



# **Radiation Safety and Nuclear Gauge Field Technician Certification Class**

## **(TDOT Employees Only)**

**2024 Version**



# Instructor



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# USDOT Hazmat Training Requirements – 49 CFR Part 172, Subpart H Training

## Training Defined:

Training means a program that ensures a hazmat employee has general knowledge, is able to recognize and identify hazardous materials, has knowledge of specific requirement's, has knowledge of emergency response information, self-protection measures and accident prevention methods and procedures.

## Who needs this training?

- Anyone who handles hazardous materials.
- Training **MUST** be completed before you are allowed to use and/or transport nuclear density gauge with TDOT.



## What is a hazardous material?

Hazardous material is a substance or material that the Secretary of Transportation has determined capable of posing an unreasonable risk to health, safety, and property.

## What companies must follow DOT training?

Any company who has employees that perform work that is regulated by the US DOT Hazardous Materials Regulations (HMR).

## What training is required?

General Awareness/Familiarization Training

Security Awareness Training

Safety Training

## How often must training be updated or repeated?

The training requirements must be repeated every **THREE** years.

\*TDOT will give a refresher test at the beginning of each calendar year.



# TDOT Nuclear Gauge Program

- In accordance with Federal Regulations, all gauges are monitored under TDOT's License with the Tennessee Department of Environment and Conservation, Division of Radiological Health (TDEC)
- This license lists all radioactive sources owned and maintained by TDOT and dictates how they will be transported, secured, and monitored.
- The license is maintained by HQ Materials & Test.



# Testing Requirements

## Test:

- **50** question test pertaining to Radiation Safety and Field Certification Course.
- **All** questions are multiple choice.
- Must score **70%** or better to pass.
- Be sure to answer all questions.
- You will receive an email from **TCAT** once your test has been graded.
- When I receive your score from TCAT, I will email you a new hazmat certificate providing you have passed the test.



# Radiation Safety Course

## What we will cover:

1. Radioactivity Awareness
2. Dosimeter Badges
3. Nuclear Gauge Storage
4. Transportation Requirements
5. Nuclear Gauge Uses
6. Emergency Response Plan



# Radioactivity Awareness



# We have 3 types of gauges



**HUMBOLDT  
5001EZ2**



**TROXLER  
3430**

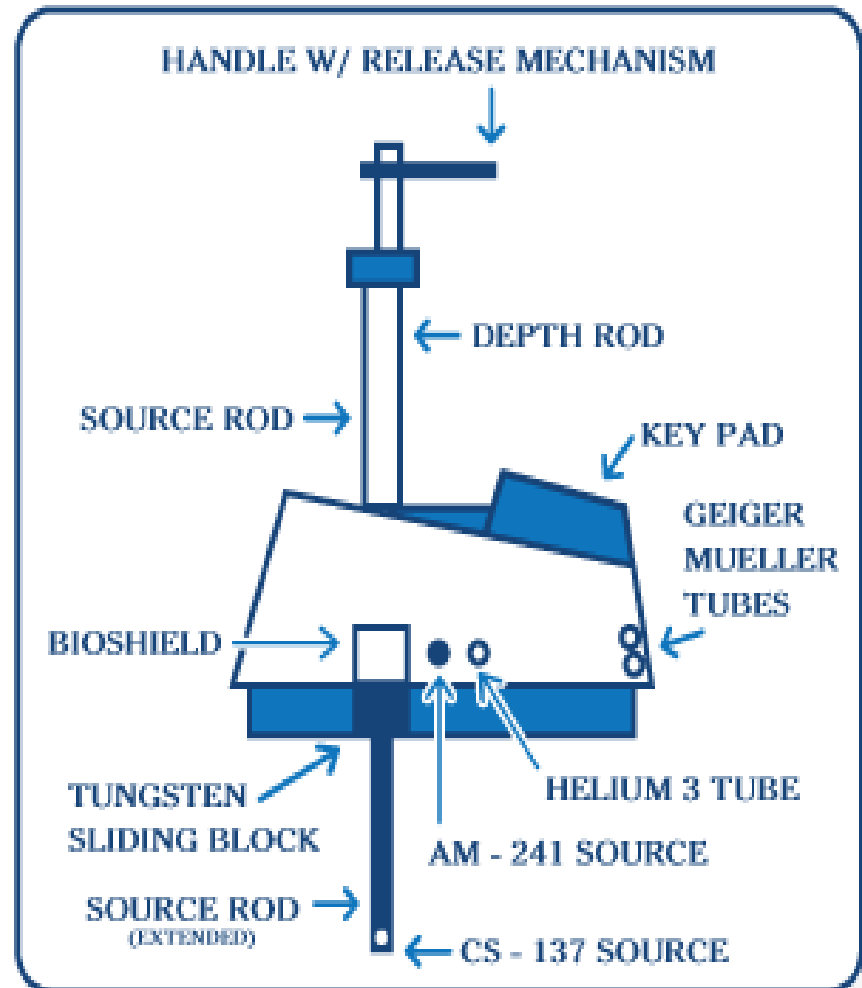


**INSTROTEK  
3500 Xplorer**



# Radioactivity

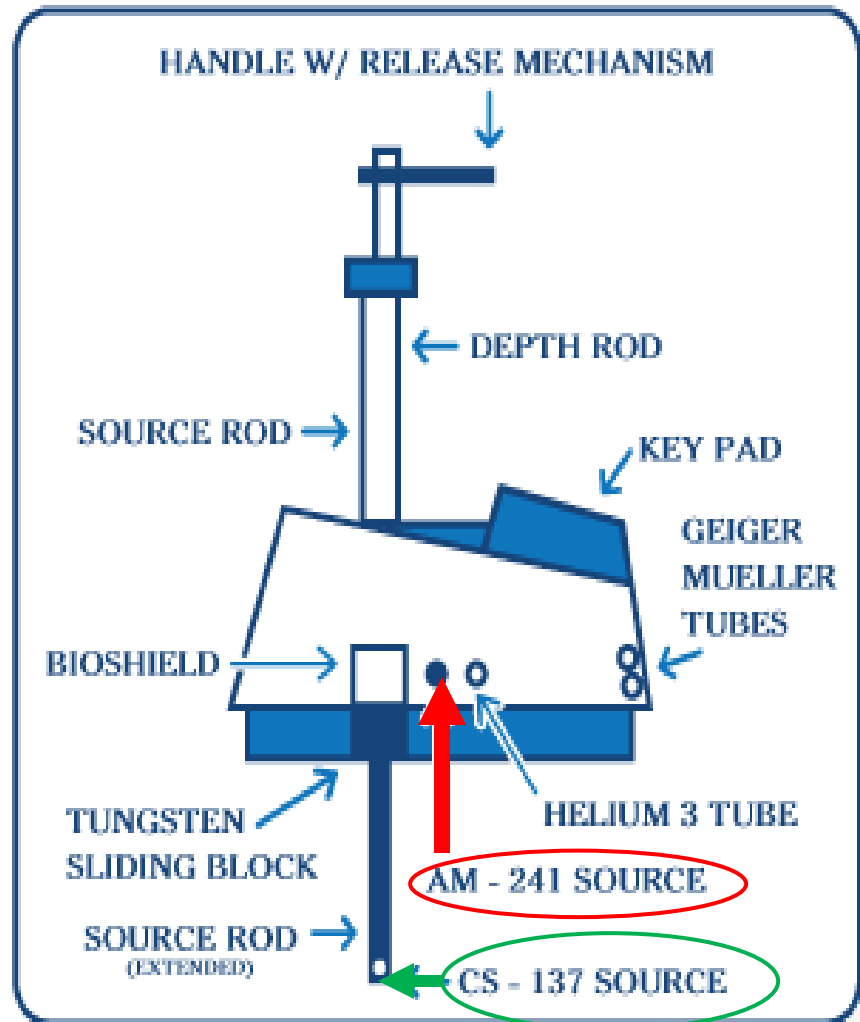
- A small amount of radioactive material is embedded at the end of the source rod and in the base of the gauge which emits radiation.
- By detecting the amount of this controlled radiation that passes through a given material, a gauge can estimate the density of that material.
  - ❖ **Higher density material** → Allows less radiation to pass through
  - ❖ **Lower density material** → Allows more radiation to pass through



# Radioactivity

Source location and type of source in our density gauges.

