drum rollers are used, and the soil between the large pieces is not compacted. The large pieces should be removed or isolated during the excavation to prevent this problem.

MOISTURE

The moisture content is a critical component of the compaction process. Moisture provides a lubricant so that the particles can move and fill void spaces. The moisture content is critical especially for cohesive soils. The ideal moisture content for a particular soil is referred to as the optimum moisture. The optimum moisture is the moisture content at which a material will compact to the maximum density for the given compactive effort. Remember that the optimum moisture and maximum density depend on the applied force. As the compactive effort increases the maximum density increases and the optimum moisture decreases. The opposite occurs when the applied force decreases; the maximum density decreases, and the optimum moisture increases. This is why different maximum densities and optimum moistures are obtained between AASHTO T 99 and AASHTO T 180. These methods have proven to be adequate for highway construction and provide the necessary standards on which to base acceptance decisions.

The field moisture can be determined with the nuclear density-moisture gauge, stove drying or speedy moisture. The nuclear gauge is generally the primary method with the speedy moisture or stove drying as the secondary methods. A nuclear gauge measures the moisture content based on the presence of hydrogen. Soils with organic materials or hydrogen rich minerals (i.e., hydrogen that is not attributed to water), will affect the accuracy of the moisture reading. Stove drying or speedy moisture tests are more appropriate in this case.

Specifications for a project usually indicate an allowable range that the moisture content of the soils can vary from the optimum moisture. The ranges are generally within plus or minus four percentage points from the optimum moisture content. Base course material may or may not have a moisture tolerance.

DENSITY

AASHTO T 99 and AASHTO T 180 have been the standards for determining the maximum dry densities and optimum moistures for soils and aggregates.
Roller pass test sections are also used to determine the maximum dry densities in the field. This involves compacting a material with a specified piece(s) of compaction equipment until the material no longer appreciably increases in density. From the test section a roller pattern can also be developed which determines the number of roller passes with a specific roller(s) necessary to achieve the desired degree of compaction.

Compacting materials increases the internal strength and load bearing capacity. The particles are rearranged, and the volume is reduced. With sufficient compactive effort, the density increases to a point that no further compaction can occur unless either the particles are broken down or water is forced from the material. Further compaction, depending on the quality of the material, may cause the particles to start breaking down. For soils and aggregate bases, the maximum densities determined by either AASHTO T 99 or AASHTO T 180 are achieved before the zero air voids is reached. Materials, such as soft shales, will break down in the compaction process and the resulting soil like material is tested as soil.

A density curve, as determined by one of the methods in AASHTO T 99 or AASHTO T 180, provides the maximum dry density and optimum moisture for a particular soil at a designated compactive effort. Soil samples can be obtained for the various soils on a project and density curves developed. When compaction tests are performed, the maximum density and optimum moisture for the soil being tested can be used to evaluate the test. Representative soil samples from a large area can be tested (such as an entire state) and a family of curves can be developed. The appropriate curve from the family of curves can be selected by performing a one-point proctor with the soil being tested. The density and moisture content of the one-point proctor is used to select the correct curve and the subsequent maximum dry density and optimum moisture for the soil.

Specifications for a project state the degree of compaction required for the different materials. For density there is a specified percentage of theoretical maximum dry density to which materials must be compacted. The percentage varies; however, 95% is a common value.

The field density can be determined by several methods such as the nuclear density gauge, sand cone, rubber balloon method, etc. The nuclear density gauge is the most common method. Some soils contain materials, for example mica, which affect the accuracy of the nuclear gauge. When these soils are encountered, other methods to determine the density are required.

COMPACTION TESTING

Testing is a verification process to determine if the desired degree of compaction has been achieved. Random selection of test sites reduces the influence of human bias. Test results and field observations can be used to make engineering decisions on the quality of the materials. A sound testing program provides necessary information to assure the final product will perform as intended.

STABILITY

Some materials compact to a very dense, high strength condition, while others are difficult to compact to a stable condition. Materials containing large quantities of silt and fine sand, for example, are very unstable under loading. Even though the materials can be placed and compacted to the desired degree, they are susceptible to rutting and shoving when loaded. When these materials are used, special construction precautions are required to limit loading until the materials are bridged by lifts of higher strength materials. This is also the case with some cohesive soils, which are weak and easily displaced under loading (pumping or rutting).

The performance of a roadway depends on drainage. Internal drainage, as well as surface drainage, is of utmost importance. The strength of the materials must be maintained after construction in order for the roadway to perform as intended. Free draining granular materials will not be appreciably affected by moisture. In comparison, an increase in the moisture content of cohesive soils results in swelling and the material becomes unstable as it loses shear strength. Provisions in the design for drainage layers to divert water away from the materials are essential. Construction personnel must watch for seepage areas, springs, etc. that were not addressed in the design.

Construction personnel should observe the reaction of materials to construction equipment. Areas which yield (pump) under the weight of construction equipment, need to be corrected. The method(s) of corrective action depends on the situation. Some of the possible corrective measures include removing the material and replacing with a suitable material, aerating the material to reduce the moisture content, bridging the area using a high strength material such as rock, stabilizing the material with lime or cement, etc.

COMPACTION CHARACTERISTICS OF SOILS AND AGGREGATES

No one method of compaction is equally suitable for all types of soil. The following review of methods for compacting fills are divided into three groups: those suitable for cohesionless soils, those for sandy or silty soils with moderate cohesion, and those for clays. Many different compaction methods are used, each with its own benefits and limitations that must be understood to be employed effectively. Compaction problems are often the result of the use of improper compaction equipment or its improper application.

For greatest efficiency the applied compactive force must be high enough, and of sufficient duration, to rearrange the particles. However, this effort must not be so high as to cause shearing of the compacted mass. A cohesionless materials strength is affected by confinement. This is most easily accomplished by wide area of load application. In cohesive materials, the strength is affected by void ratio and moisture, and less dependent on confinement.

In cohesionless materials efficient compaction results are obtained with moderate force applied to a wide area while using vibration. In cohesive materials efficient compaction requires higher pressure for dry versus wet material, with a smaller loaded area preferable.

Along with the following discussion, Tables 4.5 and 4.6 provide basic guidance concerning various compaction methods, equipment, applicable materials, and conditions.

COMPACTION OF COHESIONLESS MATERIALS

For granular materials such as sand and gravel, the best results are achieved by use of vibratory compaction equipment (vibratory rollers). Ideally, equipment should vibrate at a frequency close to the resonant frequency of the material. When this is conducted properly, void reduction can be 20 to 40 times greater than that produced by an equivalent static load. Rock fills can also be compacted effectively using vibratory equipment.

The maximum size of particles is controlled by the thickness of compacted layers. Two to four passes of vibratory rollers, moving at a speed up to 1.5 mph, are usually sufficient to achieve the desired level of compaction. Moisture control may not be necessary for granular materials due to their high permeability. Granular materials can also be compacted by use of pneumatic-tired rollers pulled by heavy track- mounted equipment. Vibrations induced by the tracked equipment work in conjunction with the static pneumatic tired rollers. Six to eight passes of such equipment are typically required to attain a satisfactory degree of compaction. Water may be added to the material to facilitate the compaction process by temporarily "lubricating" the granular material (i.e., temporarily reducing inter-particle friction).

In confined areas the use of small self-propelled, hand-operated vibratory compactors is often necessary. The weight of these compactors varies from several hundred to several thousand pounds. The vibrating force is delivered to the material with a flat plate or roller. Four-to-eight-inch layers can be effectively compacted.

The use of static rollers to compact cohesionless granular materials is inefficient and generally ineffective. A high degree of saturation is necessary to achieve acceptable results.

COMPACTION OF SANDY OR SILTY MATERIALS WITH MODERATE COHESION

As cohesion (and plasticity) of a material increases, the compacting effect of vibrations decreases greatly. Even a slight bond between particles interferes with their tendency to move into a more stable position. The lower permeability of these materials results in the development of excess pore water pressures. Use of vibratory equipment often results in shear failure of the material rather than densification.
Compaction in layers by static rollers usually provides satisfactory results.

Two types of rollers are effective with materials of this type: pneumatic-tired (rubber - tired) rollers and sheepsfoot or padfoot rollers. Pneumatic-tired rollers are most effective for compacting slightly cohesive sandy materials, mixed-grained materials ranging from gravels to silts and clays, and non-plastic silty materials (clean silts). Sheepsfoot rollers are most effective for compaction of cohesive, plastic materials.

Pneumatic-tired rollers usually consist of a cart or bin loaded with ballast, supported on a single row of four or more wheels. Tires are inflated at pressures ranging from 50 to 125 psi. The wheels have independent suspensions so that the weight is transmitted roughly equal to all wheels, even over non-uniform ground surfaces. Embankment materials are compacted in lifts or layers of six to twelve inches (when loose), using high tire pressures, and heavy loads (30 to 50 tons). Four to eight passes generally achieve the required level of compaction.

The surface of sheepsfoot rollers are usually covered with slightly rounded pads or feet. The size, shape and arrangement of the pads can vary greatly, with a typical arrangement of approximately one pad for every 100 in.2 of roller surface area. The feet extend distances typically in the range of four to eight inches from the drum, with surface areas ranging from approximately 5 to 14 in.2 Depending on the size and arrangement of the feet, contact pressures typically vary from 300 to 600 psi. Material lifts are generally thin, not exceeding six inches when compacted.

Regardless of the type of compaction equipment and the degree of cohesion and plasticity, the efficiency and effectiveness of the compaction procedure depends largely on the moisture content of the material - especially for low to non-plastic uniform fine

grained materials. If the moisture content during compaction is not almost exactly equal to the optimum moisture content (for the specific level of compactive effort), these materials cannot be compacted to a stable condition.

If an embankment is constructed using uniform material under carefully controlled conditions (layer thickness, type of compaction equipment, and number of passes kept constant), the effectiveness of compaction depends only on the moisture content of the material at the time of compaction. If all conditions remain the same except a lighter roller is used for compaction, the value of the maximum dry density is lower, and the optimum moisture content is higher (see Figure 5.14). Similar changes in the moisture-density relation for a given material will occur with variations in layer or lift thickness, type and/or weight of compaction equipment, roller speed, and rate of energy application. Therefore, the values of maximum dry density and optimum moisture content for a given material, will be specific with a given compaction procedure.

The water content at which a material is compacted affects the resulting density, strength, stability, and permeability. An increase in initial water content from a value below optimum moisture to a value above optimum moisture, generally accompanies a large decrease in the material's permeability. The decrease generally is larger with increasing clay content.

COMPACTION OF CLAY

If the natural water content (natural moisture content) of a clay is not near the optimum moisture content, it may be difficult to change the moisture, especially if the water content is too high. When clay is excavated, it is generally removed in solid blocks or chunks. An individual block of clay cannot be compacted by any of the conventional compaction procedures previously discussed. Neither vibration nor short duration pressures results in significant change in water content. Use of a sheepsfoot roller can be effective in reducing open spaces between clay chunks. Results are best if the moisture content is slightly greater than the plastic limit of the material.

If the moisture content is too high, the clay tends to stick to the roller, or the roller starts rutting or sinking into the surface. If the moisture content is considerably less than optimum, the chunks are too stiff and do not yield, with the spaces between clay blocks not effectively closed.

Table 4.5 Compaction Equipment and Methods (Navdocks DM-7)

Equipment Type	Applicability	Requirement for Compaction of 95 to 100 Percent Standard Proctor Maximum Density			Possible Variations in Equipment
		Compacted Lift Thickness, /inches)	Passes or Coverages	Dimensions and Weight of Equipment	
Sheepsfoot roller	For fine-grained soils or dirty coarse-grained soils with more than 20 percent assign the No. 200 sieve. Not suitable for clean coarse-grained soils. Particularly appropriate for compaction of impervious zone for earth dam or linings where bonding of lifts is important	6	4 to 6 passes for fine-grained soil; 6 to 8 passes for coarse-grained soil	soil type — Foot contact area, in^2 — foot contact pressures, psi fine-grained soil PI> 30 — 5 lo 12 — 250 to 500 fine-grained soil PI <30 — 7 to 14 — 200 to 400 coarse-grained soil — 10 to 14 — 150 to 250 Efficient compaction of soils wet of optimum requires less contact pressures than the same soils at lower moisture contents	For earth dam. highway and airfield work, drum of 60-in dia., loaded to 1.5 to 3 tons per lineal foot of drum is generally utilized. For smaller projects 40-in dia. Drum, loaded to .75 to 1.75 tons per lineal foot of drum is used. Foot contact pressure should be regulated to avoid shearing the soil on the third or fourthpass.
Rubber lire rollers	For clean, coarse-grained soils with 4 to 8 percent passing the No. 200 sieve For fine-grained soils or well-graded, dirty coarse-grained soils with more than 8 percent passing the No. 200 sieve	10 6 to 8	3 to 5 coverages 4 to 6 coverages	Tire inflation pressures of 60 to 80 psi for clean granular material or base course and subgrade compaction. Wheel load 18 000 to 25 000 lb Tire inflation pressure in excess of 65 psi for fine-grained soils of high plasticity. For uniform clean sands or silty fine sands, use large size tires with pressures of 40 to 50 psi	Wide variety of rubber tire compaction equipment is available. For cohesive soils, light wheel loads, such as provided by wobble-wheel equipment, may be substituted for heavy-wheel load if lift thickness ls decreased. For cohesionless soils, large-size tires are desirable to avoid shear and rutting.
Smooth wheel rollers	Appropriate for subgrade or base course compaction of well-graded sand-gravel mixtures May be used for fine-grained soils other than in earth dams. Not suitable for clean well-graded sands or silty uniform sands	8 to 12 6 to 8	4 coverages 6 coverages	Tandem type roller for base course or subgrade compaction, 10-to-15-ton weight, 300 to 500 lb per lineal inch of width of rear roller 3-Wheel roller for compaction of fine-grained soil; weights from 5 to 6 tons for materials of low plasticity to 10 tons for materials of high plasticity	3-Wheel rollers obtainable in wide range of sizes. 2-Wheel tandem rollers are available in the range of 1- to 20-ton weight. 3-Axle tandem rollers are generally used in the range of 10-to-20-ton weight. Very heavy rollers are used for proof rolling of subgrade or base course.

Table 4.5 Compaction Equipment and Methods - continued (Navdocks DM-7)					
Equipment Type	Applicability	Requirement for Compaction of 95 to 100 Percent Standard Proctor Maximum Density			Possible Variations in Equipment
		Compacted Lift Thickness, (inches)	Passes or Coverages	Dimensions and Weight of Equipment	
Vibrating baseplate compactors	For coarse-grained soils with less than about 12 percent passing No. 200 sieve. Best suited for materials with 4 to 8 percent passing No. 200 placed thoroughly wet	8 lo 10	3 coverages	Single pads or plates should weigh no less than 200 lb. May be used in tandem where working space is available. For clean coarse-grained soil, vibration frequency should be no less than 1600 cycles per minute	Vibrating pads or plates are available, hand-propelled of self-propelled, single or in gangs, with width of coverage from 1 ½ to 15 ft. Various types of vibrating-drum equipment should be considered for compaction in large areas.
Crawler tractor	Best suited for coarse-grained soils with less than 4 to 8 percent passing No. 200 sieve, placed thoroughly wet	10 to 12	3 lo4 coverages	No smaller than DB tractor with blade, 34 500 lb weight, for high compaction	Tractor weights up to 60 000 lb.
Power tamper or rammer	For difficult access, trench backfill. Suitable for all inorganic soils	4 to 6 in for silt or clay, 6 in for coarse-grained soils	2 coverages	30-lb minimum weight. Considerable range is tolerable, depending on materials and conditions	Weights up to 250 lb: for diameter 4 lo 10 in

Table 4.6 Compaction Equipment for Different Conditions			
Soil	**First choice**	**Second choice**	**Comment**
Rock fill	Vibratory	Pneumatic	--
Plastic soils, CH,MH	Sheepsfoot or padfoot	Pneumatic	Thin lifts usually needed
Low-plasticitysoils, CL, ML	Sheepsfoot or padfoot	Pneumatic, vibratory	Moisture control often critical for silty soils
Plastic sands and gravels, GC, SC	Vibratory, pneumatic	Pad foot	--
Silty sands and gravels, SM.GM	Vibratory	Pneumatic, padfoot	Moisture control often critical
Clean sands, SW,SP	Vibratory	Impact, pneumatic	--
Clean gravels, GW,GP	Vibratory	Pneumatic, impact, arid	Grid useful for oversize particles

MP 700.00.24

CHAPTER 2

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

NUCLEAR DENSITY TEST BY THE ROLLER PASS METHOD

1. PURPOSE

1.1 The purpose of this procedure is to determine the density of construction materials by the roller pass method. The procedure consists of two parts, with Part I to determine the required maximum density and Part II to compare field densities to the required maximum density.

2. SCOPE

2.1 This test method or method of testing is applicable to aggregate base courses, select material for backfilling, crushed aggregate backfills, granular material, subgrade, and random material having 40% or more of +3/4-inch material as specified in MP 717.04.21.

3. REFERENCES

3.1 MP 712.21.26

3.2 MP 717.04.21

4. EQUIPMENT

4.1 One complete nuclear density gauge unit meeting the requirements specified in MP 717.04.21. This would include the manufacturer's printout of standard counts.

4.2 One measuring tape, approximately 50 feet.

4.3 Lime, chalk, lumber crayon, or other suitable material to mark test sites

4.4 Dry silica sand

4.5 Supply of data sheets

4.6 One vehicle meeting the safety and security requirements of the Nuclear Regulatory Commission for transporting nuclear density gauges.

5. PERSONNEL TRAINING

5.1 All personnel performing the testing must meet the minimum training requirements specified in MP 717.04.21.

5.2 All personnel must know and follow the requirements of the Nuclear Regulatory Commission.

6. ROUNDING OF DATA

6.1 Test values and calculations are to be rounded according to the following procedure:

6.1.1 If the figure following the last significant number to be retained is five or larger, increase the last significant number to be retained by one.

6.1.2 If the figure following the last significant number to be retained is less than five, the last significant number is left unchanged.

6.2 Test values and calculations shall be rounded to the following nearest significant digit:

6.2.1 Form T-313[1] (Test Section)

Lift Thickness Compacted	0.1 in.
Depth Below Grade	1 ft
Length of Test Section	1 ft
Width of Test Section	1 ft
Station Number	1 ft
Offset	1 ft
Dry Density (DA)	1 PCF
Average Density (DB)	1 PCF
Maximum Density (DC)	1 PCF

6.2.2 Form T-317[1] (Quality Control Tests)

Station Number	1 ft
Offset	1 ft
Depth Below Grade	1 ft
Lift Thickness Compacted	0.1 in.
Maximum Density (dc)	1 PCF
Dry Density (de)	1 PCF
Relative Density (df)	1%
Average df (x)	0.1%
Target (f)	1%
Quality Index (ql)	0.01
Within Tolerance (dg)	1%
Minimum Percent for 100% pay (dh)	1%

7. PREPARATION FOR TESTING

7.1 Standardization of the Nuclear Gauge

[1] https://transportation.wv.gov/highways/mcst/Pages/tbox.aspx

7.1.1 Warm up the gauge according to the manufacturer's recommendations.

7.1.2 Standardization of the gauge must be performed away from metal and other objects.

7.1.3 Clean the top of the standard block and the bottom of the gauge with a cloth.

7.1.4 Standardize according to manufacturer's recommendations.

7.1.5 Compare the standard counts to the manufacturer's standard counts using tolerances acceptable to the Division. For the Troxler 3400 series gauge, the standard counts must be within ± 2% for density and ± 4% for moisture from the manufacturer's standards.

7.1.6 If the gauge is not within the specified tolerances for either moisture or density, repeat section 7.1.4 -7.1.5. If the gauge will not standardize for either moisture or density after 4 attempts, a different gauge shall be used. The gauge which failed to standardize may be used again in the future if the procedure referenced in Section 5.2.10 of MP 717.04.21 is followed and the gauge is found to be stable.

7.1.7 Gauges shall be standardized before testing and at least every four hours during testing.

7.1.8 When a gauge is to be used for testing pipe or structure backfill in a trench, first check the standardization of the gauge according to sections 7.1 - 7.1.5. If the gauge is functioning properly, standardize the gauge in the trench. The standard counts in the trench shall be used for testing in the trench only and the tolerances would not be applied to the standard counts taken in the trench. When the gauge is moved to a non-trench condition for testing, new standard counts shall be required.

8. PART I PROCEDURE FOR DETERMINING THE MAXIMUM DENSITY

8.1 All data and calculations for Part I of this procedure will be recorded on form T-313 (copy attached). Record the Contract ID, project number, lab number etc. before starting the test.

8.2 The test is to be performed at the beginning of placement of an item. However, any problems with the material, placement, or compaction equipment shall be corrected prior to performing the test.

8.3 The test section will be 100 feet long by the width being placed in one operation, except in restricted areas.

8.3.1 In restricted areas, where the 100-foot length cannot be obtained, check the project's records to determine if a maximum density for the material has been determined on the project. If the material, lift thickness, and compaction equipment remain unchanged, the existing maximum density shall be used for Part II of this procedure, if available. A maximum density determined in a restricted area shall not be used in a non-restricted area. If a maximum density is not available for the material, obtain the largest test section possible. For pipe backfill, a lift on both sides of the pipe can be used.

8.4 Divide the test section into 5 equal subsections and number the subsections. Randomly locate a test site within each of the subsections according to MP 712.21.26.

8.5 Water shall be added to untreated aggregates, if necessary, in a quantity satisfactory to the Engineer. The aggregate must visually appear wet to properly compact.

8.6 Once the material had been placed in the test section, the material shall be rolled with compaction equipment meeting the following requirements:

8.6.1 All compaction equipment must be in good working condition.

8.6.2 The materials shall be compacted with rollers providing a minimum applied force of 10 tons.

8.6.3 In restricted areas, inaccessible to conventional rollers, the compaction equipment must be satisfactory to the Engineer to provide the desired compactive effort. The Division may request verification that the above compaction equipment meets the specified requirements.

8.7 The test section shall be rolled with 12 roller passes. A roller pass is one complete coverage over the material. In restricted areas, where conventional rollers cannot be used, the material shall be compacted until it appears well densified or to the satisfaction of the Engineer.

8.8 If the material shears or breaks down during rolling, the number of roller passes may need to be reduced. The designated number of roller passes must not be changed without the approval of the Engineer.

8.9 Once the material has been rolled, testing will be performed on test sites 1 and 2.

8.10 Smooth and level the test site. Fill any voids with fines scraped from the surface, but no more than 1/8 inch.

8.10.1 Place the guide plate on the test site. Next place the drive rod in the guide plate and while standing on the plate, drive the rod at least two inches deeper than the location where the end of the gauge source rod will be when testing. The gauge source rod can be extended in two-inch (50 mm) increments. The source rod must be as deep as possible within the lift but must not extend beyond the lift. For example, a five-inch lift would be tested with the source rod in the four-inch position and the hole would be six inches deep. Carefully remove the drive rod to prevent material from falling into the hole.

8.10.2 Place the gauge over the test site and insert the source rod to the desired depth. Pull the gauge tight against the side of the hole toward the scaler. Make sure the gauge is sitting flush on the material. Mark the outline of the gauge with lime or other suitable material so the test sites can be relocated.

8.10.3 Take a one-minute density reading.

8.10.3.1 Record the dry density (DA) in Section A of form T-313. Perform the same testing on site 2.

8.11 Average the two dry densities (DA) obtained in section 8.10.3.1.

8.12 Roll the material in the test section two additional roller passes. In restricted areas, the compaction equipment would pass over the material the above indicated number of passes.

8.13 After the material has been rolled the additional number of passes, perform tests again on sites 1 and 2 according to sections 8.10 through 8.10.3 and record the values in section B.

8.14 Average the two densities according to section 8.11.

8.15 Compare the value in section 8.14 to the value obtained in section 8.11. If the increase in density is 1 PCF or less, the material is considered to have achieved its maximum density. If the increase in density is greater than 1 PCF, roll the material two additional passes according to section 8.12 and repeat the testing on sites 1 and 2. Continue the rolling and testing sequence until the increase in density between two consecutive rolling sequences is 1 PCF or less. The Division may direct the contractor to cease rolling even though the increase is more than 1 PCF if the material is breaking down.

8.16 Once the increase in density is 1 PCF or less, move the last two density readings to the maximum density determination section on form T-313. Take density measurements on sites 3, 4, and 5.

8.17 The average of the five density readings is the maximum density (DC) for this material.

8.17.1 The maximum density will be used to control the material for Part II of this procedure.

8.17.2 Division personnel may request that Part I be repeated if the test was not performed properly or the maximum density obtained does not appear to be realistic.

9. PART II QUALITY CONTROL TESTING

9.1 All test data and calculations for Part II of this procedure will be recorded on form T-317 (copy attached). Record the Contract ID, project number, item number, etc. on the form before starting the testing.

9.2 The lot number would have a prefix letter based on the following designations for the use of the material being tested:

Embankment:	F
Subgrade:	S
Base:	B
Pipe/Structure Backfill:	p

9.3 Transfer the maximum density (DC) and the lab number from form T-313 to form T-317. Record the lab number in the section for reference lab number.

9.4 Randomly locate the test site according to MP 712.21.26.

9.5 Determine the dry density (DE) with the nuclear gauge according to the procedure described in sections 8.10 through 8.10.3. The test sites do not have to be marked on the roadway.

9.6 Calculate the percent relative density (DF) by using the equation on form T-317.

9.7 Perform the remaining four tests in the lot. Five tests are always required to evaluate a lot.

9.8 Calculate the average relative density (*X)* for the five tests in the lot.

9.9 Obtain the target percentage of dry density (T) from the project's governing specifications.

9.10 Determine the range (R) of the relative densities (DF) by subtracting the smallest value from the largest.

9.11 Calculate the quality index (QL) by using the equation on form T-317.

9.12 Use the Table for Estimating the Percent of a Lot Within Tolerance (copy attached) and determine the percent within tolerance (DG) that corresponds to the QL value calculated in section 9.11 above.

9.13 Obtain the minimum percent for 100% pay (DH) from the project's governing specifications.

9.14 For a lot to meet specifications, the percent within tolerance (DG) must be equal to or greater than the minimum percent for 100% pay (DH).

10. GENERAL

10.1 Independent tests for similarity checks can be recorded on form T-317. Use only the applicable sections of the form.

10.2 If the material changes or the material is supplied from a new source, repeat Part I to obtain new control data.

10.3 If the percent relative densities are consistently above 105 percent or below 95 percent, and there is no apparent cause for the high or low values, repeat Part I to obtain new control data.