- ❖ Cesium-137 (Cs-137) is located at the end of a retractable source rod. **(GREEN)**
- ❖ **Cs-137 is a Gamma source.**
- ❖ Americium-241: Beryllium (Am-241) is located in the base of the gauge. **(RED)**
- ❖ **Am-241 is a Neutron source.**



# **Direct Transmission**

**vs.**

# **Backscatter Modes**



# Direct Transmission

## Moisture Density Gauge

### Direct Transmission

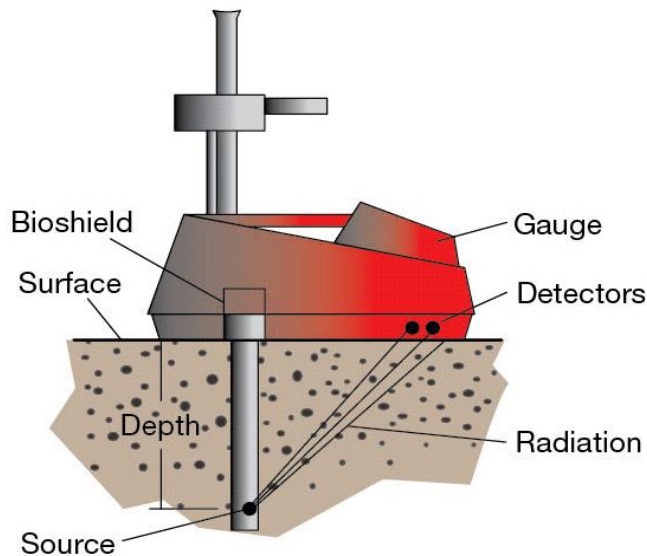


Photo courtesy: APNGA

*A moisture density gauge indicates whether a foundation is suitable for constructing a building or roadway.*

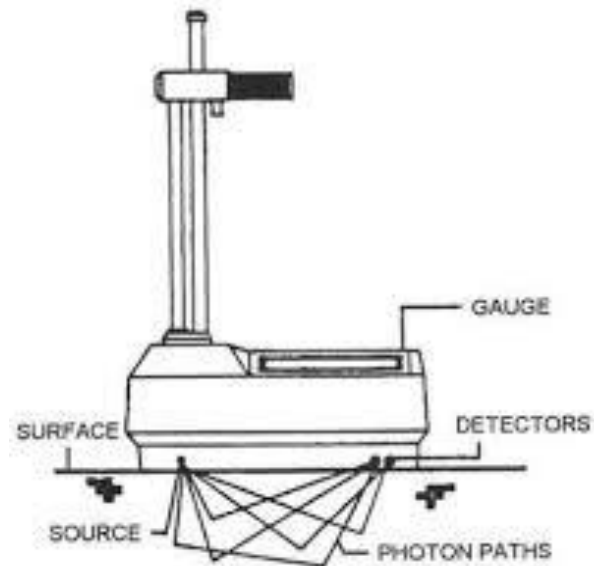


# Backscatter

## Asphalt Pavements



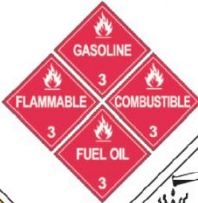
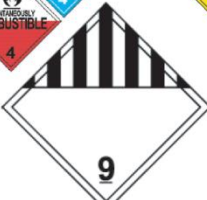
When testing dense-graded hot mix asphalt, gauges are operated in “backscatter” mode to avoid having to drive a hole through hard asphalt.



# Radioactivity

A hazardous material is one that could possibly pose a risk to public health, safety or property. Because it contains a small amount of radioactive material, a nuclear gauge qualifies as a hazardous material under **Hazard Class 7**.

## Nine Classes of Hazardous Materials

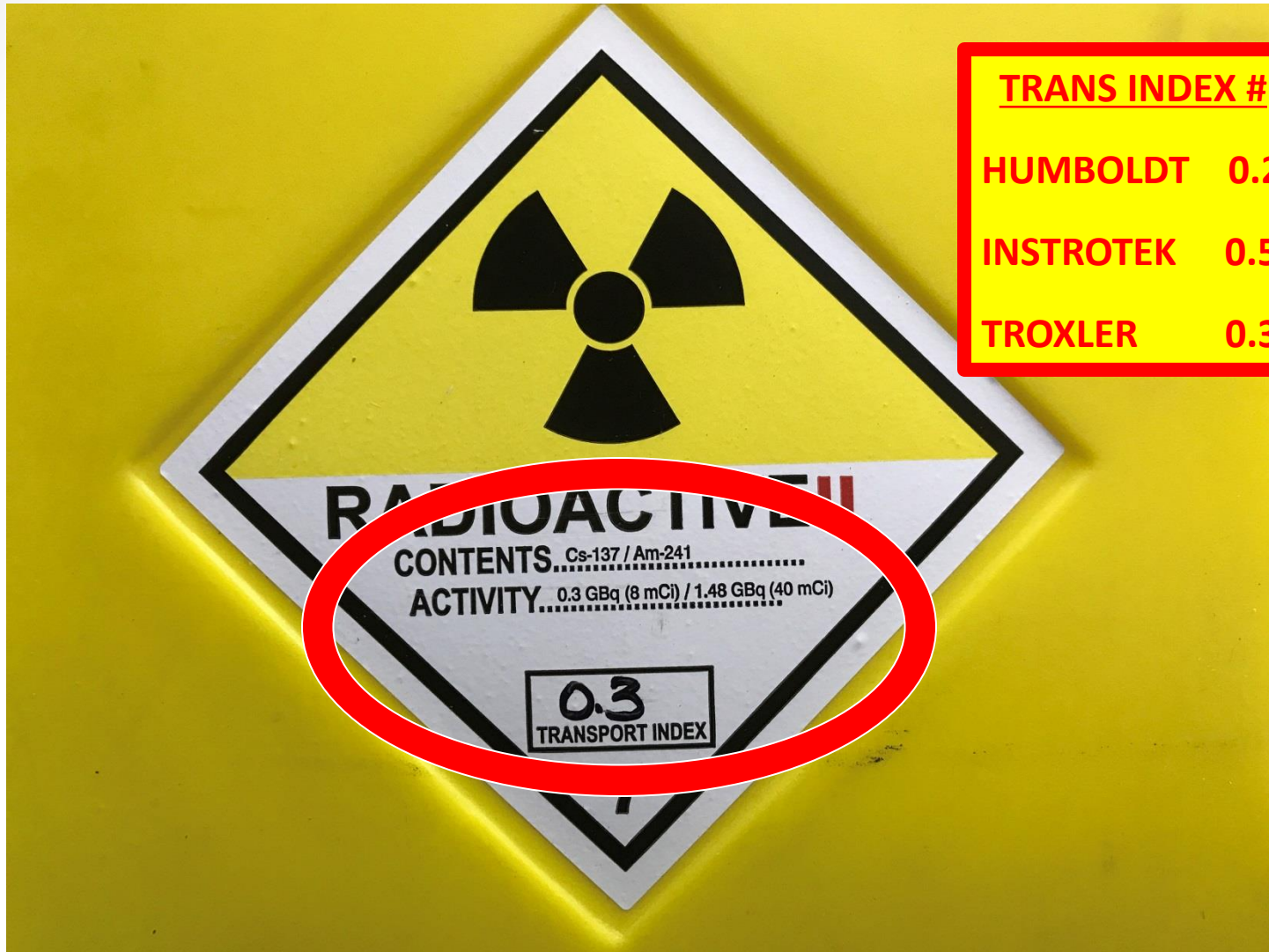
|                                                                                    |                                                                                    |                                                                                     |                                                                                                               |                                                                                       |
|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Class 1: Explosives</b><br>Divisions: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6              | <b>Class 2: Gases</b><br>Divisions: 2.1, 2.2, 2.3                                  | <b>Class 3: Flammable Liquid and Combustible Liquid</b>                             | <b>Class 4: Flammable Solid, Spontaneously Combustible, and Dangerous When Wet</b><br>Divisions 4.1, 4.2, 4.3 | <b>Class 5: Oxidizer and Organic Peroxide</b><br>Divisions 5.1, 5.2                   |
|  |   |    |                            |    |
|  |  |  |                           |  |
| <b>Class 6: Poison (Toxic) and Poison Inhalation Hazard</b>                        | <b>Class 7: Radioactive</b>                                                        | <b>Class 8: Corrosive</b>                                                           | <b>Class 9: Miscellaneous</b>                                                                                 | <b>Dangerous</b>                                                                      |

Revised 04/13

Federal Motor Carrier Safety Administration

U.S. Department of Transportation  
[www.fmcsa.dot.gov](http://www.fmcsa.dot.gov)





**DO NOT TRANSPORT IF LABEL IS NOT FILL OUT**



# Radioactivity

- There are four basic types of radiation that we are concerned with: **alpha**, **beta**, **GAMMA**, and **NEUTRON**.
- When radiation passes through living things, it gives up energy to the tissue and cells. The energy deposits may cause damage to or destroy the cell.
- If too many cells are damaged or destroyed, radiation sickness or death may occur. For this reason, radiation exposure of personnel handling radioactive materials must be held to safe limits.



# Personal Instadose Plus Dosimeter Badges



# Instadose Plus Dosimeter Badges

## Instadose Plus Dosimeter Badges:

- We now have access to real-time, on-demand dose reads and measurement data. The badge has Bluetooth Technology that can remotely transmit radiation dose data to your cell phone via Instadose Mobile App or to hotspot devices located in your construction office.
- The Regional Field Services RSO will monitor weekly dose exposures and notify anyone with abnormal readings.

## Who issues the badge?

- You will need to fill out the **DOSIMETER BADGE REQUEST FORM** and submit it to your Regional Field Services RSO. This form can be obtained from your Regional Field Service RSO.
- The issued dosimeter badge will remain with you until you are no longer required to operate or be around a density gauge.
- When that time comes, you are required to turn your assigned badge into your Field Service RSO.



# Radioactive Exposure

- Humans are exposed every year to **0.1 to 0.3** rems. This comes from several natural sources.
- A radiation dose of **400 to 450** rems in a short period would probably be fatal.
- Following safe testing protocol Nuclear Gauge operator will be exposed to **0.025 to 0.050** rems annually.
- Exposure records for TDOT are measured in millirems.

| Source  | Description                                                  | Annual Dose    |
|---------|--------------------------------------------------------------|----------------|
| Cosmic  | From the sun and other space sources.                        | 0.039-0.092rem |
| Earth   | From the natural radioactive materials in the ground         | 0.007rem       |
| Living  | Television (2 hours/day)                                     | .0003rem       |
|         | Plane (3000 mile flight)                                     | 0.002rem       |
| Housing | From the materials we use to build our homes and work places | 0.048rem       |
| Man     | Medical X-rays                                               | 0.009-0.21rem  |



# Radioactivity

**All gauge operators are required to wear a dosimeter badge.**

NRC Regulations (10 CFR) § 20.1201 Occupational dose limits for adults:

1. The annual total whole body dose should not exceed **5 rems**. This includes head, trunk, arm above the elbow, and legs above the knee.
2. The specified annual dose limit to the skin or any extremity is **50 rems**.
3. The specified annual dose limit to the eye is **15 rems**.
4. If you are a Declared Pregnant worker. Then the limit shall be limited to **0.5** rems of exposure during the pregnancy.
5. Declared pregnant workers will be asked to fill out an “Declaration of Pregnancy” form. This will be provided by your RSO.



# Badge Wear's Responsibility

## Badge Storage

- It is the responsibility of the operator to keep up with their assigned dosimeter badge.
- Badges will be stored in the office when not being actively used on a project.
- Do not leave or store the badge in your vehicle.
- In the event your dosimeter badge has become lost or damaged, it will be the operator's responsibility to notify your Field Services RSO immediately.



# Badge Wear's Responsibility

## Badge Weekly Download

It is the badge wear's responsibility to ensure their Bluetooth badge data is downloaded every Monday.

The following two options are available to complete the download process.

### **Option 1:**

Use your state issued cell phone.

Install the required Instadose Mobile App to your state issued cell phone and perform a manual download every Monday.

### **Option 2:**

Intralinks Hotspot located inside your construction office.

Ensure your badge connects to the hotspot every Monday and performs an automatic download.



# Badge Wear's Responsibility

## Badge Weekly Download

- Remember, it is the badge wear's responsibility to ensure their Bluetooth badge readings are downloaded each Monday.
- If you are having issues with the badge not downloading contact your Field Services RSO immediately.
- Regional Field Services RSOs are required to monitor and notify any personnel with an abnormal weekly radiation exposure reading greater than 50 millirems.
- TDOT's annual whole body exposure dose limit is 5 rems (5000 millirems).

### **Note:**

Recommend storing the badge as close to the hotspot as possible to ensure proper download.

Do not store your badge in a metal desk or cabinet. This will cause a non-download condition.



# DO NOT SHARE BADGES



# The **ALARA** Philosophy

## **As Low As Reasonably Achievable (ALARA)**

Before you use or transport a gauge, remember to take all the steps reasonable to limit your exposure and the public's exposure to radiation.

**This is achieved by:**

**TIME:** Always strive to limit your time around a gauge.

**SHIELDING:** Always keep the gauge source rod in the shielded stored position when not in use.

**DISTANCE:** Always step back 3 feet from the gauge when taking a test.



# Summary

- The source of radiation within a nuclear gauge is very small.
- Responsible operation of a well-maintained gauge will ensure no technician is exposed to excessive radiation.
- To further ensure safe operations, technicians must wear “**personal dosimetry badge**” which help monitor whether technicians are absorbing radiation.
- ALARA, remember “As Low As Reasonably Achievable” anytime you are transporting or testing. Time, Shielding, Distance.



# GAUGE STORAGE SITES



# Storing the Gauge

- The handle trigger will only be **LOCKED** with a Master Lock **P-581** or **P-812** for Troxler or InstoTek gauges and a American Lock **15G351** for Humboldt gauges and the gauge stored in its transport case.
- The transport case shall be locked with a **LSDA Lock only**.
- Keys to the transportation case and trigger **WILL NOT** be stored with the gauge or in the storage building.
- All storage sites will adhere to the two security barrier requirements. Gauges will need to be secured with a lock and chain/cable or inside the cage of the storage building.
- The gauge and transport case shall be stored at least **15ft** (5 m) from work areas, in a locked closet/storage area in a dry location (indoors).
- The storage area shall be marked with a radiation sign that reads **"CAUTION RADIATION AREA, RADIOACTIVE MATERIALS, AUTHORIZED PERSONNEL WITH PERSONAL MONITORING DEVICE ONLY "** on or near storage site entrance.



# Storage Site continued

- Gauges are not allowed to be permanently stored in a vehicle. The gauge must be returned and signed back to its permanent storage building once the project(s) testing it was signed out for is completed.
- In the event the gauge will be used for multiple projects in a given day/week, it must be returned to its permanent storage building and signed in when the last test is completed for the work week.
- At no time will any gauge be stored inside an employee/operator home of residence.

**Ref to SOP 7-2 (03-11-2024)**



# Storage Site continued

- All **storage sites** will maintain a SIGN IN/OUT LOG with name of operator, date signed out/in, location/project# and time signed out/in. This log will be maintained by the storage site manager and will be readily available for inspection.
- Sign in/out log sheets will be provided by your RSO as needed.
- Only nuclear gauges are allowed to be stored inside the storage site. No tools/equipment/debris of any kind is allowed to be place inside the storage site. **(Unless cleared by your RSO)**

**Ref. SOP 7-2 (03-11-2024)**



# Transporting the Gauge



# DO NOT forget to wear your Dosimeter Badge



WHEN YOU LOAD THE NUCLEAR DENSITY GAUGE IN YOUR TRUCK  
YOU ARE HAULING

# **HAZARDOUS MATERIAL.**

Let's make sure we are hauling it correctly.

If not,

*YOU* can be fined for **ALL VIOLATIONS** of state and federal regulations  
dealing with transporting **RADIOACTIVE MATERIAL.**



# Gauge Inspection

## Operators Responsibility before transporting a density gauge.

Before transporting you are required to inspect the gauge to ensure proper operation of the safety features as follows:

- Push the source rod down into the backscatter position, and then raise it back to the SAFE (shielded) position. The source rod opening in the bottom of the gauge is equipped with a spring loaded tungsten sliding block that shuts when the source rod is in the SAFE position.
- Turn the gauge over and verify that the sliding block is completely shut.
- **If any portion of the opening is uncovered, notify your Field Services RSO or TDOT RSO immediately.**



# Gauge Inspection

- I would encourage you to check the slide block after you have completed your tests each day.
- **DO NOT REMOVE THE BOTTOM PLATE TO REPAIR** if the slide block does not fully close!
- **DO NOT TRANSPORT** the gauge unless the sliding block is completely closed. Increased radiation levels *will violate* transportation regulations and cause excessive personal radiation exposure.