10.4 Test data for several lots can be recorded on form T-317.

05/31/2023
Ronald L. Stanevich, PE
Director
Materials Control, Soils & Testing Division

MP 700.00.24 Steward – Aggregate and Soils Section
RLS:R

ATTACHMENTS

TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE

Quality Index (QL) Positive Values	Percent Within Tolerance
.66	99
.65	98
.62	97
.60	96
.58	95
.57	94
.55	93
.53	92
.51	91
.50	90
.48	89
.46	88
.45	87
.44	86
.42	85
.41	84
.40	83
.38	82
.37	81
.36	80
.34	79
.33	78
.32	77
.30	76
.29	75
.28	74
.27	73
.25	72
.24	71
.23	70
.22	69
.21	68
.19	67
.18	66
.17	65
.16	64
.15	63
.14	62
.13	61
.11	60
.10	59
.09	58
.08	57
.07	56
.06	55
.05	54
.04	53
.02	52
.01	51
.00	50

Quality Index (QL) Negative Values	Percent Within Tolerance
.00	50
.01	49
.02	48
.04	47
.05	46
.06	45
.07	44
.08	43
.09	42
.10	41
.11	40
.13	39
.14	38
.15	37
.16	36
.17	35
.18	34
.19	33
.21	32
.22	31
.23	30
.24	29
.25	28
.27	27
.28	26
.29	25
.30	24
.32	23
.33	22
.34	21
.36	20
.37	19
.38	18
.40	17
.41	16
.42	15
.44	14
.45	13
.46	12
.48	11
.50	10
.51	9
.53	8
.55	7
.57	6
.58	5
.60	4
.62	3
.63	2
.66	1

West Virginia Division of Highways
Materials Control Soil and Testing Division

FORM T-313
MP 700.00.24
REV. 09-22

Lab Number _____
Auth. Number _____
Project Number _____
District Number _____
Item Number _____
Date _____ Contract ID _____

Source of Material:			Length of Test Section:		
Roller Type:			Width of Test Section:		
Roller Weight	Static:	Working:	Gauge Number		
Lift Thickness Compacted:			Manufacturer's Standards		
Depth Below Grade:			Density:	Moisture:	
Depth of Gauge Source:			Standard Counts		
Observed	Yes	No	Density:	Moisture:	

Test Site Number	1	2	3	4	5
Station Number					
Offset					

A	Number of Passes		
	Test Site	DA	Dry Density
	1		
	2		
DB	Average		

B	Number of Passes		
	Test Site	DA	Dry Density
	1		
	2		
DB	Average		

C	Number of Passes		
	Test Site	DA	Dry Density
	1		
	2		
DB	Average		

D	Number of Passes		
	Test Site	DA	Dry Density
	1		
	2		
DB	Average		

DB = ∑ DA / 2

DC = ∑ DA / 5

Maximum Density Determination		
Test Site	DA	Dry Density
1		
2		
3		
4		
5		
DC	Max. Density	

Inspector's Name: _____
Inspector's Signature: _____

Project's Evaluation

Checked By: _____
Date: _____

[2] https://transportation.wv.gov/highways/mcst/Pages/tbox.aspx

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS & TESTING DIVISION

LAB NUMBER _____
AUTH NUMBER _____
PROJECT NUMBER _____
DISTRICT _____
ITEM NUMBER _____
CONTRACT ID _____

FORM T-317
MP 700.00.24
REV. 09-22

GAUGE #	DATE						
MANUFACTURER'S DENSITY STANDARD	LOT NUMBER						
	BEGINNING STATION						
	ENDING STATION						
MANUFACTURER'S MOISTURE STANDARD	OFFSET						
	DEPTH BELOW GRADE						
	DEPTH OF GAUGE SOURCE						
	LIFT THICKNESS COMPACTED						
DC FROM TEST SECTION	DENSITY STANDARD						
$DF = \frac{DE\ (100)}{DC}$	MOISTURE STANDARD						
$\bar{X} = \frac{\sum DF}{5}$	**DC** MAXIMUM DENSITY						
$QL = \frac{\bar{X} - T}{R}$	REFRENCE LAB NUMBER						
TEST NUMBER 1	**DE** DRY DENSITY						
	DF % RELATIVE DENSITY						
TEST NUMBER 2	**DE** DRY DENSITY						
	DF % RELATIVE DENSITY						
TEST NUMBER 3	**DE** DRY DENSITY						
	DF % RELATIVE DENSITY						
TEST NUMBER 4	**DE** DRY DENSITY						
	DF % RELATIVE DENSITY						
TEST NUMBER 5	**DE** DRY DENSITY						
	DF % RELATIVE DENSITY						
LOT EVALUATION	$\bar{X}$ AVERAGE **DF**						
	T TARGET	95%	95%	95%	95%	95%	
	QL QUALITY INDEX						
	DG % WITHIN TOLERANCE						
	DH MIN. FOR 100% PAY	80%	80%	80%	80%	80%	
	DI PASS / FAIL						

INSPECTOR'S NAME: _____
INSPECTOR'S SIGNATURE: _____
PROJECT'S EVALUATION
CHECKED BY: _____ DATE: _____

[3] https://transportation.wv.gov/highways/mcst/Pages/tbox.aspx

MP 712.21.26

CHAPTER 3

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
CONTRACT ADMINISTRATION DIVISION

MATERIALS PROCEDURE

Procedure For Determining The Random Location Of Compaction Tests

---

1.0 Purpose

1.1 This procedure provides methods for determining the random locations for compaction tests.

2.0 Scope

2.1 This procedure is applicable for locating all compaction tests.

3.0 Equipment

3.1 Measuring tape, approximately 50 feet (15 m)

4.0 Procedure

4.1 Compaction test site locations are to be randomly located along the roadway centerline (length) and offset (width) randomly from this reference line. Some test site locations, such as pipe backfill, require random selection of lifts for the tests and a random determination of the side of the pipe backfill to test.

4.2 Selection of random numbers

4.2.1 Determine the number of test sites which will be required for the lot or test section.

4.2.2 The table of random numbers (Table I attached) or a calculator, which will generate random numbers, can be used.

4.2.3 The table of random numbers contains 5 sections with 2 columns of numbers in each section.

4.2.3.1 The first column of numbers in each section is for determining the test site along the centerline. The second column of numbers is for determining the distance from the centerline (offset). Either column of numbers can be used for selecting lifts to be tested.

4.2.3.2 To use the table, select a random point on the table by tossing a pencil upon the page or blindly pointing out a location with the finger. The selection of random numbers will consist of a pair of random numbers. Once the point is located, select the number in the first column for the length and the corresponding number in the right column for the width. When more than one pair of random numbers is needed, continue selecting the pairs of numbers down the page. If the bottom of the page is reached, go to the top of the next section to the right or to the top of the first section on the left side of the page if the bottom of the right most section of the page is reached. When selecting lifts to be tested, only single random numbers are needed and can be obtained from any of the columns of numbers.

4.2.3.3 To use a calculator, which will generate random numbers, select all numbers needed for a test site before selecting numbers for additional test sites.

4.3 Location of test sites

4.3.1 There are many variations in the required number of tests and the physical dimensions of the area to be tested.

4.3.2 Random location of tests on a single lift that is rectangular in shape (Example 1 attached)

4.3.2.1 Generally the Materials Procedure used for testing a material and/or Specifications requires a lot, portion of a lot, or a test section to determine the maximum density of a material to be divided into equal sublots or subsections when more than one test is required.

4.3.2.2 Divide the length of the area along the centerline by the number of tests to determine the length of each sublot or subsection.

4.3.2.3 From the beginning station number, add the length of the subsection or sublot to the station number to determine the station number for the beginning of the next sublot or subsection. Next add the length of the subsection or sublot to this station number to determine the station number at the beginning of the next subsection or sublot. Continue this procedure until the beginning station numbers for all subsections or sublots have been calculated.

4.3.2.4 Select the random numbers according to 4.2 through 4.2.3.3.

4.3.2.5 Multiply the length of the subsections or sublots by the random numbers selected for the length.

4.3.2.6 Add the values to the corresponding station numbers for the beginning of each subsection or sublot. The station numbers locate the test sites along centerline.

4.3.2.7 Next multiply the width of the test section or lot by the random numbers selected for the offset.

4.3.2.8 Determine the offset distance of the lot or test section from the centerline when the centerline is not within the area to be tested. This will usually be a constant value. Always calculate the offset by working from the side nearest the centerline. Add each of the values calculated in 4.4.2.7 to the constant value. The values establish the offset distance of each test site from the centerline. Designate rather the offset is left or right of centerline.

When the centerline is contained within the area to be tested, the offset can be calculated from the left or right side of the test area and test location designated in relation to centerline.

4.3.3 Random location of test sites on a single lift that is irregular in shape (Example 2 attached).

4.3.3.1 Determine the dimensions of the area to be tested.

4.3.3.2 Determine the minimum dimensions of a rectangle that will contain the area to be tested and has two sides parallel to centerline.

4.3.3.3 Divide the rectangle into the desired number of subsections or sublots and randomly locate the test sites locations as in sections 4.3.2 - 4.3.2.8 above. If a test site location falls outside the area to be tested, obtain a new set of random numbers for the test site and recalculate the test site location. Continue this procedure until the test site falls within the area to be tested.

4.3.4 Random selection of lifts to be tested (Example 3 attached).

4.3.4.1 When testing certain materials, especially backfill material, where an area to be backfilled will constitute a lot of material to be tested, a random selection of lifts to be tested is required.

4.3.4.2 Determine the projected number of lifts to be contained in the lot. Divide the number of lifts by the number of tests in the lot. If the value is not an even number, assign an additional lift to the first sublot and continue to assign a lift to each consecutive sublot until all remaining lifts have been assigned to a sublot.

4.3.4.3 By starting with the bottom lift, number the lifts in the lot.

4.3.4.4 Select a single random number for each test site.

4.3.4.5 Multiply each random number by the number of lifts in each sublot and round the values to whole numbers. Each value designates which lift in each sublot that will be tested.

4.3.5 Once the lifts to be tested have been selected, the random location of the test site on the lift can be determined.

4.3.6 Random selection of the side of backfill for pipe culverts.

4.3.6.1 When a lot of pipe backfill is being tested, tests should be performed on both sides of the pipe. The side to be tested can be randomly selected by using the random numbers selected for the location of the tests along the pipe. If the random number is less than 0.500, the test is on the left side and greater than 0.500 on the right side of the pipe.

Robert K. Tinney

Robert K. Tinney, Director
Contract Administration Division

TABLE 1

RANDOM NUMBERS

.858	.082	.886	.125	.263	.176	.551	.711	.355	.698
.576	.417	.242	.316	.960	.819	.444	.323	.331	.179
.687	.288	.835	.636	.596	.174	.866	.685	.066	.170
.068	.391	.739	.002	.159	.423	.629	.631	.979	.399
.140	.324	.215	.358	.663	.193	.215	.667	.627	.595
.574	.601	.623	.855	.339	.486	.065	.627	.458	.137
.966	.529	.757	.308	.025	.836	.200	.055	.510	.656
.608	.910	.944	.281	.539	.371	.217	.882	.324	.284
.215	.355	.645	.460	.719	.057	.237	.146	.135	.903
.761	.883	.771	.388	.928	.654	.815	.570	.539	.600
.869	.222	.115	.447	.658	.989	.921	.924	.560	.447
.562	.036	.302	.673	.911	.512	.972	.576	.838	.014
.481	.791	.454	.731	.770	.500	.980	.183	.385	.012
.599	.966	.356	.183	.797	.503	.180	.657	.077	.165
.464	.747	.299	.530	.675	.646	.385	.109	.780	.699
.675	.654	.221	.777	.172	.738	.324	.669	.079	.587
.279	.707	.372	.486	.340	.680	.928	.397	.337	.564
.338	.917	.942	.985	.838	.805	.278	.898	.906	.939
.316	.935	.403	.629	.130	.575	.195	.887	.142	.488
.011	.283	.762	.988	.102	.068	.902	.850	.569	.977
.683	.441	.572	.486	.732	.721	.275	.023	.088	.402
.493	.155	.530	.125	.841	.171	.794	.850	.797	.367
.059	.502	.963	.055	.128	.655	.043	.293	.792	.739
.996	.729	.370	.139	.306	.858	.183	.464	.457	.863
.240	.972	.495	.696	.350	.642	.188	.135	.470	.765

EXAMPLE I
ENGLISH

Length of test section = 100 ft
Width of section = 10 ft
Number of tests required = 5
5 equal subsections 100/5 = 20 ft
Test section starts at station 5+46

Station number at the beginning of each subsection

1. 5+46
2. 5+46 + 20 = 5+66
3. 5+66 + 20 = 5+86
4. 5+86 + 20 = 6+06
5. 6+06 + 20 = 6 +26

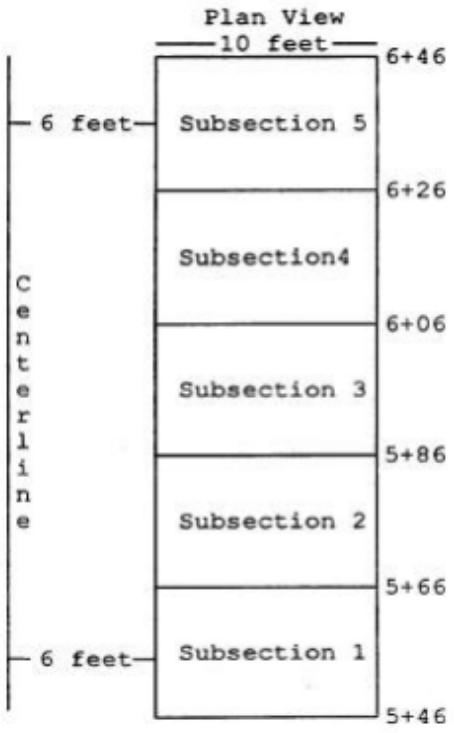
	Random Numbers	
	Length	Width
1.	.869	.222
2.	.562	.036
3.	.481	.791
4.	.599	.966
5.	.464	.747

Multiply the length of each subsection by the random numbers for the length.

1. 20 x .869 = 17
2. 20 x .562 = 11
3. 20 x .481 = 10
4. 20 x .599 = 12
5. 20 x .464 = 9

Add the values to the beginning station numbers of each subsection to determine the station number for each test.

1. 5+46 + 17 = 5+63
2. 5+66 + 11 = 5+77
3. 5+86 + 10 = 5+96
4. 6+06 + 12 = 6+18
5. 6+26 + 9 = 6 +35



Multiply the width of each subsection by the random numbers for the width.

1. 10 x .222 = 2
2. 10 x .036 = 0
3. 10 x .791 = 8
4. 10 x .966 = 10
5. 10 x .747 = 7

Add the values to the constant distance the test section is from the centerline and label the values as right of centerline .

1. 6 + 2 = 8 ft right of centerline
2. 6 + 0 = 0 ft right of centerline
3. 6 + 8 = 14 ft right of centerline
4. 6 + 10= 16 ft right of centerline
5. 6 + 7 = 13 ft right of centerline

EXAMPLE I
METRIC

Length of test section = 30.00 m
Width of section = 3.00 m
Number of tests required = 5
5 equal subsections 30/5 = 6 m
Test section starts at station 15+340

Station number at the beginning of each subsection

1. 15+340
2. 15+340 + 6 = 15+346
3. 15+346 + 6 = 15+352
4. 15+352 + 6 = 15+358
5. 15+358 + 6 = 15+364

Random Numbers

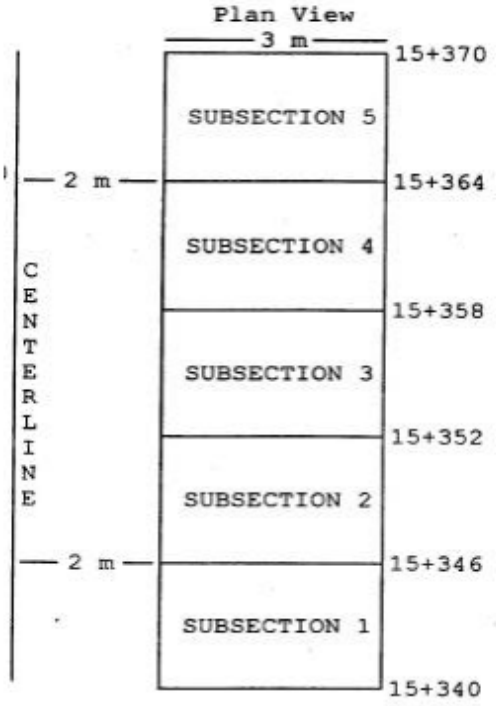
	Length	Width
1.	.869	.222
2.	.562	.036
3.	.481	.791
4.	.599	.966
5.	.464	.747

Multiply the length of each subsection by the random numbers for the length.

1. 6.00 x .869 = 5.2
2. 6.00 x .562 = 3.4
3. 6.00 x .481 = 2.9
4. 6.00 x .599 = 3.6
5. 6.00 x .464 = 2.8

Add the values to the beginning station numbers of each subsection to determine the station number for each test site.

1. 15+340 + 5.2 = 15+345.2
2. 15+346 + 3.4 = 15+349.4
3. 15+352 + 2.9 = 15+354.9
4. 15+358 + 3.6 = 15+361.6
5. 15+364 + 2.8 = 15+366.8



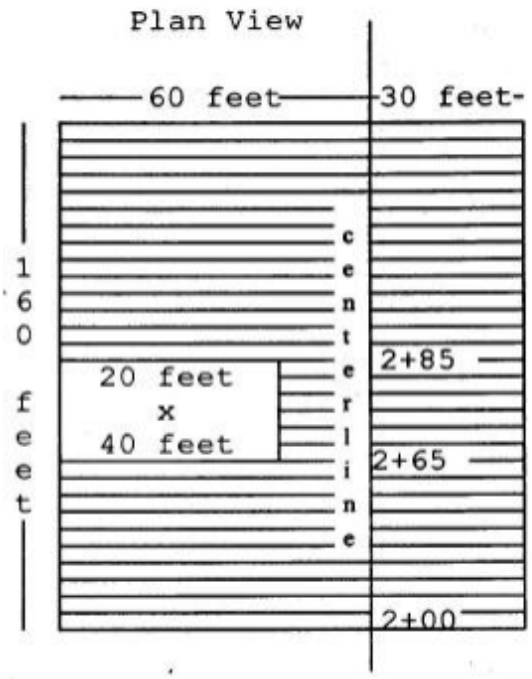
Multiply the width of the test section by the random numbers for the width.

1. 3.00 x .222 = 0.7
2. 3.00 x .036 = 0.1
3. 3.00 x .791 = 2.4
4. 3.00 x .966 = 2.9
5. 3.00 x .747 = 2.2

Add the values to the constant distance the test section is from the centerline and label the values as right of centerline.

1. 2.00 + 0.7 = 2.7 m rt of centerline
2. 2.00 + 0.1 = 2.1 m rt of centerline
3. 2.00 + 2.4 = 4.4 m rt of centerline
4. 2.00 + 2.9 + 4.9 m rt of centerline
5. 2.00 + 2.2 = 4.4 m rt of centerline

EXAMPLE 2
METRIC



The shaded area designates the lift to be tested. For this example, 2 sublots are required with 1 test in each sublot.

Since the area to be tested is not rectangular in shape, place the smallest rectangle around the area that will include all the shaded area.

Divide the rectangle into 2 equal areas (160 feet long by 90 feet wide).

Since the centerline is located within the area to be tested, the offset can be calculated and measured from either side. For this example, work from the right side.

Determine the station number for the beginning of each sublot.

Sublot No. 1 2.+00
Sublot No. 2 2+00 + 80 = 2+80

Random Numbers	
Length	Width
.902	.850
.275	.023
.794	.850

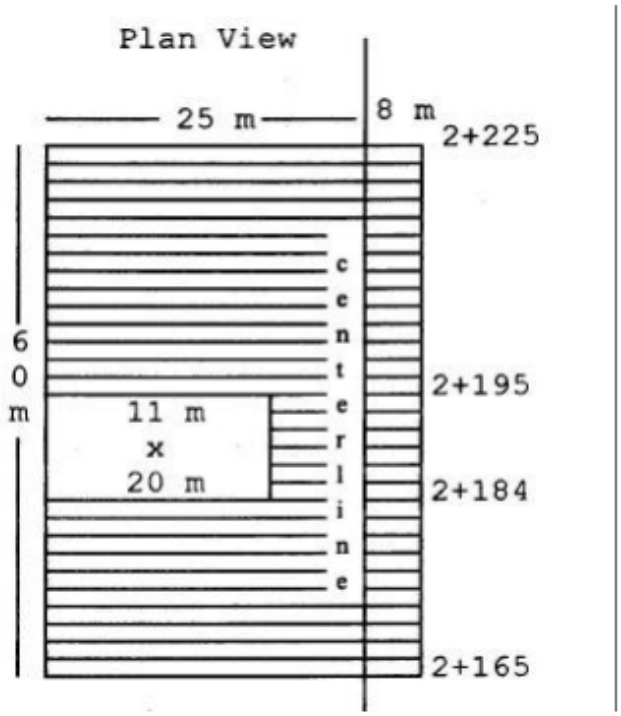
Since there is the possibility that the location of a test site may fall outside the area to be tested, an additional set of random numbers was selected.

Multiply the random number by the length of the sublot (80 x .902 = 72 feet). Add the value of the beginning station number (2+00 + 72 = 2+72). Multiply the width of the sublot by the random number (90 x .850 = 76 feet). By working from the right side, it is 30 feet to the centerline, therefore the test site is 76 - 30 = 46 feet to the left of centerline. The test site falls outside the teSt area.

By using the next set of random numbers, calculate the test site location.
80 x .275 = 22 feet
2+00 + 22 = 2+22
90 x .023 = 2 feet
30 - 2 feet = 28 feet right of centerline
The test site for sublot 1 now falls within the test area.

Calculate the test location for sublot 2.
80 x .794 = 64 feet
2+80 + 64 = 3+44
90 x .850 = 76 feet
76 - 30 = 46 feet left of centerline

EXAMPLE 2
METRIC



The shaded area designates the lift to be tested. For this example, 2 sublots are required with 1 test in each sublot.

Since the area to be tested is not rectangular in shape, place the smallest rectangle around the area that will include all the shaded area.

Divide the rectangle into 2 equal areas (30 m long by 33 m wide).

Since the centerline is located within the area to be tested, the offset can be calculated and measured from either side. For this example, work from the right side.

Determine the station number for the beginning of each sublot.

Sublot No. 1 2.+165
Sublot No. 2 2+165 + 30 = 2+195

Random Numbers	
Length	Width
.902	.850
.275	.023
.794	.850

Since there is the possibility that the location of a test site may fall outside the area to be tested, an additional set of random numbers was selected.

Multiply the random number by the length of the sublot (30 x .902 = 27.1 m). Add the value of the beginning station number (2+165 + 27.1 = 2+192.1). Multiply the width of the sublot by the random number (33 x .850 = 28.1 m). By working from the right side, it is 8 m to the centerline, therefore the test site is 28.1 - 8 = 20.1 m to the left of centerline. The test site falls outside the teSt area.

By using the next set of random numbers, calculate the test site location.
30 x .275 = 8.2 m
2+165 + 8.2 = 2+173.2
33 x .323 = 0.8 m
8 - 0.8 m = 7.2 m right of centerline
The test site for sublot 1 now falls within the test area.

Calculate the test location for sublot 2
30 x .794 = 23.8 m
2+195 + 23.8 = 2+218.8
33 x .850 = 28.0 m
28 - 8 = 20 m left of centerline

EXAMPLE 3

21 lifts of material are required to backfill the pipe.

All of the backfill material is included in 1 lot. There are 5 tests required with 1 test in each sublot.

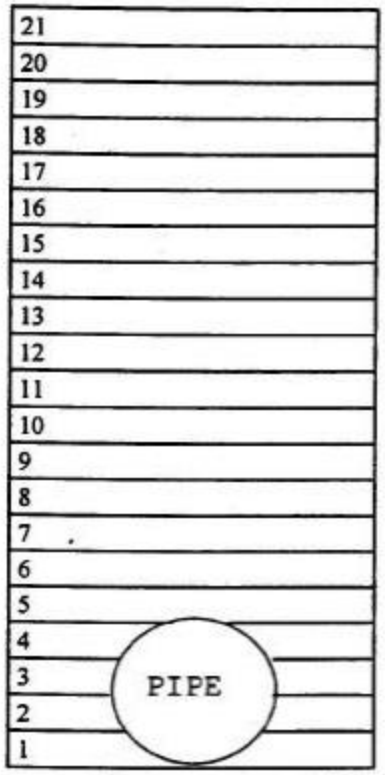
Divide the number of lifts by the number of sublots to determine the number of lifts in each sublot (21/5 = lifts with 1 lift left over). This includes the lift in sublot number 1.

Sublot Number 1	Lifts 1 - 5
Sublot Number 2	Lifts 6 - 9
Sublot Number 3	Lifts 10 - 13
Sublot Number 4	Lifts 14 - 17
Sublot Number 5	Lifts 18 - 21

Random numbers
1. .599
2. .464
3. .675
4. .279
5. .338

Multiply the number of lifts in the sublot by the random numbers. The values determine which lift in each sublot to test.

CROSS SECTION OF PIPE BACKFILL



1. 5 x .599 = 3	Test lift 3 in sublot number 1, Lift number 3
2. 4 x .464 = 2	Test lift 2 in sublot number 2, Lift number 7
3. 4 x .675 = 3	Test lift 3 in sublot number 3, Lift number 12
4. 4 x .279 = 1	Test lift 1 in sublot number 4, Lift number 14
5. 4 x .338 = 1	Test lift 1 in sublot number 5, Lift number 18

MP 700.00.50

CHAPTER 4

WEST VIRGINIA DEPARTMENT OF HIGHWAYS
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOIL AND TESTING DIVISION

MATERIALS PROCEDURE

METHOD FOR ACCEPTANCE OF COMPACTION TESTING

1.0 PURPOSE

1.1 To provide a procedure for the acceptance of compaction testing.

2.0 SCOPE

2.1 This procedure is applicable to all materials that require evaluation of compaction tests.

3.0 TESTING

3.1 The minimum frequency for acceptance testing shall be 10% of the contractor's individual tests. Five tests shall be performed in a lot for acceptance testing.

3.2 Acceptance testing shall be distributed throughout the placement of material.

3.3 The material should be categorized according to the base, subgrade, pipe backfill, embankment, etc.

4.0 EVALUATION

4.1 Calculations shall be rounded to the following significant digits according to AASHTO Method R-11.

Average (X)	0.1%
Standard Deviation	0.01
Range	1%

4.2 Determine the number of lots tested by the contractor for a particular material since the last monitoring including the lot just tested. Record the percent relative densities on the attached form.

4.3 Calculate the standard deviation (S) for the percent relative densities.

4.4 Calculate the range (R) for plus and minus 1.65 standard deviations (S) from the average (X) for the contractor's tests ($R = X \pm 1.65\ S$).

4.5 Compare the acceptance tests to the calculated range.

4.5.1 If all the acceptance tests are within the range, the testing is similar. When the testing is similar , the degree of compaction for the lots of material represented by the acceptance evaluation can be accepted.

4.5.2 If any of the 5 acceptance tests are outside the range, calculate 3 standard deviations for the contractor's tests ($R = X \pm 3\ S$).

4.5.2.1 If all acceptance tests are within the range, the testing is considered similar, however, the quality control practices by the contractor should be reviewed for possible problems.