Ref to SOP 7-2 (03-11-2024) or get with your RSO.



# LOOK CLOSELY





Closed Correctly



# Content of Gauge Case

Ensure **ALL** tools are in the case.

1. Scrapper Plate
2. Gauge
3. Standard Block
4. Drill Rod
5. A/C Charger
6. Standard Count logbook
7. Extraction Tool
8. Red Folder

Report any missing items to your RSO.



# LABEL PLACEMENT



## TRANS INDEX #

HUMBOLDT 0.2

INSTROTEK 0.5

TROXLER 0.3



# Transporting Gauge

- The handle for the gauge shall be locked with a Master Lock **P-581** or **P-812** for Troxler and InstroTek gauges and an American lock **15G351** for Humboldt gauges.
- The nuclear gauge shall be placed inside the transportation case and the transportation case shall be locked with a **LSDA LOCK only**.
- All gauge tools (drill rod, scraper plate, extraction tool and standard block) shall be stored in the transportation case as designed.

**Ref to SOP 7-2 (03-11-2024)**



# Transporting Gauge

While in transit, the following paperwork must be in the vehicle and readily accessible by the driver: (*within arm's reach*)

- Nuclear gauge shipping paper (Red & White BOL)
- Proof of Operator's Hazmat Certification (Accessible electronic copy is acceptable)

The following will be maintained in the red folder assigned to the gauge and updated as required:

- TDOT Radiation Safety Plan (SOP 7-2 section 6)
- IAEA Certificate
- Current Leak Test (***No more than 6 months old***)
- Manufacturers Closure Report

**Ref to SOP 7-2 (03-11-2024)**



# Transporting Gauge

1. Under a locked bed cover with the device secured in place with heavy chain to prevent the case from being easily removed and to prevent the case from moving more than  $\frac{1}{2}$  inch in any direct. Chain will be secured to the bed of the truck through both side handles and top handle, if present, to prevent the case from being opened and gauge being removed while secured.

**OR**

2. A mounted transportation box, specifically designed for the nuclear gauge case or one that has been approved by your RSO with two forms of locks. In either case, ensure the gauge will not move more than a  $\frac{1}{2}$  inch in any direction while being transported.

**Ref to SOP 7-2 (03-11-2024)**



# Transporting Gauge

- The bed cover and/or mounted transportation box shall be LOCKED at all times while the gauge is being transported.
- TDOT is required to have a minimum of **2 forms of security** barriers while transporting a gauge in our trucks.
- The transportation case lock ***IS NOT*** a form of security barrier.
- Transporting the gauge any other way will violate our transportation license agreement.
- **Do not transport a gauge in an open bed truck.**

Ref to SOP 7-2 (03-11-2024)



# Transporting Gauge

- Gauges are not allowed to be permanently stored in a vehicle. The gauge must be returned and signed back to its permanent storage building once the project testing it was signed out for is completed.
- In the event the gauge will be used for multiple projects in a given day/week, it must be returned to its permanent storage building and signed in when the last test is completed for the work week.
- A nuclear density gauge is not allowed to be stored inside or at an employee home or residence for any reason.
- When the vehicle is parked while the gauge is stowed for transit, the shipping paper must be placed face up in the driver's seat or driver's side dashboard.
- You must remove the gauge from the vehicle and sign it back into its storage facility before the vehicle is turned in for service or repair.

**Ref to SOP 7-2 (03-11-2024)**



# Transporting Gauge

## Summary

- Tungsten slide block is fully closed.
- Trigger and case locks are installed.
- Ensure the “**Red Folder**” is up to date & for the gauge.
- Check that all labels are readable, properly fill out and not damaged.
- **DO NOT transport gauge with missing or damaged labels.**
- Check the case itself for any damage or broken latches.
- **DO NOT transport gauge with a damaged case or missing/ broken latches.**
- Perform an inventory to ensure everything is present.
- Be sure to secure the gauge in accordance with SOP 7-2 section 4.
- Transporting the gauge any other way will violate our transportation license agreement.

**Ref to SOP 7-2 (03-11-2024)**



# Operating The Nuclear Gauge at the Project



# Operating the Gauge

- See SOP 7-1 for instructions on how to calibrate and run tests.
- Only remove the nuclear gauge from the transportation case when testing.
- If the gauge is unsecured, meaning not stored per section 1 or being transported per sections 4 of SOP 7-2, it shall be in the possession of the operator.
- The nuclear gauge must never be left unattended.





**Do not leave your gauge sitting alone.  
It just might become part of the road.**



# Operating the Gauge

- Do not operate the gauge within **30'** of another gauge.
- Do not operate the gauge within **10'** of a large object.
- When the nuclear gauge is in operation/testing only the gauge operator will be allowed near the gauge. All other personnel must be a minimum of **30'** away from the gauge when testing.
- Only exception to this will be the RSO, the RSO may be with the operator while testing.





**Do not get to  
close to the roller  
or other roadway  
equipment.**



# Operating the Gauge

- Once the operator has set the gauge and it is reading, the operator must be a minimum distance of **3'** away from the gauge.
- If it becomes necessary to move between locations inside the project, lock the handle into the **SAFE** position and place the nuclear gauge into the transport case and place in the rear of truck bed.
- At **no** time will the nuclear gauge be placed in the cab of the truck.



# Do Not transport gauge like this on job site!



# EMERGENCY RESPONSE PLAN



# EMERGENCY RESPONSE

- An Accident Happened.
- What now?
- Look in....
- SOP 7-2 section 6

## Note:

Section 6 of SOP 7-2 covers different situation you might find yourself in while transporting or testing with a gauge. However, it is impossible to cover every type of accident that could occur. If you are unsure or do not know what actions to take, call your RSO or the TDOT RSO for immediate assistance.



# Gauge was damaged



# EMERGENCY RESPONSE

## If no immediate threat to life or property:

1. Visually inspect gauge for damage.
2. Locate source rod if missing.
3. Secure Area, if gauge is damaged or source rod is unshielded.
4. Evacuate everyone to min **15'** radius.
5. If you can't find source, evacuate larger area.
6. If you locate the source, **DO NOT** pick it up. Secure the area and wait for the RSO to arrive with the necessary tools to recover the source.



# EMERGENCY RESPONSE

- If a vehicle or construction equipment is involved in incident, detain it until it can be inspected for contamination.
- **IMMEDIATELY** after the above actions contact your **Regional Field Services RSO** or the **TDOT RSO**.

## NOTE:

Copy of these instructions are in **SOP 7-2 section 6** in the Transportation Booklet.



# SOP 7-2

**\*\* ( Make sure you have the current SOP 7-2 dated March 11, 2024) \*\***

**Make sure you have read it before transporting or using the gauge.**



**If you have any questions or ideas concerning what we have covered today.**

**Please contact me  
Rocky Kelley TDOT RSO  
615-924-6254 (call or text)**

**Or email  
[rocky.kelley@tn.gov](mailto:rocky.kelley@tn.gov)**

**Thank You**





# Nuclear Gauge Field Technician Certification

2023 version



# Why are you here?

- **Proper testing practices**
  - How to verify gauge is working
  - How to determine correction factors for asphalt testing
  - How to test
- **Where to test**
  - Determine Lots
  - Determine random testing locations



# Contact Information

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**Rocky Kelley, State RSO**

**615.924.6254**

[Rocky.Kelley@tn.gov](mailto:Rocky.Kelley@tn.gov)



# Setting Up the Gauge to Test

Before we test we need to make sure that:

- The gauge is working accurately
- Determine Correction Factors if testing on asphalt.



# Standard Count

- Keep a log of your standard counts!
- Standard counts provide a quick reference check to ensure that the gauge is operating correctly.
- A standard count must to be taken **daily** on the reference standard block.



# Standard Count

Keep a daily log of all Standard Counts.

**Max Variation day to day:**

- 1% for density
- 2% for moisture.

Place the reference standard block on the surface you are about to test.

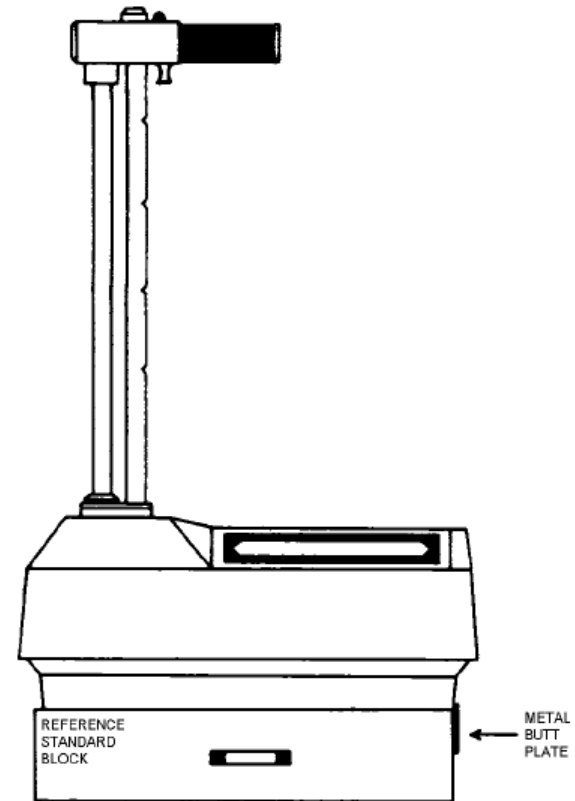


*Figure 3-3. Standard Count Position*



# Standard Count

| Moisture Count |      |
|----------------|------|
| Yesterday      | 1251 |
| Today          | 1271 |

$$\begin{aligned}\% \text{VAR} &= \frac{\text{Old} - \text{New}}{\text{Old}} \times 100 \\ &= \frac{1251 - 1271}{1251} \times 100 \\ &= \text{1.5\%} < 2\% \text{ OK}\end{aligned}$$



# Standard Count

If a standard count log has **NOT** been kept or if your **FIRST** standard count fails, do the following:

1. Take five new counts
2. Average the first four
3. Compared with the 5<sup>th</sup> reading
4. Check if the reading is within the required limits.

If the standard count still fails, call your Regional RSO.



# Standard Count

Example:

- Count 1: Density – 1650
- Count 2: Density – 1640
- Count 3: Density – 1630
- Count 4: Density – 1625
- Count 5: Density – 1624

- Moisture – 632
- Moisture – 630
- Moisture – 628
- Moisture – 632
- Moisture – 630

Average  
1636.25

Average  
630.5

$$\text{Density} = \frac{1636.25 - 1624}{1636.25} \times 100\% = 0.75\%$$

$$\text{Moisture} = \frac{630.5 - 630}{630.5} \times 100\% = 0.079\%$$



# Asphalt Test Strips



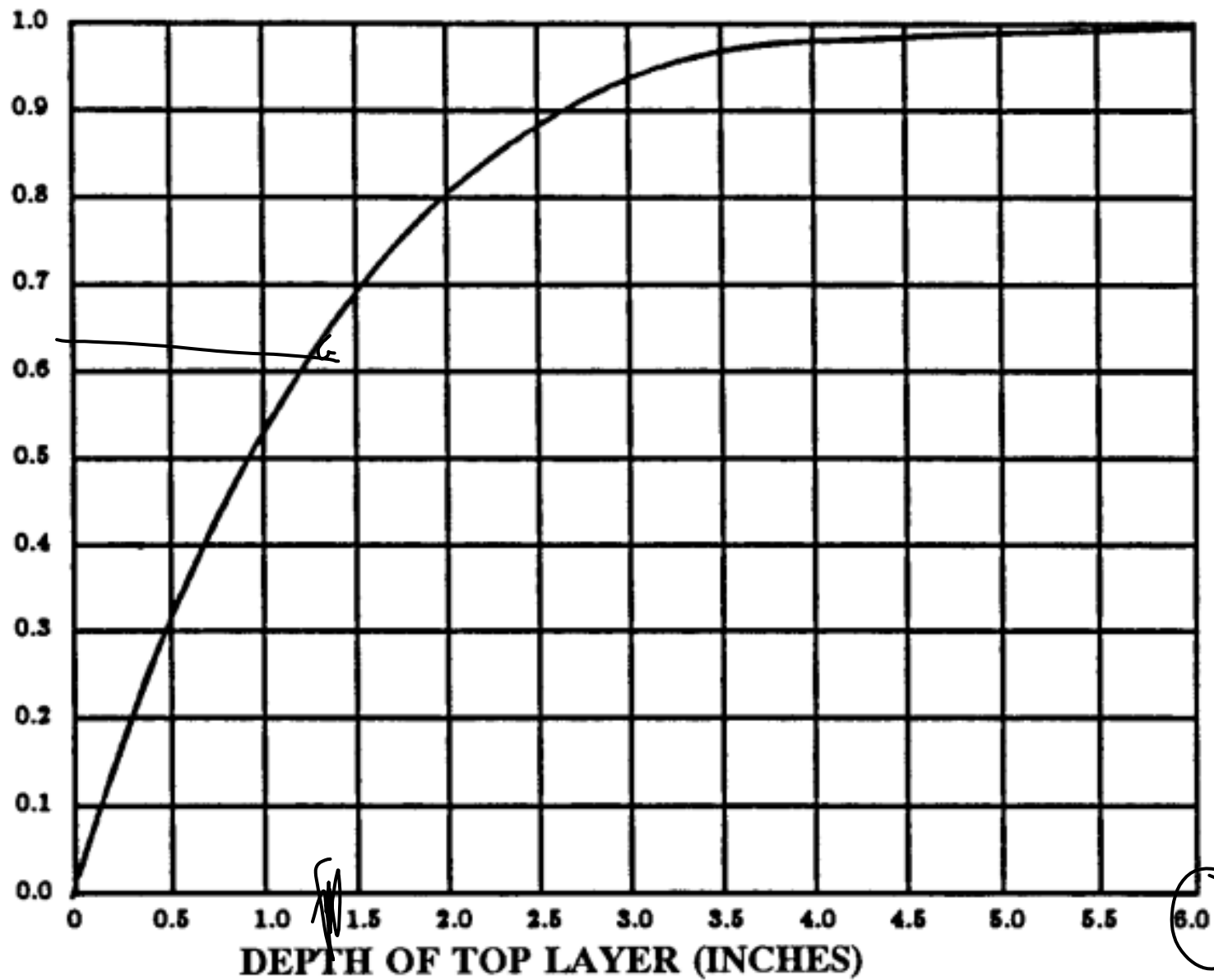
# Test Strip Calibration (Asphalt)

## TDOT Standard specifications 407.15.

- Nuclear Gauge readings are not valid on Asphalt until the gauge is correlated to the mix and project location. A new test strip shall be required for each project and each mix design used on the project (for mix types that require density testing as noted above). Uncorrelated gauges shall not be used for acceptance or assurance testing.



TOP  
LAYER  
EFFECT



# Test Strip Calibration (Asphalt)

- Required for A, BM, BM2, C, C-W, D, and E mixtures
- Each test section shall be 1 paver width/lane width wide and a minimum of 400 SY
  - 9' wide= 400' long
  - 10' wide= 360' long
  - 11' wide= 330' long
  - 12' wide= 300' long