4.5.2.2 Any test outside the standard 3 deviation range indicates that there are probably problems with the quality control system and no additional material should be placed until the problem is resolved. The investigation would include checking such areas as equipment, test procedures, location of tests, variability of materials, compaction techniques, etc. The results of the investigation shall be documented in the project files.

Gary L. Robson, Director
Materials Control, Soils
and Testing Division

PROJECT NUMBER: _____
ITEM NUMBER (S): _____
TYPE OF MATERIAL: _____
DATE: _____

QUALITY CONTROL TESTS

LOT NUMBER				
	1 2 3 4 5			
	AVERAGE (X)		STANDARD DEVIATION	
ACCEPTANCE TESTS				
TEST NUMBER	1 2 3 4 5	X + 1.65 (S) = X - 1.65 (S) = WITHIN LIMITS	 YES NO	= UPPER LIMIT = LOWER LIMIT (SIMILAR) (DISSIMILAR)
		X + + 3 (S) = X - - 3 (S) = WITHIN LIMITS	 YES NO	= UPPER LIMIT = LOWER LIMIT (SIMILAR) (DISSIMILAR)

EVALUATED BY: _____
CHECKED BY: _____

MP 717.04.21

CHAPTER 5

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

GUIDE FOR QUALITY CONTROL OF COMPACTION

1. PURPOSE

1.1 This procedure sets forth minimum guidelines for the Contractor's Quality Control (QC) Plan for embankment, subgrade, pipe and random fill used as structure backfill material and aggregate base courses. It is intended that these requirements be used as a procedural guide in detailing the inspection, sampling, and testing necessary to maintain compliance with the specification requirements.

1.2 To establish procedural guidelines for approval and documentation of a Master QC Plan.

2. SCOPE

2.1 This procedure is applicable to all items requiring compaction control except asphalt pavements. This outlines the QC procedures for Compaction items and includes procedures for approving and using Master and/or Project Specific QC Plans. This procedure also aids in documentation and retention of QC Plans in ProjectWise.

3. DEFINITIONS

3.1 Moisture/Density Gauge (Gauge) – Any gauge that has been approved for use on WVDOH projects. A list of these gauges and their applicable uses is available of the WVDOH MCST Webpage.

3.1.1 Moisture/Density Gauge is to replace all instances of the term “Nuclear Gauge” in all WVDOH documents.

4. REFERENCED DOCUMENTS

4.1 MP 100.00.03 - Method Of Evaluation of Non-Standard or Non-Conforming Materials in Construction Via DMIR

4.2 MP 109.00.21 - Basis for Charges for Non-Submittal of Sampling & Testing Documentation by the Established Deadline

4.3 MP 207.07.20 - Nuclear Field Density - Moisture Test for Random Material Having Less Than 40% of +3/4 Inch Material

4.4 MP 700.00.24 - Nuclear Density Test by The Roller Pass Methods

4.5 MP 700.00.50 - Procedure for Monitoring the Contractor's Compaction Testing of Bituminous Concrete, Base Course, Embankment, Sub-Grade and Pipe and Structural Backfill

4.6 MP 712.21.26 - Procedure for Determining Random Location of Compaction Tests

5. GENERAL REQUIREMENTS

5.1 The Contractor shall provide and maintain a QC system that will provide assurance that all materials submitted to the Division for acceptance will conform to the contract requirements whether natural, manufactured or processed by the Contractor, or procured from suppliers. The QC Plan should clearly describe the methods by which the QC Program will be conducted. For example, the items to be controlled, tests to be performed, testing frequencies, sampling locations and techniques all should be included etc. Each item should be listed separately.

5.1.1 A detailed plan of action regarding disposition of non-specification material shall be included. Such a plan shall provide for immediate notification of the Division in the event of a non-conforming situation or instance.

5.2 Inspection and testing records shall be maintained, kept current, and made available for review by the Engineer throughout the life of the contract. All other documentation, such as date of inspections, tests performed, temperature measurements, and any accuracy, calibration, or re-calibration checks performed on production or testing equipment shall be recorded and kept.

5.3 The Contractor shall maintain standard calibrated equipment and qualified personnel in accordance with the contract and Specification requirements for the applicable material.

6. QUALITY CONTROL PLAN

6.1 The Contractor shall prepare a QC Plan detailing the type and frequency of inspection, sampling, and testing necessary to measure and control the compaction properties of materials and construction governed by the Specifications. As a minimum, the sampling and testing plan should detail sampling location, sampling techniques, and test frequency. QC sampling and testing performed by the Contractor may be utilized by the Division for acceptance.

6.1.1 A QC Plan shall be developed by the Contractor and submitted to the Engineer prior to the start of construction on every project. Acceptance of the QC Plan by the Engineer will be contingent upon its concurrence with these guidelines as listed in section 6.2 through 6.4.5.2.

6.1.2 As work progresses, an addendum(s) may be required to a QC Plan to keep the QC program current. Personnel may be required to show proof of certification for testing.

6.2 QC PLAN MINIMUM REQUIREMENTS

6.2.1 The QC Plan should be on Company Letterhead, be addressed to the District which it pertains, and include the items to be controlled. An example/template is provided in Attachment 1.

6.2.2 Provide the name of the Person who is responsible for the Company's QC program and will be liaison with the Division's personnel.

6.2.3 List all inspectors' names performing compaction tests on the project and their date becoming a Certified Soils & Aggregate Compaction Inspector as per WVDOH Specification Section 106 Control of Materials.

6.2.4 Compaction field tests will be performed according to MP 207.07.20, MP 700.00.24, and Standard Specification 716.32.3

6.2.5 Soft shale tests shall be conducted according to Section 716 of the Standard Specifications.

6.2.6 Specify in the plan the methods by which each item will be tested. Table A and Table B summarize the different materials, minimum frequencies, and the appropriate test procedure or method for controlling each material.

Table A- COMPACTION CONTROL OF AGGREGATE BASE COURSES

TEST PROCEDURE	LOT SIZE	NUMBER OF TEST	MATERIAL TYPE			
			PORTLAND CEMENT TREATED AGGREGATE BASE COURSE	CRUSHED AGGREGATE BASES AND SUBBASE COURSES	HOT-MIX HOT-LAID BITUMINOUS TREATED BASE COURSE	SOIL CEMENT BASE COURSE
MP 700.00.24	2000 FEET	1 PER SUBLOT 5 PER LOT	X	X	X	
MP 207.07.20	2000 FEET	1 PER SUBLOT 5 PER LOT				X

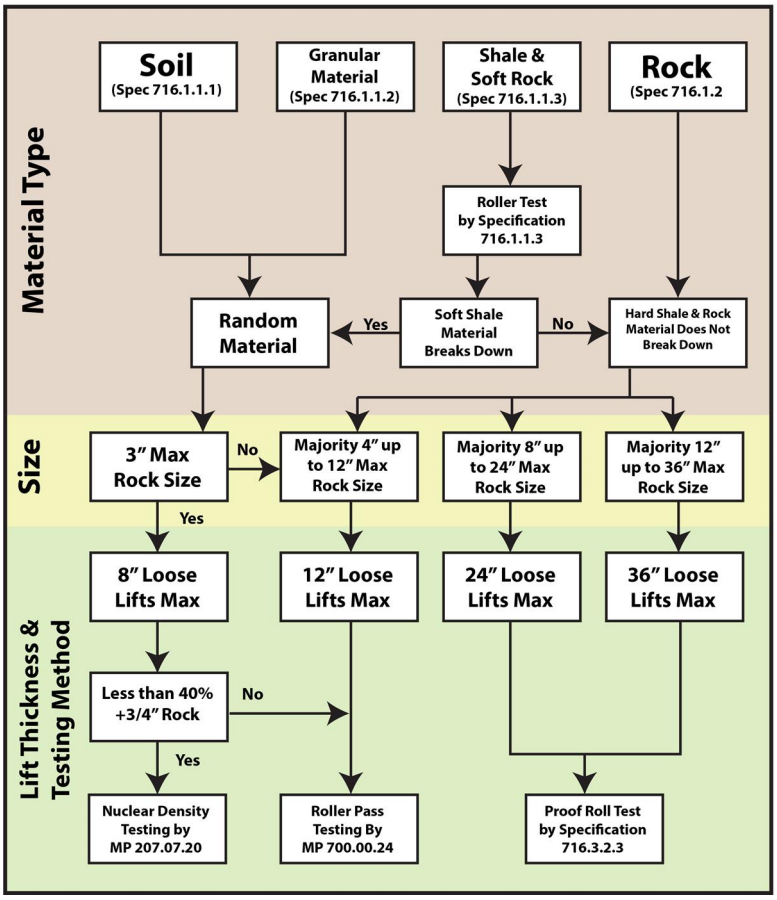
Table B - COMPACTION CONTROL OF EMBANKMENT BACKFILL AND SUBGRADE

TEST	LOT SIZE	NUMBER OF TESTS	MATERIAL WITH LESS THAN 40% RETAINED ON ¾" (19.0 mm) SIEVE	MATERIAL WITH 40% OR MORE RETAINED ON ¾" (19.0 mm) SIEVE AND CAN BE PLACED IN A 12" (300 mm) LOOSE LIFT OR LESS		MATERIAL THAT CAN BE PLACED IN A LOOSE LIFT GREATER THAN 12" (300 mm)		GRANULAR SUBGRADE	SELECT MATERIAL FOR BACKFILLING AND CLASS I AGGREGATE
				UNIFORM	NON-UNIFORM	ROCK	HARD SHALE		
MP 207.07.20	SEE STD. SPECS.	1 PER SUBLOT 5 PER LOT	X						
MP 700.00.24	SEE STD. SPECS.	1 PER SUBLOT, 5 PER LOT		X [1]	X [1]. [2]			X	X
PROOF Rolling		1 REPORT PER LIFT				X	X		

1. If a hole for a direct transmission density reading cannot be readily made due to the coarse material, proof roll the lift.
2. If density readings vary above 105 percent or below 95 percent and the material appear to be non-uniform, proof roll the lift.

6.2.7 A flow chart for embankment material, Table C, shall serve as a guide for identifying material types, maximum rock size, lift thickness and compaction test method. This table shall be included in the QC Plan for making field decisions to ensure that each type of material is properly placed and compacted.

Table C – Guide for Quality Control of Embankment Material



6.2.8 The plan shall include a statement that all necessary testing equipment will be provided to perform the procedures outlined in MP 700.00.24, MP 207.07.20, and Specification 716.3.2. The plan shall list the make and model of equipment for proof rolling and its weight per Specification 716.3.2. The plan shall list the make, model and operating weight of the roller(s) to be used for the soft shale tests and per Specification 716.1.1.3.

6.2.9 List the type of gauge to be used. The calibration frequency must be acceptable to the Division. Gauges must be calibrated according to the manufacturer's requirements. This information shall be given to the Division upon their request.

6.2.10 If applicable, outline the procedure for performing a stability check on gauges that are not within the tolerance range for standard counts during the interval between calibrations. Standard counts derived during the stability check for stable gauges may be used in lieu of the manufacturer's standards. Gauges found to be unstable cannot be used until repaired and calibrated.

6.2.11 Include in the plan the lot and sublot sizes to be used for testing each type of installation. During construction, some flexibility in lot sizes may be made if the situation warrants in order to maintain a workable system. For example, two or more areas containing small quantities of embankment material might be combined into one lot at the Contractor's option and subject to the Division's approval.

6.2.12 Specify the maximum time period for completion of a lot of embankment material. As a guide, if the desired lot size cannot be obtained within seven calendar days, then the material placed up to that time would constitute the lot and the specified number of tests for a lot would still be performed.

6.2.13 Specify in the plan when quality control tests for base and subgrade will be performed. QC tests are to be performed after the material has been shaped and final rolling has been completed.

6.2.14 The Contractor is responsible for the accuracy of their individual testing and calculations.

6.2.15 List the forms and method of distribution for tests and measurements.

6.2.16 Compaction test results are reported on forms specified in MP 207.07.20 and MP 700.00.24. The forms are supplied by the Division and available on the MCS&T Webpage[1]. The completed form shall be submitted to the Division's project supervisor, District Materials Lab, and a copy shall be retained for the Contractor's records.

6.2.17 Indicate the length of time after tests and measurements are completed that documentation will be provided.

6.2.17.1 Test results and measurements shall be made available to project personnel for review on a daily basis. Formal submission of measurements should be made within 24 hours after the measurements are taken and test results within 24 hours after testing of a lot is completed.

6.2.17.2 Tests performed in a lot before final rolling is completed should be submitted to the Project Supervisor and retained in the project files. This includes test documents for failing lots and moisture checks.

6.2.18 List the compaction equipment giving the quantity, make, model, and weight or applied force at which each roller will be operated. If ballast will be added to a roller, indicate the type and quantity of ballast and the method for verifying the gross weight. Attach the manufacturer's specifications for compaction capabilities for each roller to the plan or state the procedure for verifying the compaction capabilities of each roller in cases where the manufacturer's specifications are not available. This equipment shall meet the requirements of Section 207.7.5 of the Specifications.

6.2.19 Indicate in the plan that a minimum of a 10-ton (9.07 Mg) roller will be used for testing in accordance with MP 700.00.24 for soil and granular material only.

6.2.20 Rollers used to breakdown soft shale shall be in accordance with Section 716.1.1.3 of the Specifications and shall have a minimum of 1.5 tons per linear foot of roller drum width.

[1] https://transportation.wv.gov/highways/mcst/Pages/tbox.aspx

6.2.21 Specify the method by which proof rolling will be conducted on embankment materials. The materials to be proof rolled are summarized in Table B in Section 6.2.6.

6.2.22 List the number of passes to be made and corrective measures if soft areas are detected. Documentation should include the type of material, number of passes, and corrective action if soft areas are detected.

6.2.23 For equipment used for proof rolling explain how the gross weight will be determined for any ballast added to the operating weight. For alternate proof rollers, attach to the QC Plan the calculations used to determine that the roller meets specifications. Also, attach the manufacturer's specifications for all proof rollers to the Plan. The following calculation is used to determine if an alternate proof roller meets specifications:

ENGLISH	Metric
$c = \frac{\sqrt{(ab\pi)}}{2}$	$c = \frac{\sqrt{(ab\pi)}}{50.8}$

Where:

a = weight (force) on a single tire = pounds (kg x .009807 = kN)
b = operating tire pressure = psi (kPa)
c = weight (force) per inch (mm) width of tire = pounds per inch (Nm)
The weight (force) per inch (mm) width of tire must be equal to or greater than 1315 pounds (9.067 kN/mm).

6.2.24 Outline the procedure for notifying the Division when the test section in MP 700.00.24 will be performed. The Division shall be notified a minimum of 24 hours in advance unless other arrangements acceptable to the Division can be made.

6.2.25 Laboratory testing for random material is not required unless the material has unusual characteristics or differs from the soil and rock data used to develop the design. Testing to develop density curves, specific gravities, organic content, etc. may be required.

6.2.26 A list of test procedures is contained in Section 716 of the WVDOH Standard Specifications as a guideline for required testing should the need arise for random material.

6.2.27 Design a plan of action for the disposition of non-specification material, such as material with excessive moisture, excessive organic content, etc. These materials shall be stockpiled away from the embankment or fill placement areas. The Project Supervisor should be immediately notified in the event a nonconformance situation is detected.

6.2.28 List the method(s) and frequencies per Table D by which lift thickness measurements will be taken. If surveying of compacted lifts is not utilized, then the maximum loose lifts per Table C shall be measured.

TABLE D - LIFT THICKNESS MEASUREMENTS

MATERIAL TYPE	NUMBER OF MEASUREMENTS
EMBANKMENT	MINIMUM OF 3 PER LIFT
SUBGRADE	MINIMUM OF ONE PER 1200 FEET PER WORKING WIDTH
PIPE BACKFILL	MINIMUM OF ONE PER SIDE PER LIFT
STRUCTURE BACKFILL	MINIMUM OF ONE PER LIFT

6.3 TYPES OF QC PLAN

6.3.1 QC Plans which are intended for use on more than one project shall be defined as Master QC Plans. Section 6.4 outlines the procedures for Master QC Plan submittal and approval.

6.3.2 QC Plans which are intended for use on a single project shall be defined as Project Specific QC Plans. Project Specific QC Plans shall contain a cover letter which includes the following: project name/description, CID#, Federal and/or State Project Number.

6.3.3 A contractor may submit a Master QC Plan for field operations instead of a Project Specific QC Plan.

6.3.4 Once any QC Plan is approved for a project, the key date shall be entered in AASHTOWare software by the appropriate District Materials personnel. The first date entered shall be the date the Project QC Plan letter is received. The second date shall be when the District approves the QC Plan for use on the project.

6.4 MASTER QUALITY CONTROL PLAN

6.4.1 The intent of Master QC Plans is to facilitate the approval process in a more uniform manner. A Master QC Plan can be submitted to the Division/District by the Contractor when their work in a given District is routinely repetitive for the year. The Master Quality Control Plan is applicable for only the calendar year for which it has been approved.

6.4.2 The Contractor shall submit the Master Compaction QC Plan yearly to each District in which they have work in. If the Contractor does not have work in a given District for the year then no Master QC Plan shall be submitted to that District.

6.4.3 The District will review the submitted Master QC Plan and assign a laboratory reference number upon approval for future referencing. The District will acknowledge approval of Master QC Plan to the Contractor by letter (see Attachment #2 for an example), which will include the laboratory reference number and a copy of the approved Master QC Plan attached. This will then be scanned and placed in ProjectWise under the appropriate District's Org for that Contractor.

6.4.4 Once a project has been awarded, if a contractor elects to use the approved Master Compaction QC Plan on that project, the Contractor shall submit a letter requesting to use the Master QC Plan for that project. This letter must be on the Contractor's letterhead, be addressed to the District Engineer/Manager or their designee, and contain the following information: project number, CID#, project name/ description, type of Quality Control Plan and the laboratory reference number for the Master QC Plan (See Attachment #3 for an example).

6.4.5 The District shall review the referenced Master QC Plan to ensure that it covers all items in the project. If the referenced Master QC Plan is found to be insufficient for some items on the project, the District shall request the Contractor to submit additional information for QC of those items as an addendum on a project specific basis. When the District is satisfied with the QC Plan for this project, a letter shall be sent to the Contractor acknowledging approval (see Attachment #4 for an example), with the following attached: the Contractor's project QC Plan request letter and the Master QCP approval letter. This shall then be placed in the project's incoming-mail mailbox in ProjectWise.

6.4.5.1 A Master QC Plan that has been approved for project use shall be acceptable for the duration of that project, even if that project continues into subsequent calendar years, unless otherwise directed by the District.

6.4.5.2 For the use of Division Personnel, the District approval letter for this project must state the ProjectWise link to the referenced Master QC Plan for that Contractor. (i.e., WVDOT ORGS > District Organization #> Materials > Year>Master QC Plans…)

7. CERTIFICATION & ACCEPTANCE SAMPLING AND TESTING

7.1 The Contractor shall certify that compaction testing and sampling is in conformance with the approved QC plan, referenced MP's and referenced Standard Specifications in a letter format on the company's letterhead. The certification shall summarize what materials were encountered and the compaction method/lift thickness utilized. The letter shall state whether any deviations from the requirements of the QC plan, MP's, and Standard Specifications exist, and why.

7.2 Acceptance sampling and testing is the responsibility of the Division. QC tests by the Contractor may be used for acceptance.

7.3 The Division shall sample and test for applicable items completely independent of the contractor at a frequency equal to but not limited to approximately ten (10) percent of the frequency for testing given in the approved Quality Control Plan. Witnessing the contractor's sampling and testing activities may also be a part of the acceptance procedure, but only to the extent that such tests are considered "in addition to" the ten (10) percent independent tests.

7.4 MP 700.00.50, MP 207.07.20, and Specification Section 716.3.2.3 outlines the procedures to be followed for acceptance of compaction testing.

8. ABSENT TESTING OF MATERIAL

8.1 If the Contractor fails to perform testing of the material in accordance with the Contractor's Division Approved Quality Control Plan, payment for the portion of the item represented by the absent test shall be withheld, pending the Engineer's decision whether or not to allow the material to remain in place. Testing includes both performing the test and submitting the results as per MP 109.00.21.

8.1.1 If the Engineer allows the material to remain in place, the Division shall not pay for the material represented by the absent test. However, the Division shall pay for the cost of the placement of the material, including labor and equipment. The invoice or material supplier cost (if applicable), determined at the time of shipment, shall be used to calculate the cost of material when evaluating the total cost of labor and equipment.

8.1.1.1 If there is no material cost, the deduction shall be assessed on the tonnage of material represented by the missing test via a District Materials Inspection Report (DMIR).

Michael Mance

Digitally signed by Michael Mance
Date: 2024.08.23 14:35:26 -04'00'

Michael A. Mance, P.E.
Interim Director
Materials Control, Soils & Testing Division

MP 717.04.21 Steward – Pavement Analysis & Evaluation Section
MM:A
ATTACHMENTS

ATTACHMENT 1 - EXAMPLE GUIDE FOR COMPACTION QUALITY CONTROL PLAN

The Acme Company
20 First St.
Somewhere, WV XXXXXXX

Mr/./Ms/Mrs. _____
WV Division of Highways
District ___ Engineer/Manager
_____, WV _____

RE: (YEAR) Master Compaction QC Plan
DISTRICT: _____

Dear Mr./Ms/Mrs. _____

We are submitting our Compaction Quality Control Plan for field control, developed in accordance with sections 716 and 717 of the (year) WVDOH Standards and Specifications, (year) WVDOH Supplemental specifications, MP 700.0024, MP 207.07.20, MP 712.21.26 and MP 700.00.50.

The Quality Control Program is under the direction of _____ . They can be contacted by telephone number _____, email _____ and/or in person.

1.) All testing will be performed by qualified personnel as per WVDOH Specification Section 106 Control of Materials. Proof of personnel certification shall be provided to WVDOH inspectors upon request.

2.) Specify the methods by which each item will be tested .(IE.. 207,307…etc). Table A and Table B (attached) summarizes the different materials, minimum frequencies, and the appropriate test procedure or method for controlling each material. A flow chart for embankment material, Table C (attached), is intended to serve as a guide for making field decisions to insure that each type of material is properly placed.

3.) Testing Equipment used will be as required in MP 700.00.24 and MP 207.07.20.

4.) Type of gauge to be used (IE…. Troxler 3430, etc). State that calibration information is available upon request by the Division/District.

5.) Outline the procedure for performing a stability check on nuclear gauges which are not within the tolerance range for standard counts during the interval between calibrations. Gauges found to be unstable cannot be used until repaired and calibrated.

6.) Include in the plan the lot and sublot sizes to be used for testing each type of installation.

7.) Specify the maximum time period for completion of a lot of embankment material.

8.) Specify in the plan when quality control tests for base and subgrade will be performed.

9.) List the forms and method of distribution for tests and measurements. (The forms are specified in MP 207.02.20 and MP 700.00.24.) State that test results will be made available to WVDOH personnel on a daily basis.

10.) List the compaction equipment giving the quantity, make, model, and weight or applied force at which each roller will be operated. If ballast will be added to a roller, indicate the type and quantity of ballast and the method for verifying the gross weight. Attach the manufacturer's specifications for compaction capabilities for each roller to the plan or state the procedure for verifying the compaction capabilities of each roller in cases where the manufacturer's specifications are not available.

11.) Indicate in the plan that a minimum of a 10 ton (9.07 Mg) roller will be used for testing as per 700.00.24.

12.) Indicate in the plan that when shale materials are encountered, the shale hardness test will be performed to determine if material is a soft shale as per 716.1.1.3 of the WVDOH Standards and Specifications.

13.) Specify the method by which proof rolling will be conducted on embankment materials. The materials to be proof rolled are summarized in Table B (attached).

14.) Laboratory testing for random material is not required unless the material has unusual characteristics or differs from the soil and rock data used to develop the design. Testing to develop density curves, specific gravities, organic content, etc. may be required. The Yearly Quality Control Plan should state that these additional tests must be performed by qualified Aggregate testing personnel as per as per WVDOH Specification Section 106 Control of Materials.

15.) Design a plan of action for the disposition of non-specification material.

16.) List the method(s) and frequencies by which the lift thickness measurements will be taken.

Very Truly Yours,

_____

Title

ATTACHMENT 2

**** WVDOH LETTERHEAD ****

THE ACME COMPANY INC.
20 First St.
Somewhere, WV XXXXX

RE: Compaction Master QCP
Description: 20XX Year

Dear Mr./Ms/Mrs. _____,

Your Master Quality Control Plan**(M# - ######)** for Compaction has been reviewed and found to be acceptable for the following items:

- 207001-001 Unclassified Excavation		- 207002-001 Subgrade
- 211-001	- 307001 Items	- 604 items
- 212 Items	- 605 items	-etc….

As work progresses throughout the season an addendum(s) may be required to this QCP to keep the QC program current. **Please use M# - ###### when corresponding about this QC plan.** Please make sure that all appropriate personnel have a copy of this plan in their possession.

Very Truly Yours,

_____
Title

ATTACHMENT 3

The ACME COMPANY
20 First St.
Somewhere, WV XXXXX

********** **EXAMPLE** **********

Mr./Ms/Mrs _____
WV Division of Highways
District ___ Engineer/Manager
_____, WV _____

RE: Compaction Quality Control plan
for Field ---- Project

Fed. Project No _____
State Project No. _____
Contract ID No. _____
Description _____

Dear Mr./Ms/Mrs. _____,

We would like to use our approved Yearly Master Quality Control Plan, reference number _____ for the project referenced above. All Compaction items on the referenced project are covered by the Master Quality Control Plan.

The QC Plan is under the direction of _____, _____(title), and will be the company's contact representative to the Department of Highways District Materials and Construction Departments. He/She can be contacted in person at the project, by telephone _____ or at email account _____.

Very Truly Yours,

_____
Title

ATTACHMENT 4

**** WVDOH LETTERHEAD ****

THE ACME COMPANY INC.
20 First St.
Somewhere, WV XXXXX

RE: Compaction QC Plan
Project CID#: ########
Fed/State Project #: NHPP- ## - ####.##
Description: Falling Slide
County : XXXXXXX

Dear Mr./Ms/Mrs. _____,

Your request to use Master Quality Control Plan **(M# - ######)** for compaction on the project referenced above, has been reviewed and found to be acceptable for the following items on the referenced project:

- 207001-001 Unclassified Excavation - 207002-001 Subgrade
- 307001 Items - 604 items - 212 Items -etc….

As work progresses throughout this project an addendum(s) may be required to this QCP to keep the QC program current. **Please use M###### when corresponding about this QC plan.** Please make sure that all appropriate personnel have a copy of this plan in their possession.

For Division/District
The Master Quality Control Plan can be reviewed in ProjectWise folder shown below:

WVDOTORG> D0# > year > MASTERQCPLANS > Contractors >Contractor Name >
Name of Quality Control Plan

Very Truly Yours,

_____
Title

MP 207.07.20

CHAPTER 6

WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

NUCLEAR FIELD DENSITY - MOISTURE TEST FOR RANDOM MATERIAL HAVING LESS THAN 40% OF + 3/4 INCH MATERIAL

1. PURPOSE

1.1 This procedure is to determine the density and moisture content of random materials.

2. SCOPE

2.1 This method of testing is applicable to random materials used for embankments, subgrades, backfill, and soil cement base courses.