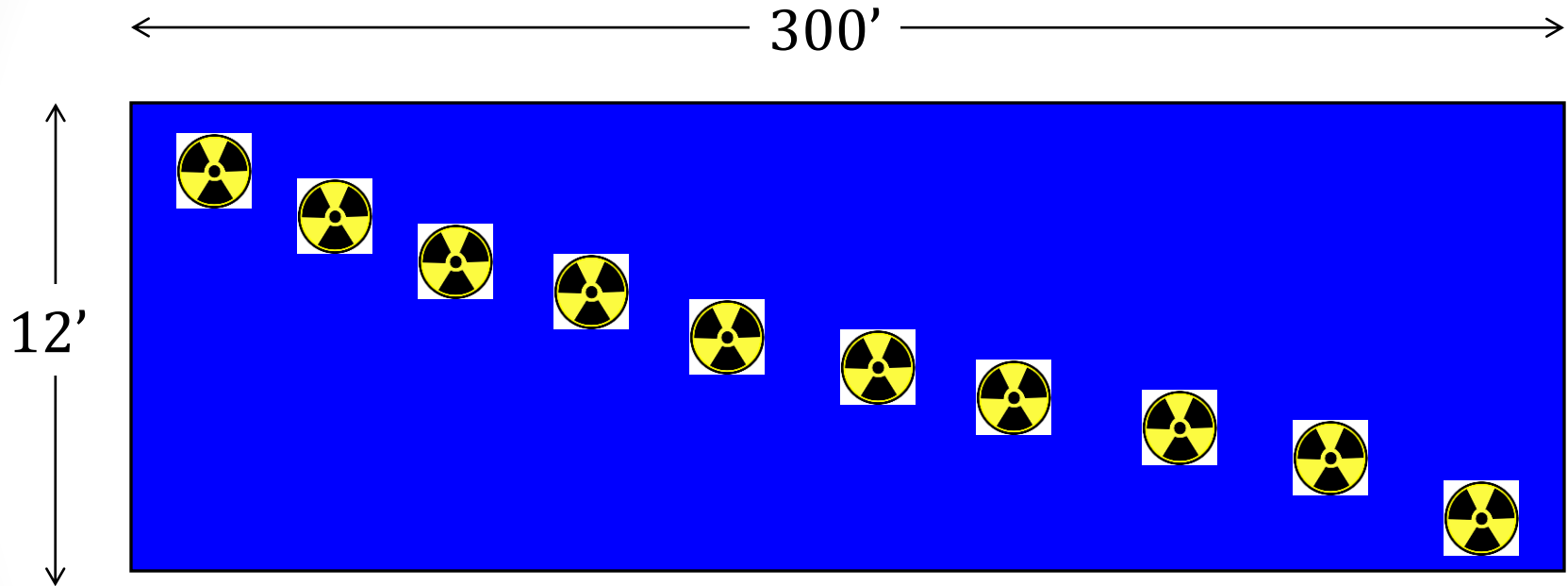


# Test Strip Calibration (Asphalt)

- Step 1: Compact test strip area



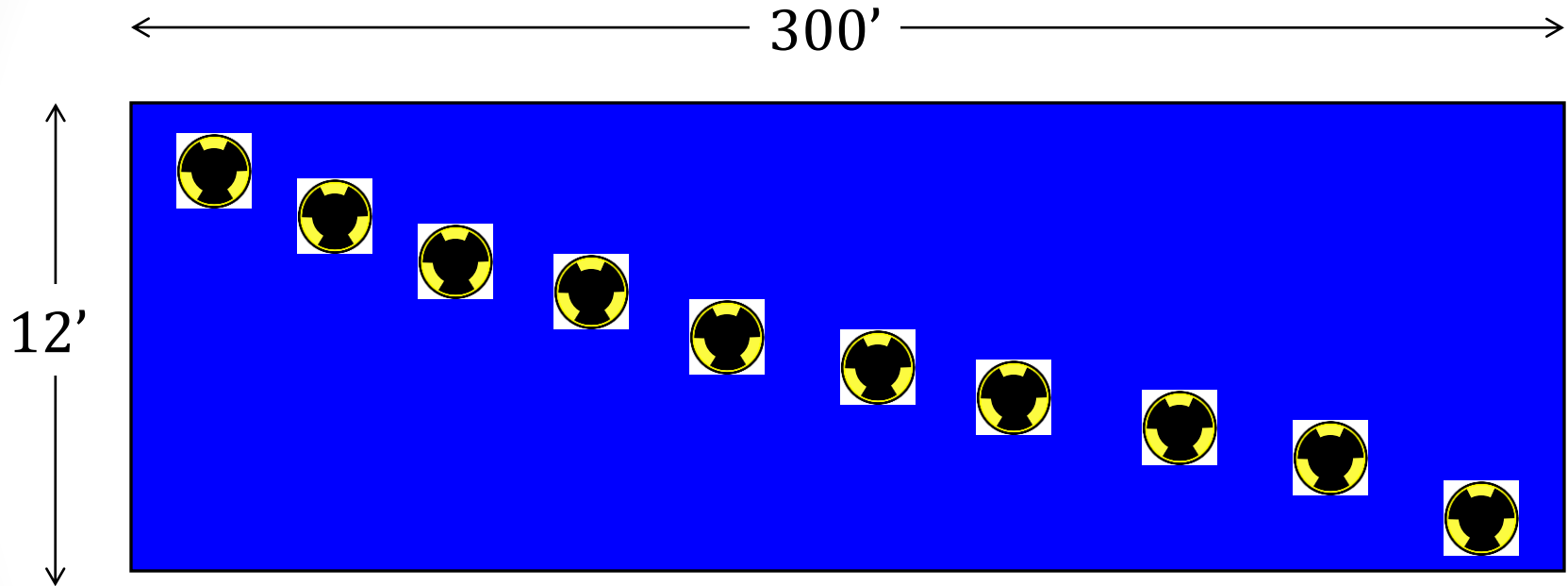
# Test Strip Calibration (Asphalt)



Step 2: Layout ten test strip test locations such that the full length and width of the test strip is covered. **Mark test location and test number on pavement with spray paint after running the test.** Write down the density ( $\text{lb}/\text{ft}^3$ ) at every location and mark the location so we can cut cores.



# Test Strip Calibration (Asphalt)



Step 3: Cores shall be cut at same locations as nuclear density tests and tested by TDOT Plant Technician for laboratory density in accordance with AASHTO T166. (NOTE: The contractor's technician shall not conduct this testing)



# Test Strip Calibration

- Now we can run the density of the cores in the lab to find the TRUE density of what we tested.



# Test Strip Calibration (Asphalt)

- Step 5: The nuclear gauge correction factor shall be the difference between the average of ten nuclear gauge readings and the average of ten core density values.



# Test Strip Calibration

## Nuclear Gauge Results:

- 140.5 lb/ft<sup>3</sup>
  - 139.7
  - 139.3
  - 134.3
  - 137.8
  - 143.1
  - 135.4
  - 138.1
  - 134.1
  - 137.6
- 1379.9  
10  
=138.0

## Core Density:

- 142.1
  - 142.7
  - 142.3
  - 139.1
  - 141.1
  - 141.6
  - 140.4
  - 141.2
  - 137.8
  - 140.2
- 1408.5  
10  
=140.9

C.F. = Core – Gauge

C.F. = 140.9 – 138.0 = 2.9 pcf



# Test Strip Calibration

- What this means is that any time we use THIS nuclear gauge on THIS mix on THIS project, we should add 2.9 to our reading.
- This correction factor ONLY applies to THIS PROJECT and THIS MIX DESIGN.



# Test Strip Calibration (Asphalt)

- **A new test strip will be required when:**
  - There is a change in job mix formulas
  - A change in the source of materials occurs
  - A change in the material from the same source is observed
  - There is reason to believe that the test strip density is not representative of the mixture being placed. For example, test results are consistently above 100% density or test results have been consistent for a steady number of days and had suddenly changed significantly.
  - A change in paving or compaction equipment occurs.



# Acceptance Testing

- Now that the gauge is confirmed to be operating correctly and we have a correction factor we can test.