3. REFFERENCED DOCUMENTS

3.1 *AASHTO Standards:*

3.1.1 AASHTO T99, Method C

3.2 *Materials Procedures:*

3.2.1 MP 712.21.26

3.2.2 MP 717.04.21U.S.

4. EQUIPMENT

4.1 One complete nuclear density-moisture gauge unit meeting the requirements specified in MP 717.04.21. A copy of the manufacturer's print-out of standard counts is to be included.

4.2 One 1/30 ft^3 proctor mold assembly with a 5.5 LB rammer meeting the requirements of AASHTO T99.

4.3 One steel foundation plate having minimum dimensions of 15 in. x 15 in. x 5/8 in. or a 200 LB block of concrete.

4.4 One extruder for removing specimens from proctor mold.

4.5 One balance having a capacity of at least 10 kg and sensitive to 1.0 g.

4.6 One stove for drying moisture samples.

4.7 One 32 oz. ballpeen hammer or equivalent.

4.8 Two pans with a capacity to hold 10 LB of material.

4.9 One pan suitable for drying moisture samples.

4.10 One wire brush

4.11 One 3/4 in. U.S. Standard Sieve

4.12 One scoop

4.13 One ruler or tape measure

4.14 One measuring tape (should be a minimum of 50 ft)

4.15 One paint brush approximately 2 in wide

4.16 One 18 in. chisel or equivalent

4.17 One draw knife

4.18 T-316 data sheets and attached tables

4.19 One appropriate vehicle for transporting nuclear gauge and test equipment

5. PERSONNEL TRAINING

5.1 All personnel performing the testing must have the minimum training requirements specified in MP 717.04.21.

5.2 All personnel must know and follow the requirements of the Nuclear Regulatory Commission.

6. ROUNDING OF DATA

6.1 Test values and calculations are to be rounded according to the following procedure:

6.1.1 If the figure following the last significant number to be retained is five or larger, increase the last significant number to be retained by one.

6.1.2 If the figure following the last significant number to be retained is less than five, the significant number is left unchanged.

6.1.3 Test values and calculations shall be rounded to the following nearest significant digit.

Station Number:	1 ft.
Offset:	1 ft.
Lift Thickness:	1/2 in.
Depth Below Grade:	1 ft.
Dry Density (DA):	1 LB/ft^3
Moisture (MA):	1 LB/ft^3
Dry Density - 3/4 in. material (DB):	1 LB/ft^3
Moisture (MB):	1%
Excavated Material + Pan (CA):	1 g
Pan (CB):	1 g
Excavated Material (CC):	1 g
+3/4 in. Material + Pan (CD):	1 g
Pan (CE):	1 g
+3/4 in. Material (CF):	1 g
+3/4 in. Material (CG):	1%
Weight of Soil + Mold (PA):	1 g
Mold (PC):	1 g
Weight of Soil (PD):	1 g
Wet Density (PE):	1 LB/ft^3
Dry Density (PF):	1 LB/ft^3
Wet Weight + Pan (SA):	1 g
Pan (SB):	1 g
Wet Weight (SC):	1 g
Dry Weight + Pan (SD):	1 g
Dry Weight (SE):	1 g
Moisture (SF):	1 g
Moisture (SG):	1%
Optimum Moisture (OA):	1%
Maximum Density (DC):	1 LB/ft^3
Relative Density (DE):	1%
Average DE (X):	0.1%
Target (T):	1%
Quality Index (L):	0.01
Within Tolerance (DF):	1%
Minimum Percent for 100% Pay (DG):	1%

7. PREPARATION FOR TESTING

7.1 Weigh the pans and proctor mold and record the weights on the sides of the equipment. The weights shall be checked at least on a monthly basis.

7.2 All test data is to be recorded on the attached form T-316.

7.3 Standardization of the nuclear gauge

7.3.1 Warm up the gauge according to the manufacturer's specifications.

7.3.2 Standardization of the gauge must be performed away from metal and other objects.

7.3.3 Clean the top of the standard block and the bottom of the gauge with a cloth.

7.3.4 Place the gauge on the standard block with the gauge turned the correct way. For the Troxler 3400 series gauges, the scaler end of the gauge must be tight against the standard block flange.

7.3.5 Make the necessary adjustments on the gauge and perform a standardization according to the manufacturer's specifications.

7.3.6 Compare the standard counts to the manufacturer's standard counts. The standard count must be within ±2% for density and ±4% for moisture from the manufacturer's standards.

7.3.7 If the gauge is not within the specified tolerances for either moisture or density, repeat Section 7.3.5 - 7.3.6. If the gauge will not standardize for either moisture or density after 4 attempts, a different gauge shall be used. The gauge which failed to standardize may be used again in the future if the procedure referenced in Section 5.2.10 of MP 717.04.21 is followed and the gauge is found to be stable.

7.3.8 When a gauge is used for testing pipe or structure backfill in a trench, first check the standardization of the gauge according to Sections 7.3.1 - 7.3.6. If the gauge is functioning properly, then standardize the gauge in the trench. The standard counts in the trench are used for testing in the trench only and the tolerances shall not be applied to the standard counts taken in the trench. When the gauge is moved to a non-trench condition for testing, new standard counts shall be required.

7.3.9 Gauges shall be standardized before testing and at least every four hours during testing.

7.4 Record the contract ID, project number, item number, etc.

7.5 The lot number has the following prefix letter designations based on the use of the material:

Embankment -	F
Subgrade -	S
Base -	B
Pipe and Structure Backfill -	P

7.6 Randomly locate the test site according to MP 712.21.26.

8. PROCEDURE

8.1 Density and moisture determination

8.1.1 Smooth the test site selected for testing. Fill any voids in the surface using the fines scraped from the surface. Avoid adding excessive fines that would form a build-up on the surface (no more than 1/8 in.).

8.1.2 Place the guide plate on the test site. Next, place the drive rod in the plate guide and while standing on the plate, drive the rod at least 2 in. deeper than the location where the end of the gauge source rod will be when testing. The gauge source rod can be extended in 2 in. increments. The source rod must be as deep as possible within the lift but must not extend beyond the lift. For example, a 5 in. (125 mm) lift shall be tested with the source rod in the 4 in. position and the hole shall be 6 in. deep. Carefully remove the drive rod to prevent material from falling into the hole.

8.1.3 Place the gauge over the test site and insert the source rod to the desired depth. Pull the gauge tight against the side of the hole toward the scaler. Make sure the gauge is sitting flush on the material.

8.1.4 Take a one-minute density and moisture reading. Record the dry density (DA) and moisture (MA).

8.2 Determination of the percent of + 3/4 in. material

8.2.1 Excavate approximately 4500 g (10 LB) of material immediately beneath the test site. Excavate the material from the test hole toward the scaler end of the gauge and to the depth of the position where the source rod was located. Keep the excavated material covered to prevent moisture loss.

8.2.2 Zero the scales. The scales shall be located in an enclosed area of the vehicle that is protected from air movement. The scales are to be checked for zero before each weighing. Weigh the excavated material (CA).

8.2.3 The material weighed in 8.2.2 shall be passed over the 3/4 in. sieve. Break up any clumps of soil that are retained on the sieve and clean the fines from the + 3/4 in. material.

8.2.4 Weigh the +3/4 in. material (CD) obtained in 8.2.3.

8.2.5 Calculate the percent of +3/4 in. material (CG) by using the equations on form T-316. If the percentage of +3/4 in. material is 40% or more, terminate the test. Refer to MP 717.04.21 for instructions

8.2.6 Determine the bulk specific gravity (CH) of the dominant +3/4 in. material by using the values from the following table:

	Bulk Specific Gravity
Soft Shale:	2.4
Hard Shale:	2.5
Sandstone:	2.5
Gravel:	2.6
Limestone:	2.7
Red Shale (Iron Bearing)	2.7

8.3 Determination of the dry density of the -3/4 in. material and percent field moisture.

8.3.1 The dry density of the -3/4 in. material (DB) shall be calculated by the equation on form T-316 or obtained from the tables in attachment 3 of this document, using the specific gravity of the + 3/4 in. material (CH), the total dry density (DA), and the percentage of + 3/4 in. material (CG).

8.3.2 Calculate the percent field moisture (MB) by the equation on form T-316.

8.4 One-point proctor

8.4.1 Place the proctor mold with collar and base attached on the foundation plate. The foundation plate must be firmly seated so that it does not rock when compacting the material. Mix the -3/4 in. material obtained in 8.2.3. Form a specimen by compacting the material in the mold in three approximately equal layers totaling a minimum of 4 1/2 in. and a maximum of 5 in. Each layer is compacted by 25 uniformly distributed blows with the metal rammer dropped freely from a height of 12 in. Stand on the edges of the mold base while compacting the specimen. The rammer must be held vertically.

8.4.2 After the specimen has been made, remove the extension collar. The sample must not extend more than 1/2 in. above nor be below the top of the mold. A new specimen shall be made if these tolerances are not met. Carefully trim the material flush with the top of the mold by using the draw knife. Fill any voids in the surface with the fines obtained from the trimming. Use the paint brush to clean the fines from the outside of the mold. Remove the mold base and by holding the mold vertically, visually check the bottom of the mold to determine if the material extends beyond the mold. Do not turn the mold upside down nor trim the bottom. If the material extends beyond the bottom of the mold, perform another specimen with special precautions to seat and tighten the mold to the base.

8.4.3 Weigh the soil plus mold (PA). Record the value in the first column of the one-point proctor section on Form T-316. Do not use the rerun column at this time.

8.4.4 Remove the specimen from the mold by using the extruder. Place the specimen back in the remaining -3/4 in. material.

8.4.5 Perform the calculations using the equations on the form T-316 to determine the dry density of the one-point proctor (PE).

8.5 Determination of the maximum density and optimum moisture

8.5.1 To determine the maximum density and optimum moisture, plot the percent field moisture (MB) and the dry density of the one-point proctor (PE) on the maximum density-optimum moisture table (attachment 2). The values at the intersection of the density line and moisture column are the maximum density (DC) and optimum moisture (OA). If there are no values given, the sample is either too wet or too dry to determine the maximum density and optimum moisture. When the plotted point is to the right of the maximum densities and optimum moistures, the sample is too wet and when the plotted value is to the left, the sample is too dry.

8.5.2 If the sample is found to be too wet, air dry the -3/4 in. material to decrease the moisture content to between four percentage points below optimum and optimum moisture. The sample is dried by spreading the sample on a non-absorbent surface. Do not dry the sample on a stove. If the sample is too dry, add water to increase the moisture content to between four percentage points below optimum and optimum moisture. Care shall be taken not to over dry or add too much water to the sample.

8.5.3 Rerun one-point proctor

8.5.3.1 Once the sample has been air dried or water added, thoroughly mix the sample, and perform another one-point proctor according to 8.4.1 - 8.4.4. Record the data in the second column (rerun) of the one-point proctor section on form T-316.

8.5.3.2 Calculate the wet density of the rerun one-point proctor (PE) by using the equations on form T-316.

8.5.4 Stove dried moisture

8.5.4.1 Scoop out a representative sample between 200 g and 400 g from the sample in 8.5.3.1. The moisture determination can be made in conjunction with making the rerun one-point proctor specimen. Place the sample in the pan for drying samples and determine the sample weight plus pan (SA).

8.5.4.2 Adjust the stove flame to a low heat so that the sample will not oxidize during drying. Occasionally stir the sample and be very careful not to lose any of the sample. Once the sample appears dry, weigh the sample, and record the weight. Place the sample back on the stove and dry for approximately two minutes. Weigh the sample and compare the two weights. The weights should be the same (constant). If there is a decrease in weight, reheat the sample again for two minutes and weigh. Continue this process until two consecutive weights are obtained. Record this weight as dry weight plus pan (SD).

8.5.4.3 By using the equations on form T-316, calculate the percent moisture (SG).

8.5.5 Use the percent moisture (SG) from the stove dried moisture to calculate the dry density of the rerun one-point proctor (PE).

8.5.6 Plot the dry density of the rerun one-point proctor (PE) and the percent stove dried moisture (SG) on the maximum density-optimum moisture table to obtain the maximum density (DC) and the optimum moisture (OA).

9. MOISTURE EVALUATION

9.1 Obtain the ± moisture tolerance (OB) from the project's governing specifications. Normally this tolerance is +3/-4.

9.2 To determine the acceptable moisture range, add the plus tolerance and subtract the minus tolerance from the optimum moisture. The field moisture (MB) must be within this range for the moisture to meet specifications. If the moisture fails specifications, corrective action is required.

10. DENSITY EVALUATION

10.1 Calculate the percent relative density (DE) by the equation on form T-316.

10.2 If the percent relative density (DE) is 105 or more, the test results may be in error. Plot the dry density of the -3/4 in. material (DB) and the percent field moisture (MB) on the maximum density-optimum moisture table to check the validity of the test results. The plotted point should fall on or to the left of the darkened blocks (zero air voids). Another method of checking the test results is to calculate the maximum moisture content possible (zero air voids) by the following equation:

Maximum moisture content possible (English) = (62.4/DB - .373)100

When the test results are equal to or less than the above evaluation, the results are acceptable.

10.3 When the conditions in 10.2 are not met, perform another complete test, including a one-point proctor, at a new random location. The checks in 10.2 shall again be made if the test results are 105% or more. If the conditions in 10.2 are still not met, obtain a sample, and determine the specific gravity of both the +3/4 in. and -3/4 in. material, performed separately. Then recalculate the test results using the specific gravity of the +3/4 in. material to determine the dry density of the -3/4 in. material (DB). If the percent relative density is still 105% or more, perform the following calculation using the specific gravity of the -3/4 in. material.

Maximum moisture content = (62.4/DB - 1/Sp. Gr.)100

The field moisture (MB) must be equal to or less than the maximum moisture content (new zero air voids). If the test results still appear to be invalid, an immediate investigation must be conducted.

11. LOT EVALUATION

11.1 Five tests are required for a lot evaluation. Each test shall be performed according to previous sections of this procedure.

11.2 Calculate the average relative density (x) for the five tests in the lot.

11.3 Obtain the target percentage of dry density (T) from the project's governing specifications.

11.4 Determine the range (R) of the relative densities (DE) by subtracting the smallest value from the largest.

11.5 Calculate the quality index (QL) by using the equation on form T-316.

11.6 Enter the table for estimating the percent of a lot within tolerance (attachment 1). Determine the percent within tolerance (DF) which corresponds to the QL value calculated in 11.5 above.

11.7 Obtain the minimum percent for 100% pay (DG) from the project's governing specifications.

11.8 For a lot to meet specifications for density, the percent within tolerance (DF) must be equal to or greater than the percent for 100% pay (DG). Corrective action is required to bring a failing lot into specification requirements.

12. GENERAL REQUIREMENTS

12.1 For a lot to meet specifications, the requirements in 9.2 and 11.8 must be met.

12.2 The maximum density, optimum moisture, and percentage of +3/4 in. material may be used for subsequent tests in a lot if the -3/4 in. material does not change. When the material changes, the determination of new control data is required. There must be at least one, one-point proctor, for each lot.

12.3 If the test results indicate that the material meets specifications and the material exhibits pumping or displacing action under the weight of construction equipment, obtain a sample of the material and determine the maximum density and optimum moisture according to AASHTO T99, Method C. Until the laboratory test results are obtained, the material in question shall be dried and re-compacted until the pumping stops. The area shall then be retested, and this moisture content used as the upper limit for moisture during the interim period.

12.4 During the compaction of soil cement base course, if the material starts to shear, cease rolling even though the required specifications for compaction are not met. The material is accepted for compaction and the proper documentation in the project's records shall be made.

12.5 Independent tests for similarity checks shall be recorded on form T-316. Use only the applicable sections of the form.

01/04/2023

Ronald L. Stanevich, P.E.
Director
Materials Control, Soils and Testing Division

MP 207.07.20 Steward – Aggregate Section
RLS:Mj
ATTACHMENTS

Attachment 1 TABLE FOR ESTIMATING PERCENT OF LOT WITHIN TOLERANCE

Quality Index (QL) Positive Values	Percent Within Tolerance
.66	99
.65	98
.62	97
.60	96
.58	95
.57	94
.55	93
.53	92
.51	91
.50	90
.48	89
.46	88
.45	87
.44	86
.42	85
.41	84
.40	83
.38	82
.37	81
.36	80
.34	79
.33	78
.32	77
.30	76
.29	75
.28	74
.27	73
.25	72
.24	71
.23	70
.22	69
.21	68
.19	67
.18	66
.17	65
.16	64
.15	63
.14	62
.13	61
.11	60
.10	59
.09	58
.08	57
.07	56
.06	55
.05	54
.04	53
.02	52
.01	51
.00	50

Quality Index (QL) Negative Values	Percent Within Tolerance
.00	50
.01	49
.02	48
.04	47
.05	46
.06	45
.07	44
.08	43
.09	42
.10	41
.11	40
.13	39
.14	38
.15	37
.16	36
.17	35
.18	34
.19	33
.21	32
.22	31
.23	30
.24	29
.25	28
.27	27
.28	26
.29	25
.30	24
.32	23
.33	22
.34	21
.36	20
.37	19
.38	18
.40	17
.41	16
.42	15
.44	14
.45	13
.46	12
.48	11
.50	10
.51	9
.53	8
.55	7
.57	6
.58	5
.60	4
.62	3
.63	2
.66	1

Attachment 2

MAXIMUM DENSITY-OPTIMUM MOISTURE TABLE

DRY DENSITY OF ONE POINT PROCTOR

	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
130			131 9																	
129		131 9	130 9	129 9																
128		130 9	130 9	128 10																
127	131 9	130 9	128 10	127 10	127 10															
126	131 9	130 9	128 10	127 10	126 10															
125	130 9	128 10	127 10	126 10	125 10															
124		128 10	126 10	125 11	125 11	124 11														
123		127 10	126 10	124 11	123 11	123 11														
122		126 10	125 11	124 11	123 11	122 12														
121		126 11	125 11	123 12	122 12	121 12	121 12													
120		125 11	124 11	122 12	121 12	120 12	120 12													
119			123 12	122 12	120 12	120 12	119 13													
118			122 12	120 12	120 12	119 13	118 13	118 13												
117				120 12	119 13	118 13	117 13	117 13												
116				119 13	118 13	117 13	117 13	116 14												
115				118 13	117 13	116 14	116 14	115 14	115 14											
114				117 13	116 14	116 14	115 14	114 14	114 14											
113					116 14	115 14	114 14	114 14	113 15											
112					115 14	115 14	113 15	113 15	112 15	112 15										
111					115 14	113 15	112 15	112 15	111 15	111 16										
110					113 15	112 15	112 15	111 15	111 16	110 16										
109						112 15	111 16	110 16	110 16	109 16	109 16									
108						111 16	110 16	110 16	109 16	109 17	108 17									
107							110 16	109 17	108 17	108 17	107 17	107 17								
106							109 17	108 17	107 17	107 17	106 18	106 18								
105							108 17	107 17	107 17	106 18	106 18	105 18	105 18							
104								107 17	106 18	105 18	105 18	104 19	104 19							
103								106 18	105 18	105 19	104 19	103 19	103 19	103 19						
102								105 18	105 19	104 19	103 19	103 20	102 20	102 20	102 20					
101									104 19	103 19	102 20	102 20	101 20	101 20	101 21					
100									103 19	102 20	101 20	101 21	100 21	100 21	100 21	100 21				
99									102 20	101 20	101 21	100 21	100 21	99 21	99 22	99 22				
98										100 21	100 21	99 221	99 22	98 22	98 22	98 22	98 22			
97										100 21	99 21	99 22	98 22	98 22	98 22	97 22	97 23			
96											99 22	98 22	98 22	98 22	97 23	97 23	96 23			
95											99 22	98 22	97 23	97 23	96 23	95 24	95 24	85 24		
94											98 22	97 23	96 23	95 24	95 24	95 24	94 24	94 24	94 24	
	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25

PERCENT MOISTURE

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
80	79	79	78	78	77	77	76	75	75	74
81	80	80	79	79	78	78	77	77	76	75
82	81	81	80	80	79	79	78	78	77	76
83	83	82	81	81	80	80	79	79	78	78
84	84	83	83	82	81	81	80	80	79	79
85	85	84	84	83	83	82	81	81	80	80
86	86	85	85	84	84	83	83	82	81	81
87	87	86	86	85	85	84	84	83	83	82
88	88	87	87	86	86	85	85	84	84	83
89	89	88	88	87	87	86	86	85	85	84
90	90	89	89	88	88	87	87	86	86	85
91	91	90	90	89	89	88	88	87	87	86
92	92	91	91	90	90	89	89	89	88	88
93	93	92	92	91	91	91	90	90	89	89
94	94	93	93	92	92	92	91	91	90	90
95	95	94	94	93	93	93	92	92	91	91
96	96	95	95	95	94	94	93	93	92	92
97	97	96	96	96	95	95	94	94	94	93
98	98	97	97	97	96	96	95	95	95	94
99	99	98	98	98	97	97	97	96	96	95
100	100	99	99	99	98	98	98	97	97	96
101	101	100	100	100	99	99	99	98	98	98
102	102	101	101	101	100	100	100	99	99	99
103	103	102	102	102	101	101	101	100	100	100
104	104	103	103	103	103	102	102	102	101	101
105	105	104	104	104	104	103	103	103	102	102
106	106	105	105	105	105	104	104	104	103	103
107	107	106	106	106	106	105	105	105	105	104
108	108	108	107	107	107	106	106	106	106	105
109	109	109	108	108	108	108	107	107	107	106
110	110	110	109	109	109	109	108	108	108	108
111	111	111	110	110	110	110	109	109	109	109
112	112	112	111	111	111	111	111	110	110	110
113	113	113	112	112	112	112	112	111	111	111
114	114	114	113	113	113	113	113	112	112	112
115	115	115	114	114	114	114	114	114	113	113
116	116	116	116	115	115	115	115	115	114	114
117	117	117	117	116	116	116	116	116	116	115
118	118	118	118	117	117	117	117	117	117	116
119	119	119	119	118	118	118	118	118	118	118
120	120	120	120	120	119	119	119	119	119	119

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
121	121	121	121	121	120	120	120	120	120	120
122	122	122	122	122	121	121	121	121	121	121
123	123	123	123	123	123	122	122	122	122	122
124	124	124	124	124	124	124	123	123	123	123
125	125	125	125	125	125	125	124	124	124	124
126	126	126	126	126	126	126	126	125	125	125
127	127	127	127	127	127	127	127	127	127	126
128	128	128	128	128	128	128	128	128	128	128
129	129	129	129	129	129	129	129	129	129	129
130	130	130	130	130	130	130	130	130	130	130
131	131	131	131	131	131	131	131	131	131	131
132	132	132	132	132	132	132	132	132	132	132
133	133	133	133	133	133	133	133	133	133	133
134	134	134	134	134	134	134	134	134	134	134
135	135	135	135	135	135	135	135	135	135	135
136	136	136	136	136	136	136	136	136	136	136
137	137	137	137	137	137	137	137	137	138	138
138	138	138	138	138	138	138	138	139	139	139
139	139	139	139	139	139	139	140	140	140	140
140	140	140	140	140	140	141	141	141	141	141
141	141	141	141	141	141	142	142	142	142	142
142	142	142	142	142	143	143	143	143	143	143
143	143	143	143	143	144	144	144	144	144	144
144	144	144	144	145	145	145	145	145	145	145
145	145	145	145	146	146	146	146	146	146	146
146	146	146	146	147	147	147	147	147	147	148
147	147	147	147	148	148	148	148	148	149	149
148	148	148	149	149	149	149	149	149	150	150
149	149	149	150	150	150	150	150	150	151	151
150	150	150	151	151	151	151	151	152	152	152
151	151	151	152	152	152	152	152	153	153	153
152	152	152	153	153	153	153	154	154	154	154
153	153	153	154	154	154	154	155	155	155	155
154	154	154	155	155	155	155	156	156	156	156
155	155	155	156	156	156	156	157	157	157	158
156	156	156	157	157	157	158	158	158	158	159
157	157	158	158	158	158	159	159	159	159	160
158	158	159	159	159	159	160	160	160	161	161
159	159	160	160	160	160	161	161	161	162	162
160	160	161	161	161	161	162	162	162	163	163

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
80	74	73	72	72	71	70	69	69	68	67
81	75	74	73	73	72	71	71	70	69	68
82	76	75	75	74	73	73	72	71	70	70
83	77	76	76	75	74	74	73	72	72	71
84	78	77	77	76	76	75	74	74	73	72
85	79	79	78	77	77	76	75	75	74	73
86	80	80	79	79	78	77	77	76	75	75
87	81	81	80	80	79	78	78	77	76	76
88	83	82	81	81	80	80	79	78	78	77
89	84	83	83	82	81	81	80	80	79	78
90	85	84	84	83	83	82	81	81	80	80
91	86	85	85	84	84	83	83	82	81	81
92	87	87	86	86	85	84	84	83	83	82
93	88	88	87	87	86	86	85	84	84	83
94	89	89	88	88	87	87	86	86	85	85
95	90	90	90	89	89	88	87	87	86	86
96	92	91	91	90	90	89	89	88	88	87
97	93	92	92	91	91	90	90	89	89	88
98	94	93	93	92	92	92	91	91	90	90
99	95	95	94	94	93	93	92	92	91	91
100	96	96	95	95	94	94	93	93	93	92
101	97	97	96	96	96	95	95	94	94	93
102	98	98	98	97	97	96	96	95	95	95
103	99	99	99	98	98	98	97	97	96	96
104	101	100	100	99	99	99	98	98	97	97
105	102	101	101	101	100	100	100	99	99	98
106	103	102	102	102	101	101	101	100	100	100
107	104	104	103	103	103	102	102	102	101	101
108	105	105	104	104	104	103	103	103	102	102
109	106	106	106	105	105	105	104	104	104	103
110	107	107	107	106	106	106	106	105	105	105
111	108	108	108	108	107	107	107	106	106	106
112	110	109	109	109	109	108	108	108	107	107
113	111	110	110	110	110	109	109	109	109	108
114	112	112	111	111	111	111	110	110	110	110
115	113	113	112	112	112	112	112	111	111	111
116	114	114	114	113	113	113	113	113	112	112
117	115	115	115	115	114	114	114	114	114	113
118	116	116	116	116	116	115	115	115	115	115
119	117	117	117	117	117	117	116	116	116	116
120	119	118	118	118	118	118	118	117	117	117

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
121	120	120	119	119	119	119	119	119	118	118
122	121	121	121	120	120	120	120	120	120	120
123	122	122	122	122	121	121	121	121	121	121
124	123	123	123	123	123	123	122	122	122	122
125	124	124	124	124	124	124	124	124	123	123
126	125	125	125	125	125	125	125	125	125	125
127	126	126	126	126	126	126	126	126	126	126
128	128	127	127	127	127	127	127	127	127	127
129	129	129	129	129	129	128	128	128	128	128
130	130	130	130	130	130	130	130	130	130	130
131	131	131	131	131	131	131	131	131	131	131
132	132	132	132	132	132	132	132	132	132	132
133	133	133	133	133	133	133	133	133	133	133
134	134	134	134	134	134	134	134	134	135	135
135	135	135	135	136	136	136	136	136	136	136
136	137	137	137	137	137	137	137	137	137	137
137	138	138	138	138	138	138	138	138	138	138
138	139	139	139	139	139	139	139	139	139	140
139	140	140	140	140	140	140	140	141	141	141
140	141	141	141	141	141	142	142	142	142	142
141	142	142	142	142	143	143	143	143	143	143
142	143	143	144	144	144	144	144	144	144	145
143	144	145	145	145	145	145	145	145	146	146
144	146	146	146	146	146	146	147	147	147	147
145	147	147	147	147	147	148	148	148	148	148
146	148	148	148	148	149	149	149	149	149	150
147	149	149	149	149	150	150	150	150	151	151
148	150	150	150	151	151	151	151	152	152	152
149	151	151	152	152	152	152	153	153	153	153
150	152	152	153	153	153	153	154	154	154	155
151	153	154	154	154	154	155	155	155	156	156
152	154	155	155	155	156	156	156	156	157	157
153	156	156	156	156	157	157	157	158	158	158
154	157	157	157	158	158	158	159	159	159	160
155	158	158	158	159	159	159	160	160	160	161
156	159	159	160	160	160	161	161	161	162	162
157	160	160	161	161	161	162	162	163	163	163
158	161	162	162	162	163	163	163	164	164	165
159	162	163	163	163	164	164	165	165	165	166
160	163	164	164	165	165	165	166	166	167	167

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
80	66	65	65	64	63	62	61	60	59	58
81	67	67	66	65	64	63	62	61	60	59
82	69	68	67	66	65	65	64	63	62	61
83	70	69	68	68	67	66	65	64	63	62
84	71	71	70	69	68	67	66	65	64	64
85	73	72	71	70	69	69	68	67	66	65
86	74	73	72	72	71	70	69	68	67	66
87	75	74	74	73	72	71	70	70	69	68
88	76	76	75	74	73	73	72	71	70	69
89	78	77	76	75	75	74	73	72	72	71
90	79	78	78	77	76	75	75	74	73	72
91	80	79	79	78	77	77	76	75	74	74
92	81	81	80	79	79	78	77	77	76	75
93	83	82	81	81	80	79	79	78	77	76
94	84	83	83	82	81	81	80	79	79	78
95	85	85	84	83	83	82	81	81	80	79
96	86	86	85	85	84	83	83	82	81	81
97	88	87	87	86	85	85	84	83	83	82
98	89	88	88	87	87	86	86	85	84	84
99	90	90	89	89	88	87	87	86	86	85
100	92	91	91	90	89	89	88	88	87	86
101	93	92	92	91	91	90	90	89	88	88
102	94	94	93	93	92	92	91	90	90	89
103	95	95	94	94	93	93	92	92	91	91
104	97	96	96	95	95	94	94	93	93	92
105	98	97	97	97	96	96	95	95	94	94
106	99	99	98	98	97	97	96	96	95	95
107	100	100	100	99	99	98	98	97	97	96
108	102	101	101	100	100	100	99	99	98	98
109	103	103	102	102	101	101	101	100	100	99
110	104	104	103	103	103	102	102	102	101	101
111	105	105	105	104	104	104	103	103	103	102
112	107	106	106	106	105	105	105	104	104	104
113	108	108	107	107	107	106	106	106	105	105
114	109	109	109	108	108	108	107	107	107	106
115	111	110	110	110	109	109	109	108	108	108
116	112	112	111	111	111	110	110	110	110	109
117	113	113	113	112	112	112	112	111	111	111
118	114	114	114	114	113	113	113	113	112	112
119	116	115	115	115	115	115	114	114	114	114
120	117	117	116	116	116	116	116	115	115	115

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
121	118	118	118	118	117	117	117	117	117	116
122	119	119	119	119	119	119	118	118	118	118
123	121	121	120	120	120	120	120	120	119	119
124	122	122	122	122	121	121	121	121	121	121
125	123	123	123	123	123	123	122	122	122	122
126	124	124	124	124	124	124	124	124	124	124
127	126	126	126	125	125	125	125	125	125	125
128	127	127	127	127	127	127	127	127	126	126
129	128	128	128	128	128	128	128	128	128	128
130	130	129	129	129	129	129	129	129	129	129
131	131	131	131	131	131	131	131	131	131	131
132	132	132	132	132	132	132	132	132	132	132
133	133	133	133	133	133	133	133	133	133	134
134	135	135	135	135	135	135	135	135	135	135
135	136	136	136	136	136	136	136	136	136	136
136	137	137	137	137	137	137	138	138	138	138
137	138	138	139	139	139	139	139	139	139	139
138	140	140	140	140	140	140	140	140	141	141
139	141	141	141	141	141	142	142	142	142	142
140	142	142	142	143	143	143	143	143	143	144
141	143	144	144	144	144	144	144	145	145	145
142	145	145	145	145	145	146	146	146	146	146
143	146	146	146	147	147	147	147	147	148	148
144	147	147	148	148	148	148	149	149	149	149
145	149	149	149	149	149	150	150	150	150	151
146	150	150	150	150	151	151	151	152	152	152
147	151	151	152	152	152	152	153	153	153	154
148	152	153	153	153	153	154	154	154	155	155
149	154	154	154	154	155	155	155	156	156	156
150	155	155	155	156	156	156	157	157	157	158
151	156	156	157	157	157	158	158	158	159	159
152	157	158	158	158	159	159	159	160	160	161
153	159	159	159	160	160	160	161	161	162	162
154	160	160	161	161	161	162	162	163	163	164
155	161	162	162	162	163	163	164	164	164	165
156	162	163	163	164	164	165	165	165	166	166
157	164	164	165	165	165	166	166	167	167	168
158	165	165	166	166	167	167	168	168	169	169
159	166	167	167	168	168	169	169	170	170	171
160	167	168	168	169	169	170	170	171	172	172

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
80	57	56	54	53	52	51	50	48	47	45
81	58	57	56	55	54	52	51	50	49	47
82	60	59	57	56	55	54	53	51	50	49
83	61	60	59	58	57	56	54	53	52	50
84	63	62	60	59	58	57	56	55	53	52
85	64	63	62	61	60	59	58	56	55	54
86	65	64	63	62	61	60	59	58	57	55
87	67	66	65	64	63	62	61	60	58	57
88	68	67	66	65	64	63	62	61	60	59
89	70	69	68	67	66	65	64	63	62	60
90	71	70	69	68	67	66	65	64	63	62
91	73	72	71	70	69	68	67	66	65	64
92	74	73	72	72	71	70	69	68	67	65
93	76	75	74	73	72	71	70	69	68	67
94	77	76	75	75	74	73	72	71	70	69
95	78	78	77	76	75	74	73	72	71	70
96	80	79	78	78	77	76	75	74	73	72
97	81	81	80	79	78	77	77	76	75	74
98	83	82	81	81	80	79	78	77	76	75
99	84	84	83	82	81	81	80	79	78	77
100	86	85	84	84	83	82	81	81	80	79
101	87	87	86	85	84	84	83	82	81	80
102	89	88	87	87	86	85	85	84	83	82
103	90	89	89	88	87	87	86	85	85	84
104	92	91	90	90	89	88	88	87	86	85
105	93	92	92	91	91	90	89	89	88	87
106	94	94	93	93	92	91	91	90	90	89
107	96	95	95	94	94	93	92	92	91	90
108	97	97	96	96	95	95	94	93	93	92
109	99	98	98	97	97	96	96	95	94	94
110	100	100	99	99	98	98	97	97	96	95
111	102	101	101	100	100	99	99	98	98	97
112	103	103	102	102	101	101	100	100	99	99
113	105	104	104	103	103	102	102	101	101	100
114	106	106	105	105	104	104	104	103	103	102
115	107	107	107	106	106	106	105	105	104	104
116	109	109	108	108	107	107	107	106	106	105
117	110	110	110	109	109	109	108	108	108	107
118	112	112	111	111	111	110	110	110	109	109
119	113	113	113	112	112	112	111	111	111	110
120	115	114	114	114	114	113	113	113	112	112

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.4

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
121	116	116	116	115	115	115	115	114	114	114
122	118	117	117	117	117	116	116	116	116	115
123	119	119	119	118	118	118	118	118	117	117
124	121	120	120	120	120	120	119	119	119	119
125	122	122	122	122	121	121	121	121	121	120
126	123	123	123	123	123	123	123	122	122	122
127	125	125	125	125	124	124	124	124	124	124
128	126	126	126	126	126	126	126	126	126	125
129	128	128	128	128	127	127	127	127	127	127
130	129	129	129	129	129	129	129	129	129	129
131	131	131	131	131	131	131	131	131	130	130
132	132	132	132	132	132	132	132	132	132	132
133	134	134	134	134	134	134	134	134	134	134
134	135	135	135	135	135	135	135	135	135	135
135	136	137	137	137	137	137	137	137	137	137
136	138	138	138	138	138	138	138	139	139	139
137	139	139	140	140	140	140	140	140	140	140
138	141	141	141	141	141	141	142	142	142	142
139	142	142	143	143	143	143	143	143	144	144
140	144	144	144	144	144	145	145	145	145	145
141	145	145	146	146	146	146	146	147	147	147
142	147	147	147	147	147	148	148	148	149	149
143	148	148	149	149	149	149	150	150	150	150
144	149	150	150	150	151	151	151	151	152	152
145	151	151	152	152	152	152	153	153	153	154
146	152	153	153	153	154	154	154	155	155	155
147	154	154	154	155	155	156	156	156	157	157
148	155	156	156	156	157	157	158	158	158	159
149	157	157	157	158	158	159	159	160	160	160
150	158	159	159	159	160	160	161	161	162	162
151	160	160	160	161	161	162	162	163	163	164
152	161	162	162	162	163	163	164	164	165	165
153	163	163	163	164	164	165	165	166	167	167
154	164	164	165	165	166	166	167	168	168	169
155	165	166	166	167	167	168	169	169	170	170
156	167	167	168	168	169	170	170	171	171	172
157	168	169	169	170	171	171	172	172	173	174
158	170	170	171	172	172	173	173	174	175	175
159	171	172	172	173	174	174	175	176	176	177
160	173	173	174	175	175	176	177	177	178	179

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
80	79	79	78	78	77	76	76	75	74	74
81	80	80	79	79	78	77	77	76	75	75
82	81	81	80	80	79	78	78	77	77	76
83	82	82	81	81	80	80	79	78	78	77
84	83	83	82	82	81	81	80	79	79	78
85	84	84	83	83	82	82	81	80	80	79
86	85	85	84	84	83	83	82	82	81	80
87	86	86	85	85	84	84	83	83	82	81
88	88	87	86	86	85	85	84	84	83	83
89	89	88	88	87	86	86	85	85	84	84
90	90	89	89	88	88	87	86	86	85	85
91	91	90	90	89	89	88	88	87	86	86
92	92	91	91	90	90	89	89	88	88	87
93	93	92	92	91	91	90	90	89	89	88
94	94	93	93	92	92	91	91	90	90	89
95	95	94	94	93	93	92	92	91	91	90
96	96	95	95	94	94	93	93	92	92	91
97	97	96	96	95	95	94	94	93	93	93
98	98	97	97	96	96	95	95	95	94	94
99	99	98	98	97	97	97	96	96	95	95
100	100	99	99	98	98	98	97	97	96	96
101	101	100	100	99	99	99	98	98	97	97
102	102	101	101	101	100	100	99	99	99	98
103	103	102	102	102	101	101	100	100	100	99
104	104	103	103	103	102	102	101	101	101	100
105	105	104	104	104	103	103	103	102	102	101
106	106	105	105	105	104	104	104	103	103	103
107	107	106	106	106	105	105	105	104	104	104
108	108	107	107	107	106	106	106	105	105	105
109	109	108	108	108	108	107	107	107	106	106
110	110	109	109	109	109	108	108	108	107	107
111	111	110	110	110	110	109	109	109	108	108
112	112	111	111	111	111	110	110	110	109	109
113	113	113	112	112	112	111	111	111	111	110
114	114	114	113	113	113	113	112	112	112	111
115	115	115	114	114	114	114	113	113	113	113
116	116	116	115	115	115	115	114	114	114	114
117	117	117	116	116	116	116	115	115	115	115
118	118	118	117	117	117	117	117	116	116	116
119	119	119	118	118	118	118	118	117	117	117
120	120	120	119	119	119	119	119	118	118	118

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
121	121	121	120	120	120	120	120	120	119	119
122	122	122	122	121	121	121	121	121	120	120
123	123	123	123	122	122	122	122	122	122	121
124	124	124	124	123	123	123	123	123	123	123
125	125	125	125	124	124	124	124	124	124	124
126	126	126	126	126	125	125	125	125	125	125
127	127	127	127	127	126	126	126	126	126	126
128	128	128	128	128	128	127	127	127	127	127
129	129	129	129	129	129	128	128	128	128	128
130	130	130	130	130	130	130	129	129	129	129
131	131	131	131	131	131	131	131	130	130	130
132	132	132	132	132	132	132	132	132	131	131
133	133	133	133	133	133	133	133	133	133	133
134	134	134	134	134	134	134	134	134	134	134
135	135	135	135	135	135	135	135	135	135	135
136	136	136	136	136	136	136	136	136	136	136
137	137	137	137	137	137	137	137	137	137	137
138	138	138	138	138	138	138	138	138	138	138
139	139	139	139	139	139	139	139	139	139	139
140	140	140	140	140	140	140	140	140	140	140
141	141	141	141	141	141	141	141	141	141	141
142	142	142	142	142	142	142	142	142	142	143
143	143	143	143	143	143	143	143	143	144	144
144	144	144	144	144	144	144	145	145	145	145
145	145	145	145	145	145	145	146	146	146	146
146	146	146	146	146	146	147	147	147	147	147
147	147	147	147	147	148	148	148	148	148	148
148	148	148	148	148	149	149	149	149	149	149
149	149	149	149	149	150	150	150	150	150	150
150	150	150	150	151	151	151	151	151	151	151
151	151	151	151	152	152	152	152	152	152	153
152	152	152	152	153	153	153	153	153	153	154
153	153	153	153	154	154	154	154	154	155	155
154	154	154	155	155	155	155	155	155	156	156
155	155	155	156	156	156	156	156	157	157	157
156	156	156	157	157	157	157	157	158	158	158
157	157	157	158	158	158	158	158	159	159	159
158	158	158	159	159	159	159	160	160	160	160
159	159	159	160	160	160	160	161	161	161	161
160	160	160	161	161	161	161	162	162	162	163

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
80	73	72	71	71	70	69	68	67	67	66
81	74	73	73	72	71	70	69	69	68	67
82	75	74	74	73	72	71	71	70	69	68
83	76	76	75	74	73	73	72	71	70	69
84	77	77	76	75	75	74	73	72	72	71
85	79	78	77	76	76	75	74	74	73	72
86	80	79	78	78	77	76	75	75	74	73
87	81	80	79	79	78	77	77	76	75	74
88	82	81	81	80	79	79	78	77	76	76
89	83	82	82	81	80	80	79	78	78	77
90	84	84	83	82	82	81	80	80	79	78
91	85	85	84	83	83	82	82	81	80	79
92	86	86	85	85	84	83	83	82	81	81
93	88	87	86	86	85	85	84	83	83	82
94	89	88	88	87	86	86	85	84	84	83
95	90	89	89	88	88	87	86	86	85	84
96	91	90	90	89	89	88	88	87	86	86
97	92	92	91	90	90	89	89	88	88	87
98	93	93	92	92	91	91	90	89	89	88
99	94	94	93	93	92	92	91	91	90	89
100	95	95	94	94	93	93	92	92	91	91
101	97	96	96	95	95	94	94	93	92	92
102	98	97	97	96	96	95	95	94	94	93
103	99	98	98	97	97	96	96	95	95	94
104	100	99	99	99	98	98	97	97	96	96
105	101	101	100	100	99	99	98	98	97	97
106	102	102	101	101	100	100	100	99	99	98
107	103	103	102	102	102	101	101	100	100	99
108	104	104	104	103	103	102	102	102	101	101
109	106	105	105	104	104	104	103	103	102	102
110	107	106	106	106	105	105	104	104	104	103
111	108	107	107	107	106	106	106	105	105	104
112	109	109	108	108	108	107	107	106	106	106
113	110	110	109	109	109	108	108	108	107	107
114	111	111	111	110	110	110	109	109	109	108
115	112	112	112	111	111	111	110	110	110	109
116	113	113	113	113	112	112	112	111	111	111
117	114	114	114	114	113	113	113	113	112	112
118	116	115	115	115	115	114	114	114	113	113
119	117	117	116	116	116	116	115	115	115	114
120	118	118	117	117	117	117	116	116	116	116

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
121	119	119	119	118	118	118	118	117	117	117
122	120	120	120	120	119	119	119	119	118	118
123	121	121	121	121	120	120	120	120	120	119
124	122	122	122	122	122	121	121	121	121	121
125	123	123	123	123	123	123	122	122	122	122
126	125	124	124	124	124	124	124	124	123	123
127	126	126	125	125	125	125	125	125	125	124
128	127	127	127	126	126	126	126	126	126	126
129	128	128	128	128	128	127	127	127	127	127
130	129	129	129	129	129	129	129	128	128	128
131	130	130	130	130	130	130	130	130	130	129
132	131	131	131	131	131	131	131	131	131	131
133	132	132	132	132	132	132	132	132	132	132
134	134	134	134	133	133	133	133	133	133	133
135	135	135	135	135	135	135	135	134	134	134
136	136	136	136	136	136	136	136	136	136	136
137	137	137	137	137	137	137	137	137	137	137
138	138	138	138	138	138	138	138	138	138	138
139	139	139	139	139	139	139	139	139	139	139
140	140	140	140	140	140	141	141	141	141	141
141	141	142	142	142	142	142	142	142	142	142
142	143	143	143	143	143	143	143	143	143	143
143	144	144	144	144	144	144	144	144	144	144
144	145	145	145	145	145	145	145	145	146	146
145	146	146	146	146	146	146	147	147	147	147
146	147	147	147	147	148	148	148	148	148	148
147	148	148	148	149	149	149	149	149	149	149
148	149	149	150	150	150	150	150	150	151	151
149	150	151	151	151	151	151	151	152	152	152
150	152	152	152	152	152	152	153	153	153	153
151	153	153	153	153	153	154	154	154	154	154
152	154	154	154	154	155	155	155	155	155	156
153	155	155	155	156	156	156	156	156	157	157
154	156	156	156	157	157	157	157	158	158	158
155	157	157	158	158	158	158	159	159	159	159
156	158	159	159	159	159	160	160	160	160	161
157	159	160	160	160	160	161	161	161	162	162
158	161	161	161	161	162	162	162	163	163	163
159	162	162	162	163	163	163	163	164	164	164
160	163	163	163	164	164	164	165	165	165	166

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
80	65	64	63	62	61	60	59	58	57	55
81	66	65	64	63	62	61	60	59	58	57
82	67	66	65	65	64	63	62	61	59	58
83	69	68	67	66	65	64	63	62	61	60
84	70	69	68	67	66	65	64	63	62	61
85	71	70	69	68	68	67	66	65	64	63
86	72	72	71	70	69	68	67	66	65	64
87	74	73	72	71	70	69	68	67	66	65
88	75	74	73	72	72	71	70	69	68	67
89	76	75	75	74	73	72	71	70	69	68
90	77	77	76	75	74	73	73	72	71	70
91	79	78	77	76	76	75	74	73	72	71
92	80	79	78	78	77	76	75	74	74	73
93	81	81	80	79	78	77	77	76	75	74
94	82	82	81	80	80	79	78	77	76	75
95	84	83	82	82	81	80	79	79	78	77
96	85	84	84	83	82	81	81	80	79	78
97	86	86	85	84	84	83	82	81	81	80
98	88	87	86	86	85	84	83	83	82	81
99	89	88	88	87	86	86	85	84	83	83
100	90	89	89	88	88	87	86	86	85	84
101	91	91	90	90	89	88	88	87	86	85
102	93	92	91	91	90	90	89	88	88	87
103	94	93	93	92	92	91	90	90	89	88
104	95	95	94	93	93	92	92	91	90	90
105	96	96	95	95	94	94	93	92	92	91
106	98	97	97	96	96	95	94	94	93	93
107	99	98	98	97	97	96	96	95	95	94
108	100	100	99	99	98	98	97	97	96	95
109	101	101	101	100	100	99	99	98	97	97
110	103	102	102	101	101	100	100	99	99	98
111	104	104	103	103	102	102	101	101	100	100
112	105	105	104	104	104	103	103	102	102	101
113	107	106	106	105	105	104	104	104	103	103
114	108	107	107	107	106	106	105	105	104	104
115	109	109	108	108	108	107	107	106	106	105
116	110	110	110	109	109	109	108	108	107	107
117	112	111	111	111	110	110	109	109	109	108
118	113	113	112	112	112	111	111	111	110	110
119	114	114	114	113	113	113	112	112	112	111
120	115	115	115	115	114	114	114	113	113	113

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
121	117	116	116	116	116	115	115	115	114	114
122	118	118	117	117	117	117	116	116	116	115
123	119	119	119	118	118	118	118	117	117	117
124	120	120	120	120	120	119	119	119	119	118
125	122	122	121	121	121	121	120	120	120	120
126	123	123	123	122	122	122	122	122	121	121
127	124	124	124	124	124	123	123	123	123	123
128	126	125	125	125	125	125	125	124	124	124
129	127	127	127	126	126	126	126	126	126	125
130	128	128	128	128	128	127	127	127	127	127
131	129	129	129	129	129	129	129	129	128	128
132	131	131	130	130	130	130	130	130	130	130
133	132	132	132	132	132	131	131	131	131	131
134	133	133	133	133	133	133	133	133	133	133
135	134	134	134	134	134	134	134	134	134	134
136	136	136	136	136	136	136	136	136	135	135
137	137	137	137	137	137	137	137	137	137	137
138	138	138	138	138	138	138	138	138	138	138
139	139	139	140	140	140	140	140	140	140	140
140	141	141	141	141	141	141	141	141	141	141
141	142	142	142	142	142	142	142	142	143	143
142	143	143	143	143	144	144	144	144	144	144
143	145	145	145	145	145	145	145	145	145	145
144	146	146	146	146	146	146	146	147	147	147
145	147	147	147	147	148	148	148	148	148	148
146	148	148	149	149	149	149	149	149	150	150
147	150	150	150	150	150	150	151	151	151	151
148	151	151	151	151	152	152	152	152	152	153
149	152	152	153	153	153	153	153	154	154	154
150	153	154	154	154	154	154	155	155	155	155
151	155	155	155	155	156	156	156	156	157	157
152	156	156	156	157	157	157	157	158	158	158
153	157	157	158	158	158	159	159	159	159	160
154	158	159	159	159	160	160	160	161	161	161
155	160	160	160	161	161	161	162	162	162	163
156	161	161	162	162	162	163	163	163	164	164
157	162	163	163	163	164	164	164	165	165	165
158	164	164	164	165	165	165	166	166	166	167
159	165	165	165	166	166	167	167	167	168	168
160	166	166	167	167	168	168	168	169	169	170

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
80	54	53	52	50	49	48	46	45	43	42
81	56	55	53	52	51	49	48	47	45	43
82	57	56	55	54	52	51	50	48	47	45
83	59	57	56	55	54	52	51	50	48	47
84	60	59	58	57	55	54	53	51	50	48
85	62	60	59	58	57	56	54	53	52	50
86	63	62	61	60	58	57	56	55	53	52
87	64	63	62	61	60	59	57	56	55	53
88	66	65	64	63	61	60	59	58	56	55
89	67	66	65	64	63	62	61	59	58	57
90	69	68	67	66	65	63	62	61	60	58
91	70	69	68	67	66	65	64	63	61	60
92	72	71	70	69	68	67	65	64	63	62
93	73	72	71	70	69	68	67	66	65	63
94	75	74	73	72	71	70	69	67	66	65
95	76	75	74	73	72	71	70	69	68	67
96	77	77	76	75	74	73	72	71	70	68
97	79	78	77	76	75	74	73	72	71	70
98	80	80	79	78	77	76	75	74	73	72
99	82	81	80	79	78	77	77	76	75	73
100	83	82	82	81	80	79	78	77	76	75
101	85	84	83	82	81	81	80	79	78	77
102	86	85	85	84	83	82	81	80	79	78
103	88	87	86	85	85	84	83	82	81	80
104	89	88	88	87	86	85	84	84	83	82
105	90	90	89	88	88	87	86	85	84	83
106	92	91	91	90	89	88	88	87	86	85
107	93	93	92	91	91	90	89	88	88	87
108	95	94	94	93	92	92	91	90	89	88
109	96	96	95	94	94	93	92	92	91	90
110	98	97	97	96	95	95	94	93	93	92
111	99	99	98	97	97	96	96	95	94	93
112	101	100	100	99	98	98	97	97	96	95
113	102	102	101	100	100	99	99	98	97	97
114	104	103	103	102	101	101	100	100	99	98
115	105	105	104	104	103	102	102	101	101	100
116	106	106	106	105	105	104	104	103	102	102
117	108	107	107	107	106	106	105	105	104	103
118	109	109	109	108	108	107	107	106	106	105
119	111	110	110	110	109	109	108	108	107	107
120	112	112	111	111	111	110	110	109	109	108

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.5

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
121	114	113	113	113	112	112	111	111	111	110
122	115	115	114	114	114	113	113	113	112	112
123	117	116	116	116	115	115	115	114	114	113
124	118	118	117	117	117	117	116	116	116	115
125	119	119	119	119	118	118	118	117	117	117
126	121	121	120	120	120	120	119	119	119	118
127	122	122	122	122	121	121	121	121	120	120
128	124	124	123	123	123	123	123	122	122	122
129	125	125	125	125	125	124	124	124	124	123
130	127	127	126	126	126	126	126	126	125	125
131	128	128	128	128	128	127	127	127	127	127
132	130	130	129	129	129	129	129	129	129	128
133	131	131	131	131	131	131	130	130	130	130
134	133	132	132	132	132	132	132	132	132	132
135	134	134	134	134	134	134	134	134	134	133
136	135	135	135	135	135	135	135	135	135	135
137	137	137	137	137	137	137	137	137	137	137
138	138	138	138	138	138	138	138	138	138	138
139	140	140	140	140	140	140	140	140	140	140
140	141	141	141	141	141	142	142	142	142	142
141	143	143	143	143	143	143	143	143	143	143
142	144	144	144	144	145	145	145	145	145	145
143	146	146	146	146	146	146	146	147	147	147
144	147	147	147	147	148	148	148	148	148	148
145	148	149	149	149	149	149	150	150	150	150
146	150	150	150	150	151	151	151	151	152	152
147	151	152	152	152	152	152	153	153	153	153
148	153	153	153	154	154	154	154	155	155	155
149	154	155	155	155	155	156	156	156	156	157
150	156	156	156	157	157	157	157	158	158	158
151	157	157	158	158	158	159	159	159	160	160
152	159	159	159	160	160	160	161	161	161	162
153	160	160	161	161	161	162	162	163	163	163
154	162	162	162	163	163	163	164	164	165	165
155	163	163	164	164	165	165	165	166	166	167
156	164	165	165	166	166	167	167	167	168	168
157	166	166	167	167	168	168	169	169	170	170
158	167	168	168	169	169	170	170	171	171	172
159	169	169	170	170	171	171	172	172	173	173
160	170	171	171	172	172	173	173	174	175	175