# Testing Policy

- Soil/Aggregate
  - Test shall be 1 minute in duration
  - Direct Transmission
  - Rod embedded approximately half the lift thickness being measured.
- Asphalt
  - Tests shall be 15 seconds
  - 4 tests per location, rotate gauge 90 degrees between tests
  - Backscatter Mode, all mixes



# Asphalt “four 90s method”

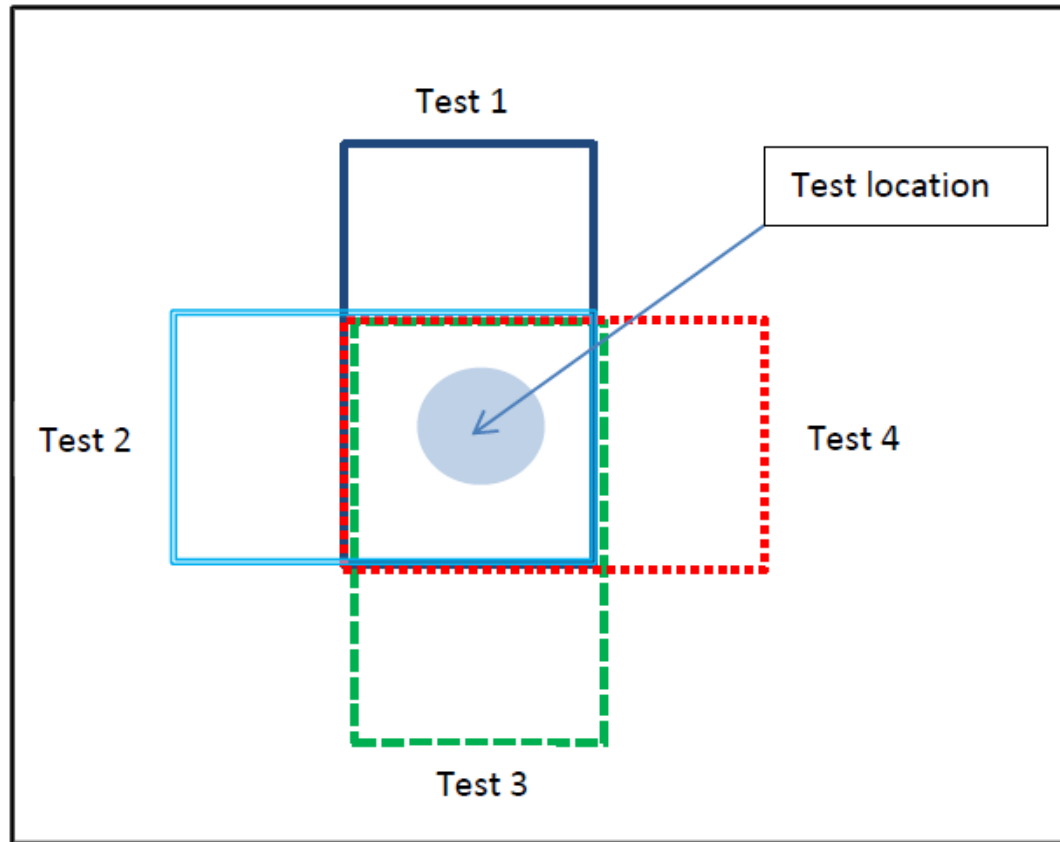


Figure 1. Testing at four 90° locations



# Quality Acceptance Testing:

## General Procedure

- Identify Density/Moisture Requirements
  - Based on type of material being placed
- Determine Required Lot Size/Number of Tests
- Determine Test Locations
- Perform Test(s)
- Report Results



# Identify Density/Moisture Requirements

- Acceptance criteria are different for Embankment, Aggregate Base, Asphalt Pavements, Etc.
- This information can be found in the corresponding section in the TDOT specs.
- The target values (soils/aggregate) are determined by TDOT Materials and Tests personnel and will be made available in the proctor density report
- The target values (asphalt) are determined by the JMF and the level of traffic, see **407.15**.



# Determine Required: Lot Size/Number of Tests

- S.O.P. 1-1: Sampling and Testing Guide
  - Describes the testing frequency for all materials
  - Lists the person responsible for either obtaining the sample or performing the test.
  - Available in PDF format at:

<http://www.tdot.state.tn.us/materials/fieldops/sop/default.htm>

**(see example in Part Five of S.O.P. 1-1)**



# TDOT Sampling Procedure (Asphalt)

## • SOP 1-1

| ASPHALT                     |                                                                    |                          |                   |                            |                                                                                                                              |                                                                                               |
|-----------------------------|--------------------------------------------------------------------|--------------------------|-------------------|----------------------------|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------|
| Asphalt Plant Mix Pavements | Aggregate                                                          | Fractured Face Count     | Project Inspector | Per project                | Coarse aggregate stockpiles                                                                                                  | Plus No. 4 (4.75 mm) sieve material, gravel mixes only.                                       |
|                             |                                                                    | Glassy Particles by mass |                   |                            |                                                                                                                              | Plus No. 4 (4.75 mm) sieve material, slag mixes only.                                         |
|                             | All Plant Mix Asphalt                                              | Mix Temperature          |                   | Every 5 <sup>th</sup> load | From the truck prior to leaving the plant and on the roadway prior to deposit into the paver or the material transfer device | Temperatures on the roadway are to be recorded on the delivery ticket.                        |
|                             |                                                                    | 10 Minute Boil Test      |                   | Per day                    | From the truck at the asphalt plant                                                                                          |                                                                                               |
|                             | Plant Mix Asphalt (Grading A, B, BM, BM2, C, CW, D, E, E-Shoulder) | Density                  |                   | Every 1,000 tons           | As soon as practical after compaction                                                                                        | Each lot shall be divided into 5 equal sub-lots, and one test shall be performed per sub-lot. |



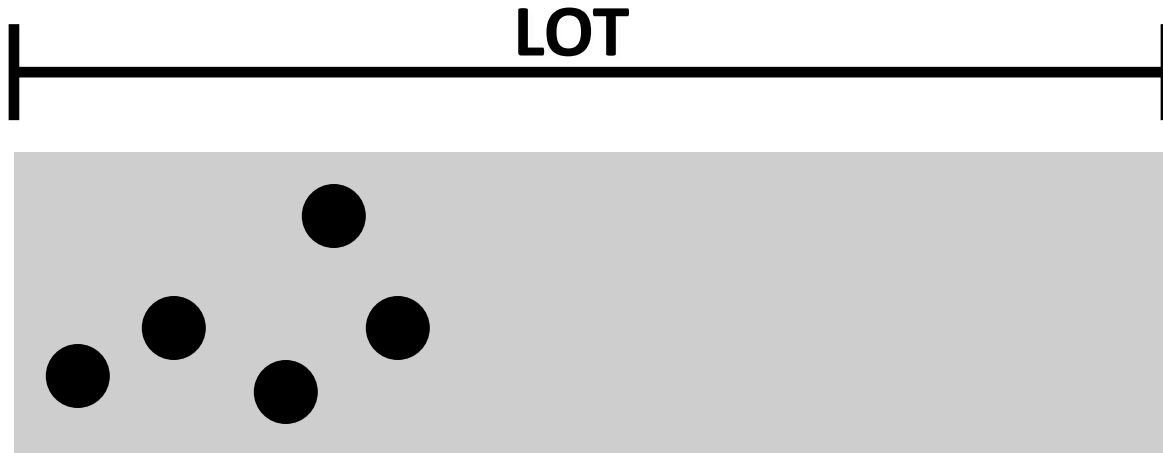
# TDOT Sampling Procedure

| EMBANKMENT/SUBGRADE                           |                                          |                                    |                   |                                                                                                                                                                                                                                                                                                    |                                                                                            |                                                                                                           |
|-----------------------------------------------|------------------------------------------|------------------------------------|-------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| Embankment                                    | Soil                                     | Proctor Density & Optimum Moisture | Project Inspector | As required by material changes                                                                                                                                                                                                                                                                    | Cuts sampled prior to construction. Borrow pits sampled as required prior to placement.    | Submit 50-75 pound sample to M&T.                                                                         |
|                                               |                                          | Density, Moisture                  |                   | <p>Five tests each 10 inches of lift not to exceed 1,500 feet of roadway or 5,000 cubic yards</p> <p>Exception: Within 50 feet of a bridge end (deck or box), one test will be performed for each lift. The test will be performed alternately on the embankment and on the backfill material.</p> | During construction, immediately after compaction.                                         | Density tests will not be required for embankment containing more than 50% of plus ¾ inch sieve material. |
| Subgrade Preparation                          | Soil                                     | Proctor Density & Optimum Moisture | Project Inspector | As required by material changes                                                                                                                                                                                                                                                                    | May be sampled before grading construction or after grading prior to sub-grade preparation | Submit 50-75 pound sample to M&T.                                                                         |
|                                               |                                          | Density, Moisture                  |                   | Five tests per 10,000 square-yard lot for top 6 inches                                                                                                                                                                                                                                             | Immediately before placing pavement                                                        |                                                                                                           |
| Subgrade Treatment (Lime) OR Soil-Cement Base | Soil-Cement Mixture OR Soil-Lime Mixture | Proctor Density, Optimum Moisture  | Project Inspector | Prior to beginning of construction                                                                                                                                                                                                                                                                 | At beginning of compaction                                                                 | Additional tests may be required to account for material changes. Submit 50-75 pound sample to M&T.       |
|                                               |                                          | Pulverization                      |                   | Every 10,000 square yards                                                                                                                                                                                                                                                                          | After mixing, before compaction                                                            | Sieve test requirement. See Standard Specs. 304.06.                                                       |
|                                               |                                          | Density, Moisture                  |                   | Five tests per 10,000 square-yard lot                                                                                                                                                                                                                                                              | Immediately following compaction                                                           |                                                                                                           |
|                                               |                                          | Thickness                          |                   |                                                                                                                                                                                                                                                                                                    | After final finish of base                                                                 |                                                                                                           |