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
80	79	79	78	77	77	76	75	75	74	73
81	80	80	79	78	78	77	76	76	75	74
82	81	81	80	79	79	78	77	77	76	75
83	82	82	81	81	80	79	79	78	77	76
84	83	83	82	82	81	80	80	79	78	77
85	84	84	83	83	82	81	81	80	79	79
86	85	85	84	84	83	82	82	81	80	80
87	86	86	85	85	84	83	83	82	81	81
88	87	87	86	86	85	85	84	83	83	82
89	88	88	87	87	86	86	85	84	84	83
90	89	89	88	88	87	87	86	85	85	84
91	90	90	89	89	88	88	87	86	86	85
92	91	91	90	90	89	89	88	88	87	86
93	92	92	91	91	90	90	89	89	88	87
94	94	93	92	92	91	91	90	90	89	89
95	95	94	94	93	92	92	91	91	90	90
96	96	95	95	94	94	93	92	92	91	91
97	97	96	96	95	95	94	94	93	92	92
98	98	97	97	96	96	95	95	94	94	93
99	99	98	98	97	97	96	96	95	95	94
100	100	99	99	98	98	97	97	96	96	95
101	101	100	100	99	99	98	98	97	97	96
102	102	101	101	100	100	99	99	98	98	97
103	103	102	102	101	101	100	100	100	99	99
104	104	103	103	102	102	102	101	101	100	100
105	105	104	104	103	103	103	102	102	101	101
106	106	105	105	104	104	104	103	103	102	102
107	107	106	106	106	105	105	104	104	103	103
108	108	107	107	107	106	106	105	105	105	104
109	109	108	108	108	107	107	106	106	106	105
110	110	109	109	109	108	108	108	107	107	106
111	111	110	110	110	109	109	109	108	108	107
112	112	111	111	111	110	110	110	109	109	109
113	113	112	112	112	111	111	111	110	110	110
114	114	113	113	113	112	112	112	111	111	111
115	115	114	114	114	114	113	113	113	112	112
116	116	115	115	115	115	114	114	114	113	113
117	117	116	116	116	116	115	115	115	114	114
118	118	117	117	117	117	116	116	116	116	115
119	119	119	118	118	118	117	117	117	117	116
120	120	120	119	119	119	119	118	118	118	117

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
121	121	121	120	120	120	120	119	119	119	119
122	122	122	121	121	121	121	120	120	120	120
123	123	123	122	122	122	122	122	121	121	121
124	124	124	123	123	123	123	123	122	122	122
125	125	125	124	124	124	124	124	123	123	123
126	126	126	125	125	125	125	125	125	124	124
127	127	127	127	126	126	126	126	126	125	125
128	128	128	128	127	127	127	127	127	127	126
129	129	129	129	128	128	128	128	128	128	127
130	130	130	130	129	129	129	129	129	129	129
131	131	131	131	131	130	130	130	130	130	130
132	132	132	132	132	131	131	131	131	131	131
133	133	133	133	133	132	132	132	132	132	132
134	134	134	134	134	134	133	133	133	133	133
135	135	135	135	135	135	135	134	134	134	134
136	136	136	136	136	136	136	135	135	135	135
137	137	137	137	137	137	137	137	136	136	136
138	138	138	138	138	138	138	138	138	138	137
139	139	139	139	139	139	139	139	139	139	139
140	140	140	140	140	140	140	140	140	140	140
141	141	141	141	141	141	141	141	141	141	141
142	142	142	142	142	142	142	142	142	142	142
143	143	143	143	143	143	143	143	143	143	143
144	144	144	144	144	144	144	144	144	144	144
145	145	145	145	145	145	145	145	145	145	145
146	146	146	146	146	146	146	146	146	146	146
147	147	147	147	147	147	147	147	147	147	147
148	148	148	148	148	148	148	148	148	149	149
149	149	149	149	149	149	149	149	150	150	150
150	150	150	150	150	150	150	151	151	151	151
151	151	151	151	151	151	152	152	152	152	152
152	152	152	152	152	152	153	153	153	153	153
153	153	153	153	153	154	154	154	154	154	154
154	154	154	154	154	155	155	155	155	155	155
155	155	155	155	156	156	156	156	156	156	156
156	156	156	156	157	157	157	157	157	157	157
157	157	157	157	158	158	158	158	158	158	159
158	158	158	158	159	159	159	159	159	160	160
159	159	159	160	160	160	160	160	160	161	161
160	160	160	161	161	161	161	161	161	162	162

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
80	72	71	71	70	69	68	67	66	65	64
81	73	73	72	71	70	69	68	67	67	66
82	74	74	73	72	71	70	70	69	68	67
83	76	75	74	73	72	72	71	70	69	68
84	77	76	75	74	74	73	72	71	70	69
85	78	77	76	76	75	74	73	72	71	71
86	79	78	78	77	76	75	74	74	73	72
87	80	79	79	78	77	76	76	75	74	73
88	81	81	80	79	78	78	77	76	75	74
89	82	82	81	80	80	79	78	77	76	76
90	83	83	82	81	81	80	79	78	78	77
91	85	84	83	83	82	81	80	80	79	78
92	86	85	84	84	83	82	82	81	80	79
93	87	86	86	85	84	84	83	82	81	81
94	88	87	87	86	85	85	84	83	83	82
95	89	88	88	87	87	86	85	85	84	83
96	90	90	89	88	88	87	86	86	85	84
97	91	91	90	90	89	88	88	87	86	86
98	92	92	91	91	90	89	89	88	87	87
99	94	93	92	92	91	91	90	89	89	88
100	95	94	94	93	92	92	91	91	90	89
101	96	95	95	94	94	93	92	92	91	91
102	97	96	96	95	95	94	94	93	92	92
103	98	98	97	97	96	95	95	94	94	93
104	99	99	98	98	97	97	96	95	95	94
105	100	100	99	99	98	98	97	97	96	96
106	101	101	101	100	100	99	98	98	97	97
107	103	102	102	101	101	100	100	99	99	98
108	104	103	103	102	102	101	101	100	100	99
109	105	104	104	104	103	103	102	102	101	101
110	106	106	105	105	104	104	103	103	102	102
111	107	107	106	106	105	105	104	104	104	103
112	108	108	107	107	107	106	106	105	105	104
113	109	109	109	108	108	107	107	106	106	106
114	110	110	110	109	109	109	108	108	107	107
115	112	111	111	110	110	110	109	109	108	108
116	113	112	112	112	111	111	111	110	110	109
117	114	113	113	113	112	112	112	111	111	111
118	115	115	114	114	114	113	113	113	112	112
119	116	116	115	115	115	114	114	114	113	113
120	117	117	117	116	116	116	115	115	115	114

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
121	118	118	118	117	117	117	117	116	116	116
122	119	119	119	119	118	118	118	117	117	117
123	121	120	120	120	120	119	119	119	118	118
124	122	121	121	121	121	120	120	120	120	119
125	123	123	122	122	122	122	121	121	121	121
126	124	124	123	123	123	123	123	122	122	122
127	125	125	125	124	124	124	124	124	123	123
128	126	126	126	126	125	125	125	125	125	124
129	127	127	127	127	127	126	126	126	126	126
130	128	128	128	128	128	128	127	127	127	127
131	130	129	129	129	129	129	129	128	128	128
132	131	131	130	130	130	130	130	130	129	129
133	132	132	132	131	131	131	131	131	131	131
134	133	133	133	133	132	132	132	132	132	132
135	134	134	134	134	134	134	133	133	133	133
136	135	135	135	135	135	135	135	135	134	134
137	136	136	136	136	136	136	136	136	136	136
138	137	137	137	137	137	137	137	137	137	137
139	139	138	138	138	138	138	138	138	138	138
140	140	140	140	140	140	139	139	139	139	139
141	141	141	141	141	141	141	141	141	141	141
142	142	142	142	142	142	142	142	142	142	142
143	143	143	143	143	143	143	143	143	143	143
144	144	144	144	144	144	144	144	144	144	144
145	145	145	145	145	145	145	145	145	146	146
146	146	146	146	147	147	147	147	147	147	147
147	148	148	148	148	148	148	148	148	148	148
148	149	149	149	149	149	149	149	149	149	149
149	150	150	150	150	150	150	150	150	150	151
150	151	151	151	151	151	151	151	152	152	152
151	152	152	152	152	152	153	153	153	153	153
152	153	153	153	154	154	154	154	154	154	154
153	154	154	155	155	155	155	155	155	155	156
154	155	156	156	156	156	156	156	156	157	157
155	157	157	157	157	157	157	158	158	158	158
156	158	158	158	158	158	159	159	159	159	159
157	159	159	159	159	160	160	160	160	160	161
158	160	160	160	160	161	161	161	161	162	162
159	161	161	161	162	162	162	162	163	163	163
160	162	162	163	163	163	163	164	164	164	164

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
80	63	62	61	60	59	58	57	56	54	53
81	65	64	63	61	60	59	58	57	56	55
82	66	65	64	63	62	61	60	58	57	56
83	67	66	65	64	63	62	61	60	59	57
84	68	67	66	65	64	63	62	61	60	59
85	70	69	68	67	66	65	64	63	61	60
86	71	70	69	68	67	66	65	64	63	62
87	72	71	70	69	68	67	66	65	64	63
88	73	73	72	71	70	69	68	67	66	65
89	75	74	73	72	71	70	69	68	67	66
90	76	75	74	73	72	71	70	69	68	67
91	77	76	76	75	74	73	72	71	70	69
92	79	78	77	76	75	74	73	72	71	70
93	80	79	78	77	76	76	75	74	73	72
94	81	80	79	79	78	77	76	75	74	73
95	82	82	81	80	79	78	77	76	75	75
96	84	83	82	81	80	80	79	78	77	76
97	85	84	83	83	82	81	80	79	78	77
98	86	85	85	84	83	82	81	81	80	79
99	87	87	86	85	84	84	83	82	81	80
100	89	88	87	86	86	85	84	83	83	82
101	90	89	89	88	87	86	86	85	84	83
102	91	91	90	89	88	88	87	86	85	85
103	92	92	91	90	90	89	88	88	87	86
104	94	93	92	92	91	90	90	89	88	87
105	95	94	94	93	92	92	91	90	90	89
106	96	96	95	94	94	93	92	92	91	90
107	97	97	96	96	95	94	94	93	92	92
108	99	98	98	97	96	96	95	94	94	93
109	100	99	99	98	98	97	97	96	95	95
110	101	101	100	100	99	98	98	97	97	96
111	103	102	102	101	100	100	99	99	98	97
112	104	103	103	102	102	101	101	100	99	99
113	105	105	104	104	103	103	102	101	101	100
114	106	106	105	105	104	104	103	103	102	102
115	108	107	107	106	106	105	105	104	104	103
116	109	108	108	108	107	107	106	106	105	105
117	110	110	109	109	108	108	107	107	106	106
118	111	111	111	110	110	109	109	108	108	107
119	113	112	112	111	111	111	110	110	109	109
120	114	114	113	113	112	112	112	111	111	110

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
121	115	115	114	114	114	113	113	113	112	112
122	116	116	116	115	115	115	114	114	114	113
123	118	117	117	117	116	116	116	115	115	115
124	119	119	118	118	118	117	117	117	116	116
125	120	120	120	119	119	119	118	118	118	117
126	122	121	121	121	120	120	120	119	119	119
127	123	123	122	122	122	121	121	121	121	120
128	124	124	124	123	123	123	123	122	122	122
129	125	125	125	125	124	124	124	124	123	123
130	127	126	126	126	126	126	125	125	125	125
131	128	128	127	127	127	127	127	126	126	126
132	129	129	129	129	128	128	128	128	128	127
133	130	130	130	130	130	130	129	129	129	129
134	132	132	131	131	131	131	131	131	130	130
135	133	133	133	133	132	132	132	132	132	132
136	134	134	134	134	134	134	133	133	133	133
137	135	135	135	135	135	135	135	135	135	135
138	137	137	137	136	136	136	136	136	136	136
139	138	138	138	138	138	138	138	138	137	137
140	139	139	139	139	139	139	139	139	139	139
141	141	141	140	140	140	140	140	140	140	140
142	142	142	142	142	142	142	142	142	142	142
143	143	143	143	143	143	143	143	143	143	143
144	144	144	144	144	144	144	144	144	145	145
145	146	146	146	146	146	146	146	146	146	146
146	147	147	147	147	147	147	147	147	147	147
147	148	148	148	148	148	148	149	149	149	149
148	149	149	150	150	150	150	150	150	150	150
149	151	151	151	151	151	151	151	151	152	152
150	152	152	152	152	152	153	153	153	153	153
151	153	153	153	154	154	154	154	154	154	155
152	154	155	155	155	155	155	155	156	156	156
153	156	156	156	156	156	157	157	157	157	157
154	157	157	157	158	158	158	158	158	159	159
155	158	158	159	159	159	159	160	160	160	160
156	160	160	160	160	160	161	161	161	161	162
157	161	161	161	161	162	162	162	163	163	163
158	162	162	163	163	163	163	164	164	164	165
159	163	164	164	164	164	165	165	165	166	166
160	165	165	165	165	166	166	166	167	167	167

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
80	52	50	49	48	46	45	43	42	40	38
81	53	52	51	49	48	46	45	43	42	40
82	55	53	52	51	49	48	46	45	43	41
83	56	55	54	52	51	49	48	46	45	43
84	58	56	55	54	52	51	49	48	46	45
85	59	58	57	55	54	53	51	50	48	46
86	60	59	58	57	55	54	53	51	50	48
87	62	61	60	58	57	56	54	53	51	50
88	63	62	61	60	59	57	56	54	53	51
89	65	64	63	61	60	59	57	56	55	53
90	66	65	64	63	62	60	59	58	56	55
91	68	67	66	64	63	62	61	59	58	56
92	69	68	67	66	65	63	62	61	60	58
93	71	70	68	67	66	65	64	62	61	60
94	72	71	70	69	68	67	65	64	63	61
95	74	73	71	70	69	68	67	66	64	63
96	75	74	73	72	71	70	69	67	66	65
97	76	75	74	73	72	71	70	69	68	66
98	78	77	76	75	74	73	72	71	69	68
99	79	78	77	76	75	74	73	72	71	70
100	81	80	79	78	77	76	75	74	73	71
101	82	81	80	79	79	78	76	75	74	73
102	84	83	82	81	80	79	78	77	76	75
103	85	84	83	83	82	81	80	79	78	76
104	87	86	85	84	83	82	81	80	79	78
105	88	87	86	86	85	84	83	82	81	80
106	89	89	88	87	86	85	84	83	82	81
107	91	90	89	89	88	87	86	85	84	83
108	92	92	91	90	89	88	88	87	86	85
109	94	93	92	92	91	90	89	88	87	86
110	95	95	94	93	92	92	91	90	89	88
111	97	96	95	95	94	93	92	92	91	90
112	98	98	97	96	95	95	94	93	92	91
113	100	99	98	98	97	96	96	95	94	93
114	101	100	100	99	99	98	97	96	96	95
115	103	102	101	101	100	99	99	98	97	96
116	104	103	103	102	102	101	100	100	99	98
117	105	105	104	104	103	103	102	101	101	100
118	107	106	106	105	105	104	103	103	102	101
119	108	108	107	107	106	106	105	104	104	103
120	110	109	109	108	108	107	107	106	105	105

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.6

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
121	111	111	110	110	109	109	108	108	107	106
122	113	112	112	111	111	110	110	109	109	108
123	114	114	113	113	112	112	111	111	110	110
124	116	115	115	114	114	113	113	112	112	111
125	117	117	116	116	115	115	115	114	114	113
126	118	118	118	117	117	117	116	116	115	115
127	120	120	119	119	119	118	118	117	117	116
128	121	121	121	120	120	120	119	119	119	118
129	123	123	122	122	122	121	121	121	120	120
130	124	124	124	123	123	123	122	122	122	121
131	126	125	125	125	125	124	124	124	123	123
132	127	127	127	126	126	126	126	125	125	125
133	129	128	128	128	128	128	127	127	127	126
134	130	130	130	129	129	129	129	129	128	128
135	132	131	131	131	131	131	130	130	130	130
136	133	133	133	133	132	132	132	132	132	131
137	134	134	134	134	134	134	134	133	133	133
138	136	136	136	136	135	135	135	135	135	135
139	137	137	137	137	137	137	137	137	137	136
140	139	139	139	139	139	138	138	138	138	138
141	140	140	140	140	140	140	140	140	140	140
142	142	142	142	142	142	142	142	142	142	141
143	143	143	143	143	143	143	143	143	143	143
144	145	145	145	145	145	145	145	145	145	145
145	146	146	146	146	146	146	146	146	146	146
146	147	148	148	148	148	148	148	148	148	148
147	149	149	149	149	149	149	149	150	150	150
148	150	150	151	151	151	151	151	151	151	151
149	152	152	152	152	152	153	153	153	153	153
150	153	153	154	154	154	154	154	154	155	155
151	155	155	155	155	155	156	156	156	156	156
152	156	156	157	157	157	157	157	158	158	158
153	158	158	158	158	159	159	159	159	160	160
154	159	159	160	160	160	160	161	161	161	161
155	160	161	161	161	162	162	162	162	163	163
156	162	162	163	163	163	163	164	164	164	165
157	163	164	164	164	165	165	165	166	166	166
158	165	165	166	166	166	167	167	167	168	168
159	166	167	167	167	168	168	169	169	169	170
160	168	168	168	169	169	170	170	171	171	171

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
80	79	79	78	77	76	76	75	74	73	72
81	80	80	79	78	77	77	76	75	74	74
82	81	81	80	79	79	78	77	76	75	75
83	82	82	81	80	80	79	78	77	77	76
84	83	83	82	81	81	80	79	78	78	77
85	84	84	83	82	82	81	80	79	79	78
86	85	85	84	83	83	82	81	81	80	79
87	86	86	85	84	84	83	82	82	81	80
88	87	87	86	85	85	84	83	83	82	81
89	88	88	87	87	86	85	85	84	83	82
90	89	89	88	88	87	86	86	85	84	84
91	90	90	89	89	88	87	87	86	85	85
92	91	91	90	90	89	88	88	87	86	86
93	92	92	91	91	90	89	89	88	88	87
94	93	93	92	92	91	91	90	89	89	88
95	94	94	93	93	92	92	91	90	90	89
96	95	95	94	94	93	93	92	91	91	90
97	96	96	95	95	94	94	93	93	92	91
98	97	97	96	96	95	95	94	94	93	92
99	99	98	97	97	96	96	95	95	94	94
100	100	99	99	98	97	97	96	96	95	95
101	101	100	100	99	99	98	97	97	96	96
102	102	101	101	100	100	99	99	98	97	97
103	103	102	102	101	101	100	100	99	99	98
104	104	103	103	102	102	101	101	100	100	99
105	105	104	104	103	103	102	102	101	101	100
106	106	105	105	104	104	103	103	102	102	101
107	107	106	106	105	105	104	104	103	103	102
108	108	107	107	106	106	105	105	104	104	104
109	109	108	108	107	107	106	106	106	105	105
110	110	109	109	108	108	108	107	107	106	106
111	111	110	110	109	109	109	108	108	107	107
112	112	111	111	110	110	110	109	109	108	108
113	113	112	112	112	111	111	110	110	110	109
114	114	113	113	113	112	112	111	111	111	110
115	115	114	114	114	113	113	112	112	112	111
116	116	115	115	115	114	114	114	113	113	112
117	117	116	116	116	115	115	115	114	114	114
118	118	117	117	117	116	116	116	115	115	115
119	119	118	118	118	117	117	117	116	116	116
120	120	119	119	119	119	118	118	118	117	117

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
121	121	120	120	120	120	119	119	119	118	118
122	122	121	121	121	121	120	120	120	119	119
123	123	122	122	122	122	121	121	121	121	120
124	124	124	123	123	123	122	122	122	122	121
125	125	125	124	124	124	124	123	123	123	122
126	126	126	125	125	125	125	124	124	124	124
127	127	127	126	126	126	126	125	125	125	125
128	128	128	127	127	127	127	126	126	126	126
129	129	129	128	128	128	128	128	127	127	127
130	130	130	129	129	129	129	129	128	128	128
131	131	131	130	130	130	130	130	129	129	129
132	132	132	131	131	131	131	131	131	130	130
133	133	133	133	132	132	132	132	132	131	131
134	134	134	134	133	133	133	133	133	133	132
135	135	135	135	134	134	134	134	134	134	134
136	136	136	136	135	135	135	135	135	135	135
137	137	137	137	137	136	136	136	136	136	136
138	138	138	138	138	137	137	137	137	137	137
139	139	139	139	139	139	138	138	138	138	138
140	140	140	140	140	140	139	139	139	139	139
141	141	141	141	141	141	141	140	140	140	140
142	142	142	142	142	142	142	142	141	141	141
143	143	143	143	143	143	143	143	143	142	142
144	144	144	144	144	144	144	144	144	144	144
145	145	145	145	145	145	145	145	145	145	145
146	146	146	146	146	146	146	146	146	146	146
147	147	147	147	147	147	147	147	147	147	147
148	148	148	148	148	148	148	148	148	148	148
149	149	149	149	149	149	149	149	149	149	149
150	150	150	150	150	150	150	150	150	150	150
151	151	151	151	151	151	151	151	151	151	151
152	152	152	152	152	152	152	152	152	152	152
153	153	153	153	153	153	153	153	153	153	154
154	154	154	154	154	154	154	154	154	155	155
155	155	155	155	155	155	155	156	156	156	156
156	156	156	156	156	156	156	157	157	157	157
157	157	157	157	157	157	158	158	158	158	158
158	158	158	158	158	159	159	159	159	159	159
159	159	159	159	159	160	160	160	160	160	160
160	160	160	160	160	161	161	161	161	161	161

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
80	72	71	70	69	68	67	66	65	64	63
81	73	72	71	70	69	68	67	66	65	64
82	74	73	72	71	70	69	68	67	66	65
83	75	74	73	72	71	71	70	69	68	67
84	76	75	74	74	73	72	71	70	69	68
85	77	76	76	75	74	73	72	71	70	69
86	78	78	77	76	75	74	73	72	71	70
87	79	79	78	77	76	75	74	74	73	72
88	81	80	79	78	77	77	76	75	74	73
89	82	81	80	79	79	78	77	76	75	74
90	83	82	81	81	80	79	78	77	76	75
91	84	83	82	82	81	80	79	78	78	77
92	85	84	84	83	82	81	80	80	79	78
93	86	85	85	84	83	82	82	81	80	79
94	87	87	86	85	84	84	83	82	81	80
95	88	88	87	86	86	85	84	83	83	82
96	90	89	88	87	87	86	85	85	84	83
97	91	90	89	89	88	87	87	86	85	84
98	92	91	90	90	89	88	88	87	86	85
99	93	92	92	91	90	90	89	88	87	87
100	94	93	93	92	91	91	90	89	89	88
101	95	95	94	93	93	92	91	91	90	89
102	96	96	95	94	94	93	93	92	91	90
103	97	97	96	96	95	94	94	93	92	92
104	99	98	97	97	96	96	95	94	94	93
105	100	99	99	98	97	97	96	96	95	94
106	101	100	100	99	99	98	97	97	96	95
107	102	101	101	100	100	99	99	98	97	97
108	103	103	102	101	101	100	100	99	99	98
109	104	104	103	103	102	102	101	100	100	99
110	105	105	104	104	103	103	102	102	101	100
111	106	106	105	105	104	104	103	103	102	102
112	108	107	107	106	106	105	105	104	103	103
113	109	108	108	107	107	106	106	105	105	104
114	110	109	109	108	108	107	107	106	106	105
115	111	110	110	110	109	109	108	108	107	107
116	112	112	111	111	110	110	109	109	108	108
117	113	113	112	112	111	111	111	110	110	109
118	114	114	113	113	113	112	112	111	111	110
119	115	115	115	114	114	113	113	113	112	112
120	117	116	116	115	115	115	114	114	113	113

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	11	12	13	14	15	16	17	18	19	20
121	118	117	117	117	116	116	115	115	115	114
122	119	118	118	118	117	117	117	116	116	115
123	120	120	119	119	119	118	118	117	117	117
124	121	121	120	120	120	119	119	119	118	118
125	122	122	122	121	121	121	120	120	120	119
126	123	123	123	122	122	122	121	121	121	120
127	124	124	124	124	123	123	123	122	122	122
128	125	125	125	125	124	124	124	124	123	123
129	127	126	126	126	126	125	125	125	124	124
130	128	128	127	127	127	127	126	126	126	125
131	129	129	128	128	128	128	127	127	127	127
132	130	130	130	129	129	129	129	128	128	128
133	131	131	131	131	130	130	130	130	129	129
134	132	132	132	132	131	131	131	131	131	130
135	133	133	133	133	133	132	132	132	132	132
136	134	134	134	134	134	134	133	133	133	133
137	136	135	135	135	135	135	135	135	134	134
138	137	137	136	136	136	136	136	136	136	135
139	138	138	138	137	137	137	137	137	137	137
140	139	139	139	139	139	138	138	138	138	138
141	140	140	140	140	140	140	140	139	139	139
142	141	141	141	141	141	141	141	141	141	140
143	142	142	142	142	142	142	142	142	142	142
144	143	143	143	143	143	143	143	143	143	143
145	145	145	145	144	144	144	144	144	144	144
146	146	146	146	146	146	146	146	146	145	145
147	147	147	147	147	147	147	147	147	147	147
148	148	148	148	148	148	148	148	148	148	148
149	149	149	149	149	149	149	149	149	149	149
150	150	150	150	150	150	150	150	150	150	150
151	151	151	151	151	151	152	152	152	152	152
152	152	153	153	153	153	153	153	153	153	153
153	154	154	154	154	154	154	154	154	154	154
154	155	155	155	155	155	155	155	155	155	155
155	156	156	156	156	156	156	156	156	157	157
156	157	157	157	157	157	157	158	158	158	158
157	158	158	158	158	159	159	159	159	159	159
158	159	159	159	160	160	160	160	160	160	160
159	160	160	161	161	161	161	161	161	162	162
160	161	162	162	162	162	162	162	163	163	163

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
80	62	61	60	58	57	56	55	53	52	51
81	63	62	61	60	59	57	56	55	54	52
82	64	63	62	61	60	59	57	56	55	54
83	66	65	64	62	61	60	59	58	56	55
84	67	66	65	64	63	61	60	59	58	56
85	68	67	66	65	64	63	62	60	59	58
86	69	68	67	66	65	64	63	62	61	59
87	71	70	69	68	67	65	64	63	62	61
88	72	71	70	69	68	67	66	65	63	62
89	73	72	71	70	69	68	67	66	65	64
90	75	74	73	72	71	70	68	67	66	65
91	76	75	74	73	72	71	70	69	68	66
92	77	76	75	74	73	72	71	70	69	68
93	78	77	76	76	75	74	73	72	70	69
94	80	79	78	77	76	75	74	73	72	71
95	81	80	79	78	77	76	75	74	73	72
96	82	81	80	79	79	78	77	76	75	74
97	83	83	82	81	80	79	78	77	76	75
98	85	84	83	82	81	80	79	78	77	76
99	86	85	84	83	83	82	81	80	79	78
100	87	86	86	85	84	83	82	81	80	79
101	88	88	87	86	85	84	84	83	82	81
102	90	89	88	87	87	86	85	84	83	82
103	91	90	89	89	88	87	86	85	85	84
104	92	92	91	90	89	88	88	87	86	85
105	93	93	92	91	91	90	89	88	87	86
106	95	94	93	93	92	91	90	90	89	88
107	96	95	95	94	93	93	92	91	90	89
108	97	97	96	95	95	94	93	92	92	91
109	99	98	97	97	96	95	94	94	93	92
110	100	99	99	98	97	97	96	95	94	94
111	101	100	100	99	99	98	97	97	96	95
112	102	102	101	101	100	99	99	98	97	96
113	104	103	102	102	101	101	100	99	99	98
114	105	104	104	103	103	102	101	101	100	99
115	106	106	105	104	104	103	103	102	101	101
116	107	107	106	106	105	105	104	103	103	102
117	109	108	108	107	107	106	105	105	104	104
118	110	109	109	108	108	107	107	106	106	105
119	111	111	110	110	109	109	108	108	107	106
120	112	112	112	111	111	110	110	109	108	108

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	21	22	23	24	25	26	27	28	29	30
121	114	113	113	112	112	111	111	110	110	109
122	115	115	114	114	113	113	112	112	111	111
123	116	116	115	115	115	114	114	113	113	112
124	118	117	117	116	116	115	115	115	114	114
125	119	118	118	118	117	117	116	116	115	115
126	120	120	119	119	119	118	118	117	117	116
127	121	121	121	120	120	120	119	119	118	118
128	123	122	122	122	121	121	121	120	120	119
129	124	124	123	123	123	122	122	122	121	121
130	125	125	125	124	124	124	123	123	123	122
131	126	126	126	126	125	125	125	124	124	124
132	128	127	127	127	127	126	126	126	125	125
133	129	129	128	128	128	128	127	127	127	126
134	130	130	130	129	129	129	129	128	128	128
135	131	131	131	131	131	130	130	130	130	129
136	133	133	132	132	132	132	131	131	131	131
137	134	134	134	133	133	133	133	133	132	132
138	135	135	135	135	135	134	134	134	134	134
139	137	136	136	136	136	136	136	135	135	135
140	138	138	138	137	137	137	137	137	137	136
141	139	139	139	139	139	138	138	138	138	138
142	140	140	140	140	140	140	140	140	139	139
143	142	142	141	141	141	141	141	141	141	141
144	143	143	143	143	143	143	142	142	142	142
145	144	144	144	144	144	144	144	144	144	144
146	145	145	145	145	145	145	145	145	145	145
147	147	147	147	147	147	147	147	147	146	146
148	148	148	148	148	148	148	148	148	148	148
149	149	149	149	149	149	149	149	149	149	149
150	150	150	151	151	151	151	151	151	151	151
151	152	152	152	152	152	152	152	152	152	152
152	153	153	153	153	153	153	153	153	154	154
153	154	154	154	154	155	155	155	155	155	155
154	156	156	156	156	156	156	156	156	156	156
155	157	157	157	157	157	157	157	158	158	158
156	158	158	158	158	159	159	159	159	159	159
157	159	159	160	160	160	160	160	160	161	161
158	161	161	161	161	161	161	162	162	162	162
159	162	162	162	162	163	163	163	163	163	164
160	163	163	164	164	164	164	164	165	165	165

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
80	49	48	46	45	43	42	40	38	36	34
81	51	49	48	46	45	43	41	40	38	36
82	52	51	49	48	46	45	43	41	40	38
83	54	52	51	49	48	46	45	43	41	39
84	55	54	52	51	49	48	46	45	43	41
85	57	55	54	52	51	49	48	46	45	43
86	58	57	55	54	52	51	49	48	46	44
87	59	58	57	55	54	53	51	49	48	46
88	61	60	58	57	56	54	53	51	49	48
89	62	61	60	58	57	56	54	53	51	49
90	64	63	61	60	59	57	56	54	53	51
91	65	64	63	62	60	59	57	56	54	53
92	67	66	64	63	62	60	59	58	56	54
93	68	67	66	65	63	62	61	59	58	56
94	70	68	67	66	65	63	62	61	59	58
95	71	70	69	68	66	65	64	62	61	59
96	73	71	70	69	68	67	65	64	63	61
97	74	73	72	71	69	68	67	66	64	63
98	75	74	73	72	71	70	68	67	66	64
99	77	76	75	74	72	71	70	69	68	66
100	78	77	76	75	74	73	72	70	69	68
101	80	79	78	77	76	74	73	72	71	69
102	81	80	79	78	77	76	75	74	72	71
103	83	82	81	80	79	78	76	75	74	73
104	84	83	82	81	80	79	78	77	76	74
105	86	85	84	83	82	81	80	78	77	76
106	87	86	85	84	83	82	81	80	79	78
107	88	88	87	86	85	84	83	82	81	79
108	90	89	88	87	86	85	84	83	82	81
109	91	91	90	89	88	87	86	85	84	83
110	93	92	91	90	89	88	88	87	86	84
111	94	93	93	92	91	90	89	88	87	86
112	96	95	94	93	92	92	91	90	89	88
113	97	96	96	95	94	93	92	91	90	89
114	99	98	97	96	96	95	94	93	92	91
115	100	99	99	98	97	96	95	95	94	93
116	102	101	100	99	99	98	97	96	95	94
117	103	102	102	101	100	99	99	98	97	96
118	104	104	103	102	102	101	100	99	99	98
119	106	105	105	104	103	103	102	101	100	99
120	107	107	106	105	105	104	103	103	102	101

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF 2.7

PERCENT of + 3/4 MATERIAL

DD	31	32	33	34	35	36	37	38	39	40
121	109	108	108	107	106	106	105	104	104	103
122	110	110	109	108	108	107	107	106	105	104
123	112	111	111	110	109	109	108	108	107	106
124	113	113	112	112	111	110	110	109	108	108
125	115	114	114	113	112	112	111	111	110	109
126	116	116	115	115	114	113	113	112	112	111
127	117	117	117	116	116	115	115	114	113	113
128	119	118	118	118	117	117	116	116	115	114
129	120	120	120	119	119	118	118	117	117	116
130	122	121	121	121	120	120	119	119	118	118
131	123	123	122	122	122	121	121	120	120	119
132	125	124	124	124	123	123	122	122	122	121
133	126	126	125	125	125	124	124	124	123	123
134	128	127	127	127	126	126	126	125	125	124
135	129	129	128	128	128	128	127	127	127	126
136	130	130	130	130	129	129	129	128	128	128
137	132	132	131	131	131	131	130	130	130	129
138	133	133	133	133	132	132	132	132	131	131
139	135	135	134	134	134	134	134	133	133	133
140	136	136	136	136	136	135	135	135	135	134
141	138	138	137	137	137	137	137	137	136	136
142	139	139	139	139	139	138	138	138	138	138
143	141	141	140	140	140	140	140	140	140	139
144	142	142	142	142	142	142	141	141	141	141
145	144	143	143	143	143	143	143	143	143	143
146	145	145	145	145	145	145	145	145	145	144
147	146	146	146	146	146	146	146	146	146	146
148	148	148	148	148	148	148	148	148	148	148
149	149	149	149	149	149	149	149	149	149	149
150	151	151	151	151	151	151	151	151	151	151
151	152	152	152	152	152	153	153	153	153	153
152	154	154	154	154	154	154	154	154	154	154
153	155	155	155	155	156	156	156	156	156	156
154	157	157	157	157	157	157	157	158	158	158
155	158	158	158	158	159	159	159	159	159	159
156	159	160	160	160	160	160	161	161	161	161
157	161	161	161	162	162	162	162	162	163	163
158	162	163	163	163	163	163	164	164	164	164
159	164	164	164	165	165	165	165	166	166	166
160	165	166	166	166	166	167	167	167	168	168

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

LAB NUMBER _____
AUTHORIZATION NUMBER _____
PROJECT NUMBER _____
DISTRICT _____
LOT NUMBER _____
ITEM NUMBER _____

FORM T-316
MP 207.07.20
REV. 08-22

GAUGE NUMBER		TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY		STATION NUMBER	ft.					
MOISTURE		OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY		LIFT THICKNESS	ft.					
MOISTURE		DEPTH OF SOURCE	ft.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3											
		MA	MOISTURE	lb/ft3											
		DB	DRY DENSITY -3/4	lb/ft3											
MB = $\frac{MA(100)}{DB}$		**MB**	MOISTURE	%											
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams											
CC = CA - CB		**CB**	PAN	grams											
CF = CD - CE		**CC**	EXCAVATED MAT.	grams											
CG = $\frac{CF(100)}{CC}$		**CD**	PLUS +3/4 MAT. + PAN	grams											
		CE	PAN	grams											
PC = PA - PB		**CF**	PLUS 3/4 MAT	grams											
PD = PC (0.066)		**CG**	PLUS 3/4 MAT	%											
PE = $\frac{PD(100)}{100+MB}$		**CH**	SPECIFIC GRAVITY												
					RERUN		RERUN		RERUN		RERUN		RERUN		
PE (RERUN) = $\frac{PD(100)}{100+SG}$	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams											
		PB	MOLD	grams											
RERUN PROCTOR		**PC**	WEIGHT OF SOIL	grams											
		PD	WET DENSITY	lb/ft^3											
		PE	DRY DENSITY	lb/ft3											
SC = SA - SB	STOVE DRIED MOISTURE	**SA**	WET WEIGHT + PAN	grams											
SE = SD - SB		**SB**	PAN	grams											
SF = SC - SE		**SC**	WET WEIGHT	grams											
SG = $\frac{SF(100)}{SE}$		**SD**	DRY WEIGHT + PAN	grams											
		SE	DRY WEIGHT	grams											
DE = $\frac{DB(100)}{DC}$		**SF**	MOISTURE	grams											
		SG	MOISTURE	%											
$\bar{X}$ = $\frac{\sum DE}{5}$	MOIST. EVAL	**OA**	OPTIMUM MOISTURE	%											
		OB	PLUS / MINUS TOLER.												
		OC	PASS / FAIL												
QL = $\frac{\bar{X}-T}{R}$	DEN EVAL	**DC**	MAXIMUM DENSITY	lb/ft3											
		DE	RELATIVE DENSITY	%											
	LOT EVALUATION	$\bar{X}$	AVERAGE **DE**	%											
		T	TARGET	%											
		QL	QUALITY INDEX												
		DF	WITHIN TOLERANCE	%											
		DG	MIN. FOR 100% PAY	%											
		DH	PASS / FAIL												

INSPECTORS NAME:

INSPECTORS SIGNATURE:

PROJECT'S EVALUATION

CHECKED BY:

DATE:

ONE-POINT PROCTOR EXAMPLE

MP 207.07.20

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

LAB NUMBER _____
AUTHORIZATION NUMBER _____
PROJECT NUMBER _____
DISTRICT _____
LOT NUMBER _____
ITEM NUMBER _____

FORM T-316
MP 207.07.20
REV. 08-22

GAUGE NUMBER		**TEST NUMBER**		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY		STATION NUMBER	ft.					
MOISTURE		OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY		LIFT THICKNESS	ft.					
MOISTURE		DEPTH OF SOURCE	ft.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3											
		MA	MOISTURE	lb/ft3											
		DB	DRY DENSITY -3/4	lb/ft3											
MB = $\frac{MA(100)}{DB}$		**MB**	MOISTURE	%											
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams											
CC = CA - CB		**CB**	PAN	grams											
CF = CD - CE		**CC**	EXCAVATED MAT.	grams											
CG = $\frac{CF(100)}{CC}$		**CD**	PLUS +3/4 MAT. + PAN	grams											
		CE	PAN	grams											
PC = PA - PB		**CF**	PLUS 3/4 MAT	grams											
PD = PC (0.066)		**CG**	PLUS 3/4 MAT	%											
PE = $\frac{PD(100)}{100+MB}$		**CH**	SPECIFIC GRAVITY												
					RERUN		RERUN		RERUN		RERUN		RERUN		
PE (RERUN) = $\frac{PD(100)}{100+SG}$	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams											
		PB	MOLD	grams											
RERUN PROCTOR		**PC**	WEIGHT OF SOIL	grams											
		PD	WET DENSITY	lb/ft^3											
		PE	DRY DENSITY	lb/ft3											
SC = SA - SB	STOVE DRIED MOISTURE	**SA**	WET WEIGHT + PAN	grams											
SE = SD - SB		**SB**	PAN	grams											
SF = SC - SE		**SC**	WET WEIGHT	grams											
SG = $\frac{SF(100)}{SE}$		**SD**	DRY WEIGHT + PAN	grams											
		SE	DRY WEIGHT	grams											
DE = $\frac{DB(100)}{DC}$		**SF**	MOISTURE	grams											
		SG	MOISTURE	%											
$\bar{X}$ = $\frac{\sum DE}{5}$	MOIST. EVAL	**OA**	OPTIMUM MOISTURE	%											
		OB	PLUS / MINUS TOLER.												
		OC	PASS / FAIL												
QL = $\frac{\bar{X}-T}{R}$	DEN EVAL	**DC**	MAXIMUM DENSITY	lb/ft3											
		DE	RELATIVE DENSITY	%											
	LOT EVALUATION	$\bar{X}$	AVERAGE **DE**	%											
		T	TARGET	%											
		QL	QUALITY INDEX												
		DF	WITHIN TOLERANCE	%											
		DG	MIN. FOR 100% PAY	%											
		DH	PASS / FAIL												

INSPECTORS NAME:

INSPECTORS SIGNATURE:

PROJECT'S EVALUATION

CHECKED BY:

DATE:

GAUGE NUMBER	36688	TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY	2935	STATION NUMBER	ft.					
MOISTURE	664	OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY	2902	LIFT THICKNESS	in.					
MOISTURE	658	DEPTH OF SOURCE	in.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3	127										
		MA	MOISTURE	lb/ft^3	12										
		DB	DRY DENSITY -3/4	lb/ft^3											
MB = MA (100) / DB		**MB**	MOISTURE	%											
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams											
CC = CA - CB		**CB**	PAN	grams											
CF = CD - CE		**CC**	EXCAVATED MAT.	grams											
CG = CF (100) / CC		**CD**	PLUS 3/4 MAT. + PAN	grams											
		CE	PAN	grams											
PC = PA - PB		**CF**	PLUS 3/4 MAT.	grams											
PD = PC (0.066)		**CG**	PLUS 3/4 MAT.	%											
PE = PD (100) / 100 + MB		**CH**	SPECIFIC GRAVITY												
						RERUN		**RERUN**		**RERUN**		**RERUN**		**RERUN**	
RERUN PROCTOR **PE (RERUN) =** PD (100) / 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams											
		PB	MOLD	grams											
		PC	WEIGHT OF SOIL	grams											
		PD	WET DENSITY	lb/ft^3											
		PE	DRY DENSITY	lb/ft^3											

GAUGE NUMBER	36688	TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY	2935	STATION NUMBER	ft.					
MOISTURE	664	OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY	2902	LIFT THICKNESS	in.					
MOISTURE	658	DEPTH OF SOURCE	in.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3	127										
		MA	MOISTURE	lb/ft^3	12										
		DB	DRY DENSITY -3/4	lb/ft^3											
MB = MA (100) / DB		**MB**	MOISTURE	%											
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams	4910										
CC = CA - CB		**CB**	PAN	grams	600										
CF = CD - CE		**CC**	EXCAVATED MAT.	grams	4310										
CG = CF (100) / CC		**CD**	PLUS 3/4 MAT. + PAN	grams											
		CE	PAN	grams											
PC = PA - PB		**CF**	PLUS 3/4 MAT.	grams											
PD = PC (0.066)		**CG**	PLUS 3/4 MAT.	%											
PE = PD (100) / 100 + MB		**CH**	SPECIFIC GRAVITY												
						RERUN		**RERUN**		**RERUN**		**RERUN**		**RERUN**	
RERUN PROCTOR **PE (RERUN) =** PD (100) / 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams											
		PB	MOLD	grams											
		PC	WEIGHT OF SOIL	grams											
		PD	WET DENSITY	lb/ft^3											
		PE	DRY DENSITY	lb/ft^3											

GAUGE NUMBER	36688		TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS			DATE						
DENSITY	2935		STATION NUMBER	ft.					
MOISTURE	664		OFFSET	ft.					
GAUGE STANDARD COUNTS			DEPTH BELOW GRADE	ft.					
DENSITY	2902		LIFT THICKNESS	in.					
MOISTURE	658		DEPTH OF SOURCE	in.					
DB FROM TABLES		Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3	127				
			MA	MOISTURE	lb/ft^3	12				
			DB	DRY DENSITY -3/4	lb/ft^3					
MB = MA (100) / DB			**MB**	MOISTURE	%					
CC = CA - CB		PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams	4910				
			CB	PAN	grams	600				
CF = CD - CE			**CC**	EXCAVATED MAT.	grams	4310				
CG = CF (100) / CC			**CD**	PLUS 3/4 MAT. + PAN	grams	859				
			CE	PAN	grams	600				
PC = PA - PB			**CF**	PLUS 3/4 MAT.	grams	259				
PD = PC (0.066)			**CG**	PLUS 3/4 MAT.	%					
PE = PD (100) / 100 + MB			**CH**	SPECIFIC GRAVITY						
						RERUN		RERUN		RERUN		RERUN		RERUN
RERUN PROCTOR **PE (RERUN) =** PD (100) / 100 + SG		ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams									
			PB	MOLD	grams									
			PC	WEIGHT OF SOIL	grams									
			PD	WET DENSITY	lb/ft^3									
			PE	DRY DENSITY	lb/ft^3									

GAUGE NUMBER	36688	TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY	2935	STATION NUMBER	ft.					
MOISTURE	664	OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY	2902	LIFT THICKNESS	in.					
MOISTURE	658	DEPTH OF SOURCE	in.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3	127										
		MA	MOISTURE	lb/ft^3	12										
		DB	DRY DENSITY -3/4	lb/ft^3											
MB = MA (100) / DB		**MB**	MOISTURE	%											
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams	4910										
CC = CA - CB		**CB**	PAN	grams	600										
CF = CD - CE		**CC**	EXCAVATED MAT.	grams	4310										
CG = CF (100) / CC		**CD**	PLUS 3/4 MAT. + PAN	grams	859										
		CE	PAN	grams	600										
PC = PA - PB		**CF**	PLUS 3/4 MAT.	grams	259										
PD = PC (0.066)		**CG**	PLUS 3/4 MAT.	%	6										
PE = PD (100) / 100 + MB		**CH**	SPECIFIC GRAVITY												
						RERUN		RERUN		RERUN		RERUN		RERUN	
RERUN PROCTOR **PE (RERUN) =** PD (100) / 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams											
		PB	MOLD	grams											
		PC	WEIGHT OF SOIL	grams											
		PD	WET DENSITY	lb/ft^3											
		PE	DRY DENSITY	lb/ft^3											

GAUGE NUMBER	36688	TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY	2935	STATION NUMBER	ft.					
MOISTURE	664	OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY	2902	LIFT THICKNESS	in.					
MOISTURE	658	DEPTH OF SOURCE	in.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3	127										
		MA	MOISTURE	lb/ft^3	12										
		DB	DRY DENSITY -3/4	lb/ft^3											
MB = MA (100) / DB		**MB**	MOISTURE	%											
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams	4910										
CC = CA - CB		**CB**	PAN	grams	600										
CF = CD - CE		**CC**	EXCAVATED MAT.	grams	4310										
CG = CF (100) / CC		**CD**	PLUS 3/4 MAT. + PAN	grams	859										
		CE	PAN	grams	600										
PC = PA - PB		**CF**	PLUS 3/4 MAT.	grams	259										
PD = PC (0.066)		**CG**	PLUS 3/4 MAT.	%	6										
PE = PD (100) / 100 + MB		**CH**	SPECIFIC GRAVITY		2.6										
						RERUN		RERUN		RERUN		RERUN		RERUN	
RERUN PROCTOR **PE (RERUN) =** PD (100) / 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams											
		PB	MOLD	grams											
		PC	WEIGHT OF SOIL	grams											
		PD	WET DENSITY	lb/ft^3											
		PE	DRY DENSITY	lb/ft^3											

CH

MP 207.07.20
ATTACHMENT NO. 5
18 OF 32

WEST VIRGINIA DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING

DENSITY OF -3/4 INCH MATERIAL WITH THE +3/4 INCH MATERIAL SPECIFIC GRAVITY OF **2.6**

PERCENT of + 3/4 MATERIAL

DD	1	2	3	4	5	6	7	8	9	10
121	121	121	120	120	120	120	119	119	119	119
122	122	122	121	121	121	121	120	120	120	120
123	123	123	122	122	122	122	122	121	121	121
124	124	124	123	123	123	123	123	122	122	122
125	125	125	124	124	124	124	124	123	123	123
126	126	126	125	125	125	125	125	125	124	124
127	127	127	127	126	126	126	126	126	125	125
128	128	128	128	127	127	127	127	127	127	126
129	129	129	129	128	128	128	128	128	128	127
130	130	130	130	129	129	129	129	129	129	129
131	131	131	131	131	130	130	130	130	130	130
132	132	132	132	132	131	131	131	131	131	131
133	133	133	133	133	132	132	132	132	132	132
134	134	134	134	134	134	133	133	133	133	133
135	135	135	135	135	135	135	134	134	134	134

DA

CG

GAUGE NUMBER	36688			TEST NUMBER		1		2		3		4		5		
MANUFACTURER'S STANDARDS				DATE												
DENSITY	2935			STATION NUMBER	ft.											
MOISTURE	664			OFFSET	ft.											
GAUGE STANDARD COUNTS				DEPTH BELOW GRADE	ft.											
DENSITY	2902			LIFT THICKNESS	in.											
MOISTURE	658			DEPTH OF SOURCE	in.											
DB FROM TABLES		Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3	127										
			MA	MOISTURE	lb/ft^3	12										
			DB	DRY DENSITY -3/4	lb/ft^3	126										
MB = MA (100) / DB			**MB**	MOISTURE	%	10										
		PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams	4910										
CC = CA - CB			**CB**	PAN	grams	600										
CF = CD - CE			**CC**	EXCAVATED MAT.	grams	4310										
CG = CF (100) / CC			**CD**	PLUS 3/4 MAT. + PAN	grams	859										
			CE	PAN	grams	600										
PC = PA - PB			**CF**	PLUS 3/4 MAT.	grams	259										
PD = PC (0.066)			**CG**	PLUS 3/4 MAT.	%	6										
PE = PD (100) / 100 + MB			**CH**	SPECIFIC GRAVITY		2.6										
							RERUN		RERUN		RERUN		RERUN		RERUN	
RERUN PROCTOR **PE (RERUN) =** PD (100) / 100 + SG		ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams											
			PB	MOLD	grams											
			PC	WEIGHT OF SOIL	grams											
			PD	WET DENSITY	lb/ft^3											
			PE	DRY DENSITY	lb/ft^3											

GAUGE NUMBER	36688	TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY	2935	STATION NUMBER	ft.					
MOISTURE	664	OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY	2902	LIFT THICKNESS	in.					
MOISTURE	658	DEPTH OF SOURCE	in.					

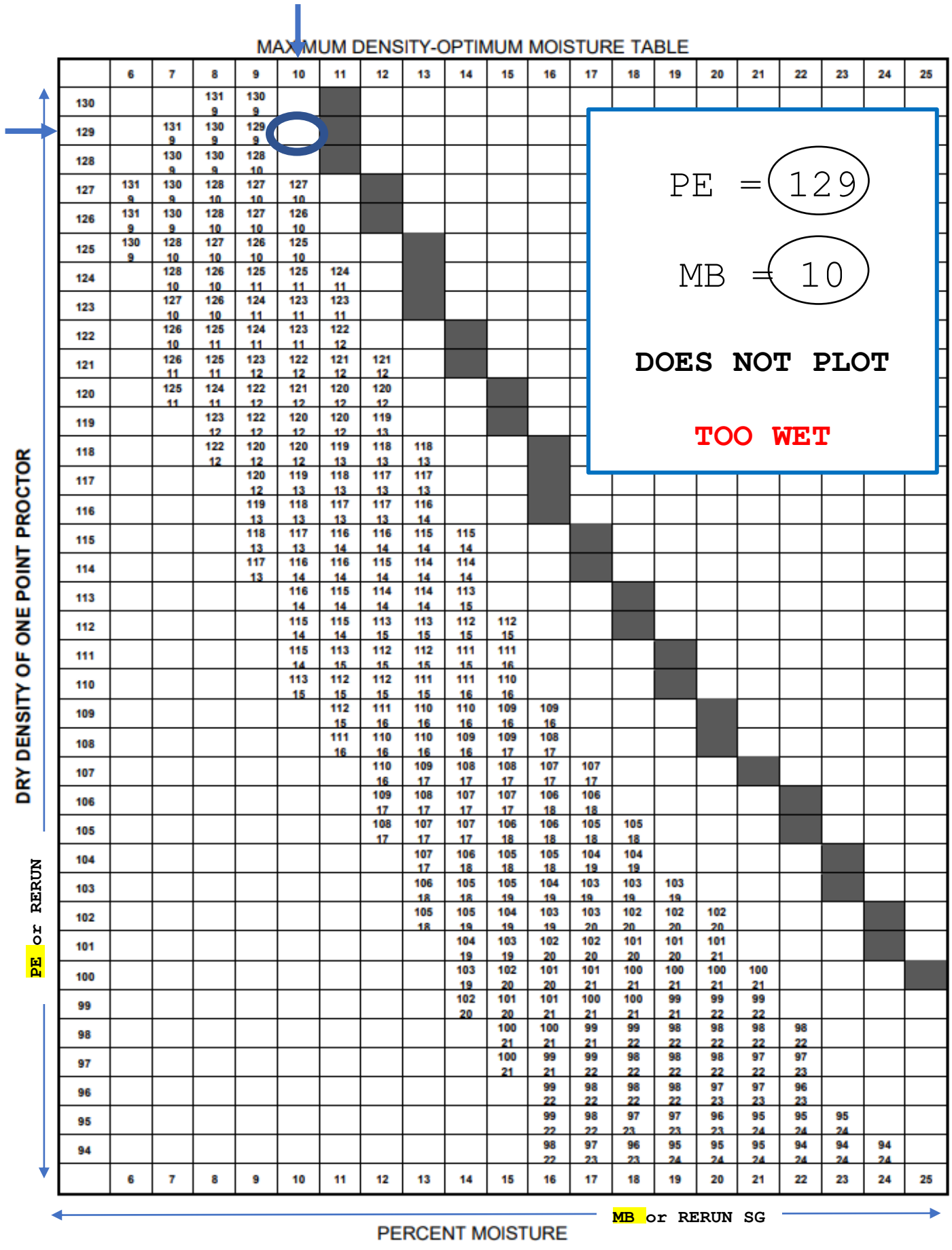
DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3	127									
		MA	MOISTURE	lb/ft^3	12									
		DB	DRY DENSITY -3/4	lb/ft^3	126									
MB = MA (100) / DB		**MB**	MOISTURE	%	10									
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams	4910									
CC = CA - CB		**CB**	PAN	grams	600									
CF = CD - CE		**CC**	EXCAVATED MAT.	grams	4310									
CG = CF (100) / CC		**CD**	PLUS 3/4 MAT. + PAN	grams	859									
		CE	PAN	grams	600									
PC = PA - PB		**CF**	PLUS 3/4 MAT.	grams	259									
PD = PC (0.066)		**CG**	PLUS 3/4 MAT.	%	6									
PE = PD (100) / 100 + MB		**CH**	SPECIFIC GRAVITY		2.6									
						RERUN		RERUN		RERUN		RERUN		RERUN
RERUN PROCTOR **PE (RERUN) =** PD (100) / 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180									
		PB	MOLD	grams	2023									
		PC	WEIGHT OF SOIL	grams	2157									
		PD	WET DENSITY	lb/ft^3										
		PE	DRY DENSITY	lb/ft^3										

GAUGE NUMBER	36688	TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY	2935	STATION NUMBER	ft.					
MOISTURE	664	OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY	2902	LIFT THICKNESS	in.					
MOISTURE	658	DEPTH OF SOURCE	in.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3	127											
		MA	MOISTURE	lb/ft^3	12											
		DB	DRY DENSITY -3/4	lb/ft^3	126											
MB = MA (100) / DB		**MB**	MOISTURE	%	10											
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams	4910											
CC = CA - CB		**CB**	PAN	grams	600											
CF = CD - CE		**CC**	EXCAVATED MAT.	grams	4310											
CG = CF (100) / CC		**CD**	PLUS 3/4 MAT. + PAN	grams	859											
		CE	PAN	grams	600											
PC = PA - PB		**CF**	PLUS 3/4 MAT.	grams	259											
PD = PC (0.066)		**CG**	PLUS 3/4 MAT.	%	6											
PE = PD (100) / 100 + MB		**CH**	SPECIFIC GRAVITY		2.6											
						RERUN		RERUN		RERUN		RERUN		RERUN		
RERUN PROCTOR **PE (RERUN) =** PD (100) / 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180											
		PB	MOLD	grams	2023											
		PC	WEIGHT OF SOIL	grams	2157											
		PD	WET DENSITY	lb/ft^3	142											
		PE	DRY DENSITY	lb/ft^3												

GAUGE NUMBER	36688	TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY	2935	STATION NUMBER	ft.					
MOISTURE	664	OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY	2902	LIFT THICKNESS	in.					
MOISTURE	658	DEPTH OF SOURCE	in.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3	127									
		MA	MOISTURE	lb/ft^3	12									
		DB	DRY DENSITY -3/4	lb/ft^3	126									
MB = MA (100) / DB		**MB**	MOISTURE	%	10									
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams	4910									
CC = CA - CB		**CB**	PAN	grams	600									
CF = CD - CE		**CC**	EXCAVATED MAT.	grams	4310									
CG = CF (100) / CC		**CD**	PLUS 3/4 MAT. + PAN	grams	859									
		CE	PAN	grams	600									
PC = PA - PB		**CF**	PLUS 3/4 MAT.	grams	259									
PD = PC (0.066)		**CG**	PLUS 3/4 MAT.	%	6									
PE = PD (100) / 100 + MB		**CH**	SPECIFIC GRAVITY		2.6									
						RERUN		RERUN		RERUN		RERUN		RERUN
RERUN PROCTOR **PE (RERUN)** = PD (100) / 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180									
		PB	MOLD	grams	2023									
		PC	WEIGHT OF SOIL	grams	2157									
		PD	WET DENSITY	lb/ft^3	142									
		PE	DRY DENSITY	lb/ft^3	129									


MAXIMUM DENSITY-OPTIMUM MOISTURE TABLE
DRY DENSITY OF ONE POINT PROCTOR
PE or RERUN
PERCENT MOISTURE
MB or RERUN SG
PE = 129
MB = 10
DOES NOT PLOT
TOO WET

GAUGE NUMBER	36688	TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY	2935	STATION NUMBER	ft.					
MOISTURE	664	OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY	2902	LIFT THICKNESS	in.					
MOISTURE	658	DEPTH OF SOURCE	in.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3	127										
		MA	MOISTURE	lb/ft^3	12										
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MB = MA (100) / DB		**MB**	MOISTURE	%	10										
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams	4910										
CC = CA - CB		**CB**	PAN	grams	600										
CF = CD - CE		**CC**	EXCAVATED MAT.	grams	4310										
CG = CF (100) / CC		**CD**	PLUS 3/4 MAT. + PAN	grams	859										
		CE	PAN	grams	600										
PC = PA - PB		**CF**	PLUS 3/4 MAT.	grams	259										
PD = PC (0.066)		**CG**	PLUS 3/4 MAT.	%	6										
PE = PD (100) / 100 + MB		**CH**	SPECIFIC GRAVITY		2.6										
						RERUN		RERUN		RERUN		RERUN		RERUN	
RERUN PROCTOR **PE (RERUN) =** PD (100) / 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180	4131									
		PB	MOLD	grams	2023	2023									
		PC	WEIGHT OF SOIL	grams	2157	2108									
		PD	WET DENSITY	lb/ft^3	142	139									
		PE	DRY DENSITY	lb/ft^3	129										

GAUGE NUMBER	36688	TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY	2935	STATION NUMBER	ft.					
MOISTURE	664	OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY	2902	LIFT THICKNESS	in.					
MOISTURE	658	DEPTH OF SOURCE	in.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3	127										
		MA	MOISTURE	lb/ft^3	12										
		DB	DRY DENSITY -3/4	lb/ft^3	126										
MB = MA (100) / DB		**MB**	MOISTURE	%	10										
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams	4910										
CC = CA - CB		**CB**	PAN	grams	600										
CF = CD - CE		**CC**	EXCAVATED MAT.	grams	4310										
CG = CF (100) / CC		**CD**	PLUS 3/4 MAT. + PAN	grams	859										
		CE	PAN	grams	600										
PC = PA - PB		**CF**	PLUS 3/4 MAT.	grams	259										
PD = PC (0.066)		**CG**	PLUS 3/4 MAT.	%	6										
~~**PE** = PD (100) / 100 + MB~~		**CH**	SPECIFIC GRAVITY		2.6										
						RERUN		RERUN		RERUN		RERUN		RERUN	
RERUN PROCTOR **PE (RERUN)** = PD (100) / 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180	4131									
		PB	MOLD	grams	2023	2023									
		PC	WEIGHT OF SOIL	grams	2157	2108									
		PD	WET DENSITY	lb/ft^3	142	139									
		PE	DRY DENSITY	lb/ft^3	129										

RERUN PROCTOR

PE (RERUN) = $\frac{PD\ (100)}{100 + SG}$

SC = SA - SB

SE = SD - SB

SF = SC - SE

SG = $\frac{SF\ (100)}{SE}$

DE = $\frac{DB\ (100)}{DC}$

$\overline{X} = \frac{\Sigma\ DE}{5}$

$QL = \frac{\overline{X} - T}{R}$

					RERUN		RERUN		RERUN		RERUN		RERUN	
ONE POINT PROCTOR	PA	WEIGHT SOIL & MOLD	grams	4180	4131									
	PB	MOLD	grams	2023	2023									
	PC	WEIGHT OF SOIL	grams	2157	2108									
	PD	WET DENSITY	lb/ft^3	142	139									
	PE	DRY DENSITY	lb/ft^3	129										
STOVE DRIED MOISTURE	SA	WET WEIGHT + PAN	grams											
	SB	PAN	grams											
	SC	WET WEIGHT	grams											
	SD	DRY WEIGHT + PAN	grams											
	SE	DRY WEIGHT	grams											
	SF	MOISTURE	grams											
	SG	MOISTURE	%											
MOIST. EVAL.	OA	OPTIMUM MOISTURE	%											
	OB	PLUS / MINUS TOLER.												
	OC	PASS / FAIL												
DEN EVAL	DC	MAXIMUM DENSITY	lb/ft^3											
	DE	RELATIVE DENSITY	%											
LOT EVALUATION	$\overline{X}$	AVERAGE **DE**	%											
	T	TARGET	%											
	QL	QUALITY INDEX												
	DF	WITHIN TOLERANCE	%											
	DG	MIN. FOR 100% PAY	%											
	DH	PASS / FAIL	YES	NO										

INSPECTOR'S NAME:

INSPECTOR'S SIGNATURE:

PROJECT'S EVALUATION

CHECKED BY:

DATE:

NEED SG

						RERUN		RERUN		RERUN		RERUN		RERUN
RERUN PROCTOR **PE (RERUN) =** PD (100) 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180	4131								
		PB	MOLD	grams	2023	2023								
		PC	WEIGHT OF SOIL	grams	2157	2108								
		PD	WET DENSITY	lb/ft^3	142	139								
		PE	DRY DENSITY	lb/ft^3	129									
SC = SA - SB	STOVE DRIED MOISTURE	**SA**	WET WEIGHT + PAN	grams	2027									
SE = SD - SB		**SB**	PAN	grams	1811									
SF = SC - SE		**SC**	WET WEIGHT	grams	216									
SG = SF (100) SE		**SD**	DRY WEIGHT + PAN	grams										
		SE	DRY WEIGHT	grams										
DE = DB (100) DC		**SF**	MOISTURE	grams										
		SG	MOISTURE	%										
$\overline{X} = \frac{\Sigma DE}{5}$	MOIST. EVAL.	**OA**	OPTIMUM MOISTURE	%										
		OB	PLUS / MINUS TOLER.											
		OC	PASS / FAIL											
$QL = \frac{\overline{X} - T}{R}$	DEN EVAL	**DC**	MAXIMUM DENSITY	lb/ft^3										
		DE	RELATIVE DENSITY	%										
	LOT EVALUATION	$\overline{X}$	AVERAGE **DE**	%		INSPECTOR'S NAME:								
		T	TARGET	%		INSPECTOR'S SIGNATURE:								
		QL	QUALITY INDEX											
		DF	WITHIN TOLERANCE	%		PROJECT'S EVALUATION								
		DG	MIN. FOR 100% PAY	%		CHECKED BY:								
		DH	PASS / FAIL	YES	NO	DATE:								

						RERUN		RERUN		RERUN		RERUN		RERUN
RERUN PROCTOR **PE (RERUN) =** PD (100) 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180	4131								
		PB	MOLD	grams	2023	2023								
		PC	WEIGHT OF SOIL	grams	2157	2108								
		PD	WET DENSITY	lb/ft^3	142	139								
		PE	DRY DENSITY	lb/ft^3	129									
SC = SA - SB **SE** = SD - SB **SF** = SC - SE **SG** = SF (100) / SE **DE** = DB (100) / DC	STOVE DRIED MOISTURE	**SA**	WET WEIGHT + PAN	grams	2027									
		SB	PAN	grams	1811									
		SC	WET WEIGHT	grams	216									
		SD	DRY WEIGHT + PAN	grams	2011									
		SE	DRY WEIGHT	grams	200									
		SF	MOISTURE	grams										
		SG	MOISTURE	%										
$\overline{X} = \frac{\Sigma DE}{5}$	MOIST. EVAL.	**OA**	OPTIMUM MOISTURE	%										
		OB	PLUS / MINUS TOLER.											
		OC	PASS / FAIL											
$QL = \frac{\overline{X} - T}{R}$	DEN EVAL	**DC**	MAXIMUM DENSITY	lb/ft^3										
		DE	RELATIVE DENSITY	%										
	LOT EVALUATION	$\overline{X}$	AVERAGE **DE**	%										
		T	TARGET	%										
		QL	QUALITY INDEX											
		DF	WITHIN TOLERANCE	%										
		DG	MIN. FOR 100% PAY	%										
		DH	PASS / FAIL	YES	NO									

INSPECTOR'S NAME:	
INSPECTOR'S SIGNATURE:	
PROJECT'S EVALUATION	
CHECKED BY:	
DATE:	

RERUN PROCTOR

PE (RERUN) = $\frac{PD\ (100)}{100 + SG}$

SC = SA - SB

SE = SD - SB

SF = SC - SE

SG = $\frac{SF\ (100)}{SE}$

DE = $\frac{DB\ (100)}{DC}$

$\overline{X} = \frac{\Sigma\ DE}{5}$

$QL = \frac{\overline{X} - T}{R}$

						RERUN		RERUN		RERUN		RERUN		RERUN
ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180	4131									
	PB	MOLD	grams	2023	2023									
	PC	WEIGHT OF SOIL	grams	2157	2108									
	PD	WET DENSITY	lb/ft^3	142	139									
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STOVE DRIED MOISTURE	**SA**	WET WEIGHT + PAN	grams	2027										
	SB	PAN	grams	1811										
	SC	WET WEIGHT	grams	216										
	SD	DRY WEIGHT + PAN	grams	2011										
	SE	DRY WEIGHT	grams	200										
	SF	MOISTURE	grams	16										
	SG	MOISTURE	%											
MOIST. EVAL.	**OA**	OPTIMUM MOISTURE	%											
	OB	PLUS / MINUS TOLER.												
	OC	PASS / FAIL												
DEN EVAL	**DC**	MAXIMUM DENSITY	lb/ft^3											
	DE	RELATIVE DENSITY	%											
LOT EVALUATION	$\overline{X}$	AVERAGE **DE**	%											
	T	TARGET	%											
	QL	QUALITY INDEX												
	DF	WITHIN TOLERANCE	%											
	DG	MIN. FOR 100% PAY	%											
	DH	PASS / FAIL	YES	NO										

INSPECTOR'S NAME:

INSPECTOR'S SIGNATURE:

PROJECT'S EVALUATION

CHECKED BY:

DATE:

						RERUN	RERUN	RERUN	RERUN	RERUN
RERUN PROCTOR **PE (RERUN) =** PD (100) 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180	4131				
		PB	MOLD	grams	2023	2023				
		PC	WEIGHT OF SOIL	grams	2157	2108				
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SC = SA - SB	STOVE DRIED MOISTURE	**SA**	WET WEIGHT + PAN	grams	2027					
SE = SD - SB		**SB**	PAN	grams	1811					
SF = SC - SE		**SC**	WET WEIGHT	grams	216					
SG = SF (100) / SE		**SD**	DRY WEIGHT + PAN	grams	2011					
		SE	DRY WEIGHT	grams	200					
DE = DB (100) / DC		**SF**	MOISTURE	grams	16					
		SG	MOISTURE	%	8					
$\overline{X} = \frac{\Sigma\ DE}{5}$	MOIST. EVAL.	**OA**	OPTIMUM MOISTURE	%						
		OB	PLUS / MINUS TOLER.							
		OC	PASS / FAIL							
$QL = \frac{\overline{X} - T}{R}$	DEN EVAL	**DC**	MAXIMUM DENSITY	lb/ft^3						
		DE	RELATIVE DENSITY	%						
	LOT EVALUATION	$\overline{X}$	AVERAGE **DE**	%		INSPECTOR'S NAME:				
		T	TARGET	%		INSPECTOR'S SIGNATURE:				
		QL	QUALITY INDEX							
		DF	WITHIN TOLERANCE	%		PROJECT'S EVALUATION				
		DG	MIN. FOR 100% PAY	%		CHECKED BY:				
		DH	PASS / FAIL	YES	NO	DATE:				

RERUN PROCTOR

PE (RERUN) = $\frac{PD\ (100)}{100 + SG}$

SC = SA - SB

SE = SD - SB

SF = SC - SE

SG = $\frac{SF\ (100)}{SE}$

DE = $\frac{DB\ (100)}{DC}$

$\overline{X} = \frac{\Sigma\ DE}{5}$

$QL = \frac{\overline{X} - T}{R}$

						RERUN		RERUN		RERUN		RERUN		RERUN
ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180	4131									
	PB	MOLD	grams	2023	2023									
	PC	WEIGHT OF SOIL	grams	2157	2108									
	PD	WET DENSITY	lb/ft^3	142	139									
	PE	DRY DENSITY	lb/ft^3	129	129									
STOVE DRIED MOISTURE	**SA**	WET WEIGHT + PAN	grams	2027										
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	SC	WET WEIGHT	grams	216										
	SD	DRY WEIGHT + PAN	grams	2011										
	SE	DRY WEIGHT	grams	200										
	SF	MOISTURE	grams	16										
	SG	MOISTURE	%	8										
MOIST. EVAL.	**OA**	OPTIMUM MOISTURE	%											
	OB	PLUS / MINUS TOLER.												
	OC	PASS / FAIL												
DEN EVAL	**DC**	MAXIMUM DENSITY	lb/ft^3											
	DE	RELATIVE DENSITY	%											
LOT EVALUATION	$\overline{X}$	AVERAGE **DE**	%											
	T	TARGET	%											
	QL	QUALITY INDEX												
	DF	WITHIN TOLERANCE	%											
	DG	MIN. FOR 100% PAY	%											
	DH	PASS / FAIL	YES	NO										

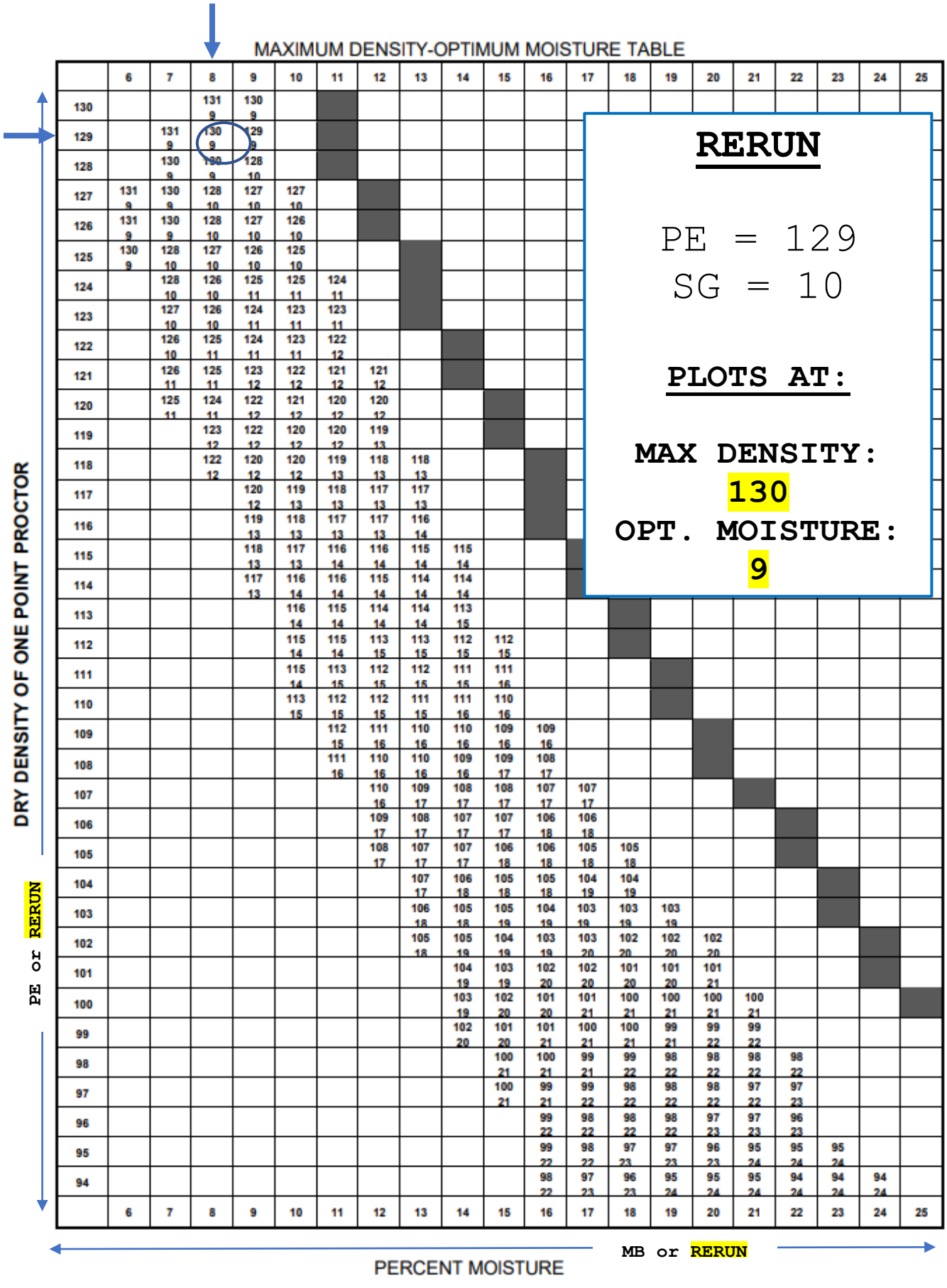
INSPECTOR'S NAME:

INSPECTOR'S SIGNATURE:

PROJECT'S EVALUATION

CHECKED BY:

DATE:


MAXIMUM DENSITY-OPTIMUM MOISTURE TABLE
RERUN
PE = 129
SG = 10
PLOTS AT:
MAX DENSITY:
130
OPT. MOISTURE:
9
DRY DENSITY OF ONE POINT PROCTOR
PE or RERUN
PERCENT MOISTURE
MB or RERUN

						RERUN		RERUN		RERUN		RERUN		RERUN
RERUN PROCTOR **PE (RERUN) =** PD (100) 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180	4131								
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SC = SA - SB	STOVE DRIED MOISTURE	**SA**	WET WEIGHT + PAN	grams	2027									
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		SE	DRY WEIGHT	grams	200									
DE = DB (100) DC		**SF**	MOISTURE	grams	16									
		SG	MOISTURE	%	8									
$\overline{X} = \frac{\Sigma DE}{5}$	MOIST. EVAL.	**OA**	OPTIMUM MOISTURE	%	9									
		OB	PLUS / MINUS TOLER.		+3/-4									
		OC	PASS / FAIL											
$QL = \frac{\overline{X} - T}{R}$	DEN EVAL	**DC**	MAXIMUM DENSITY	lb/ft^3	130									
		DE	RELATIVE DENSITY	%										
	LOT EVALUATION	$\overline{X}$	AVERAGE **DE**	%										
		T	TARGET	%										
		QL	QUALITY INDEX											
		DF	WITHIN TOLERANCE	%										
		DG	MIN. FOR 100% PAY	%										
		DH	PASS / FAIL	YES	NO									

Specification

% Moisture (MB)

Must be within +3 and -4 of Optimum Moisture

Optimum Moisture = 9%

9+3=12

9-4=5

Range = 5% to 12%

INSPECTOR'S NAME:

INSPECTOR'S SIGNATURE:

PROJECT'S EVALUATION

CHECKED BY:

DATE:

GAUGE NUMBER	36688	TEST NUMBER		1	2	3	4	5
MANUFACTURER'S STANDARDS		DATE						
DENSITY	2935	STATION NUMBER	ft.					
MOISTURE	664	OFFSET	ft.					
GAUGE STANDARD COUNTS		DEPTH BELOW GRADE	ft.					
DENSITY	2902	LIFT THICKNESS	in.					
MOISTURE	658	DEPTH OF SOURCE	in.					

DB FROM TABLES	Field Density Moisture	**DA**	TOTAL DRY DENSITY	lb/ft^3	127										
		MA	MOISTURE	lb/ft^3	12										
		DB	DRY DENSITY -3/4	lb/ft^3	126										
MB = MA (100) / DB		**MB**	MOISTURE	%	10										
	PLUS 3/4 MATERIAL DETERMINATION	**CA**	EXC. MATERIAL + PAN	grams	4910										
CC = CA - CB		**CB**	PAN	grams	600										
CF = CD - CE		**CC**	EXCAVATED MAT.	grams	4310										
CG = CF (100) / CC		**CD**	PLUS 3/4 MAT. + PAN	grams	859										
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PD = PC (0.066)		**CG**	PLUS 3/4 MAT.	%	6										
PE = PD (100) / 100 + MB		**CH**	SPECIFIC GRAVITY		2.6										
						RERUN		RERUN		RERUN		RERUN		RERUN	
RERUN PROCTOR **PE (RERUN) =** PD (100) / 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180	4131									
		PB	MOLD	grams	2023	2023									
		PC	WEIGHT OF SOIL	grams	2157	2108									
		PD	WET DENSITY	lb/ft^3	142	139									
		PE	DRY DENSITY	lb/ft^3	129	129									

% MOISTURE (MB)

+3/-4 of Optimum 9

Range
5% to 12%

						RERUN		RERUN		RERUN		RERUN		RERUN		RERUN
RERUN PROCTOR **PE (RERUN) =** PD (100) 100 + SG	ONE POINT PROCTOR	**PA**	WEIGHT SOIL & MOLD	grams	4180	4131										
		PB	MOLD	grams	2023	2023										
		PC	WEIGHT OF SOIL	grams	2157	2108										
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SC = SA - SB	STOVE DRIED MOISTURE	**SA**	WET WEIGHT + PAN	grams	2027											
SE = SD - SB		**SB**	PAN	grams	1811											
SF = SC - SE		**SC**	WET WEIGHT	grams	216											
SG = SF (100) SE		**SD**	DRY WEIGHT + PAN	grams	2011											
		SE	DRY WEIGHT	grams	200											
DE = DB (100) DC		**SF**	MOISTURE	grams	16											
		SG	MOISTURE	%	8											
$\overline{X} = \frac{\Sigma\ DE}{5}$	MOIST. EVAL.	**OA**	OPTIMUM MOISTURE	%	9											
		OB	PLUS / MINUS TOLER.		+3/-4											
		OC	PASS / FAIL		PASS											
$QL = \frac{\overline{X} - T}{R}$	DEN EVAL	**DC**	MAXIMUM DENSITY	lb/ft^3	130											
		DE	RELATIVE DENSITY	%	97											
	LOT EVALUATION	$\overline{X}$	AVERAGE **DE**	%			INSPECTOR'S NAME:									
		T	TARGET	%			INSPECTOR'S SIGNATURE:									
		QL	QUALITY INDEX													
		DF	WITHIN TOLERANCE	%			PROJECT'S EVALUATION									
		DG	MIN. FOR 100% PAY	%			CHECKED BY:									
		DH	PASS / FAIL	YES	NO		DATE:									

West Virginia Department of Transportation

Report Fraud, Waste and Abuse

Call the WVDOT

Office of Investigations

HOTLINE

1-866-206-2728

Mail:

WVDOT Office of Investigations
1900 Kanawha Boulevard East
Building #5 Room 503
Charleston, WV 25305

Email:

DOT.Fraud@wv.gov

Designed by the WVDOT Office of Communications