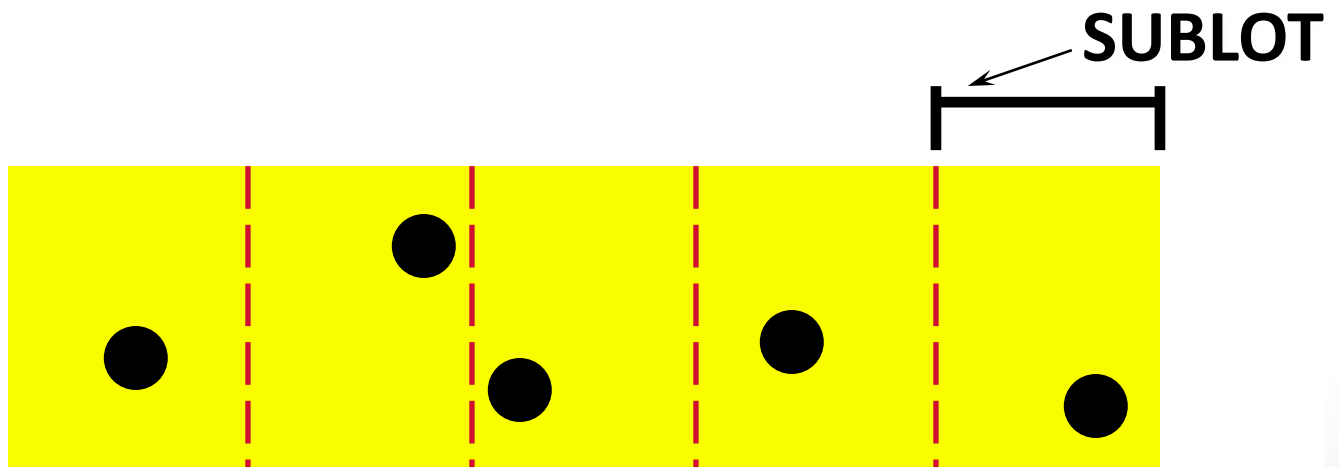


# Lots and Sublots

**Random  
Sampling**



**Stratified  
Random  
Sampling**



# Random Sampling

- Any portion of the population has equal chance of being selected
- Bias is introduced when judgment is used
- Use random number tables or other means.



# Random Number Table

|            |            |            |            |            |            |            |            |            |            |
|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| <b>.20</b> | <b>.68</b> | <b>.98</b> | <b>.30</b> | <b>.27</b> | <b>.84</b> | <b>.54</b> | <b>.31</b> | <b>.05</b> | <b>.88</b> |
| <b>.61</b> | <b>.17</b> | <b>.38</b> | <b>.62</b> | <b>.55</b> | <b>.59</b> | <b>.67</b> | <b>.73</b> | <b>.43</b> | <b>.23</b> |
| <b>.27</b> | <b>.38</b> | <b>.84</b> | <b>.99</b> | <b>.72</b> | <b>.51</b> | <b>.48</b> | <b>.81</b> | <b>.77</b> | <b>.76</b> |
| <b>.24</b> | <b>.38</b> | <b>.40</b> | <b>.34</b> | <b>.76</b> | <b>.87</b> | <b>.60</b> | <b>.75</b> | <b>.49</b> | <b>.56</b> |
| <b>.88</b> | <b>.52</b> | <b>.25</b> | <b>.51</b> | <b>.79</b> | <b>.41</b> | <b>.33</b> | <b>.08</b> | <b>.32</b> | <b>.47</b> |
| <b>.62</b> | <b>.36</b> | <b>.97</b> | <b>.61</b> | <b>.28</b> | <b>.50</b> | <b>.81</b> | <b>.29</b> | <b>.75</b> | <b>.82</b> |
| <b>.94</b> | <b>.83</b> | <b>.35</b> | <b>.66</b> | <b>.42</b> | <b>.70</b> | <b>.44</b> | <b>.30</b> | <b>.54</b> | <b>.45</b> |

*\*For additional random # tables, see SOP 1-1*



# Testing Locations

- STEP 1-
  - Determine LOT size, and with known lane width, determine LOT and subplot lengths
- STEP 2-
  - With known beginning station, determine beginning subplot stations



# Testing Locations

- STEP 3-
  - Using random number table, or calculator, select 5 numbers.
- STEP 4-
  - Multiply a random number by the subplot Length.
- STEP 5-
  - Add to beginning subplot stations to determine longitudinal testing locations. *A second random number is used to find transverse location for S&A*



# Testing Locations

## STATIONS

- A “station” is a unit used in roadway construction to indicate a longitudinal location along the roadway.
- One station = 100 feet
- i.e. Station 1+00 equals 100 feet  
Station 4+50 equals 450 feet  
Station 105+60 equals 10,560 feet



# Example Problem

- Situation
  - Placing D-mix, lane is 12 feet wide
  - Spread Rate is 132.5 lb/yd<sup>2</sup>
  - Beginning Station 100+00



# Asphalt Lots and Sublots

| Spread<br>(lb/SY) | Lot/<br>Sublot | Mat Width (Feet) |       |       |       |       |       |       |      |      |      |
|-------------------|----------------|------------------|-------|-------|-------|-------|-------|-------|------|------|------|
|                   |                | 4                | 6     | 8     | 9     | 10    | 11    | 12    | 14   | 15   | 16   |
| 132.5             | Lot            | 34000            | 22600 | 17000 | 15100 | 13600 | 12300 | 11300 | 9700 | 9100 | 8500 |
|                   | Sublot         | 6800             | 4520  | 3400  | 3020  | 2720  | 2460  | 2260  | 1940 | 1820 | 1700 |
| 154.5             | Lot            | 29100            | 19400 | 14600 | 12900 | 11700 | 10600 | 9700  | 8300 | 7800 | 7300 |
|                   | Sublot         | 5820             | 3880  | 2920  | 2580  | 2340  | 2120  | 1940  | 1660 | 1560 | 1460 |
| 226               | Lot            | 19900            | 13300 | 10000 | 8800  | 8000  | 7200  | 6600  | 5700 | 5300 | 5000 |
|                   | Sublot         | 3980             | 2660  | 2000  | 1760  | 1600  | 1440  | 1320  | 1140 | 1060 | 1000 |
| 254.25            | Lot            | 17700            | 11800 | 8800  | 7900  | 7100  | 6400  | 5900  | 5100 | 4700 | 4400 |
|                   | Sublot         | 3540             | 2360  | 1760  | 1580  | 1420  | 1280  | 1180  | 1020 | 940  | 880  |
| 282.5             | Lot            | 15900            | 10600 | 8000  | 7100  | 6400  | 5800  | 5300  | 4600 | 4200 | 4000 |
|                   | Sublot         | 3180             | 2120  | 1600  | 1420  | 1280  | 1160  | 1060  | 920  | 840  | 800  |
| 310.75            | Lot            | 14500            | 9700  | 7200  | 6400  | 5800  | 5300  | 4800  | 4100 | 3900 | 3600 |
|                   | Sublot         | 2900             | 1940  | 1440  | 1280  | 1160  | 1060  | 960   | 820  | 780  | 720  |
| 345               | Lot            | 13000            | 8700  | 6500  | 5800  | 5200  | 4700  | 4300  | 3700 | 3500 | 3300 |
|                   | Sublot         | 2600             | 1740  | 1300  | 1160  | 1040  | 940   | 860   | 740  | 700  | 660  |
| 460               | Lot            | 9800             | 6500  | 4900  | 4300  | 3900  | 3600  | 3300  | 2800 | 2600 | 2400 |
|                   | Sublot         | 1960             | 1300  | 980   | 860   | 780   | 720   | 660   | 560  | 520  | 480  |

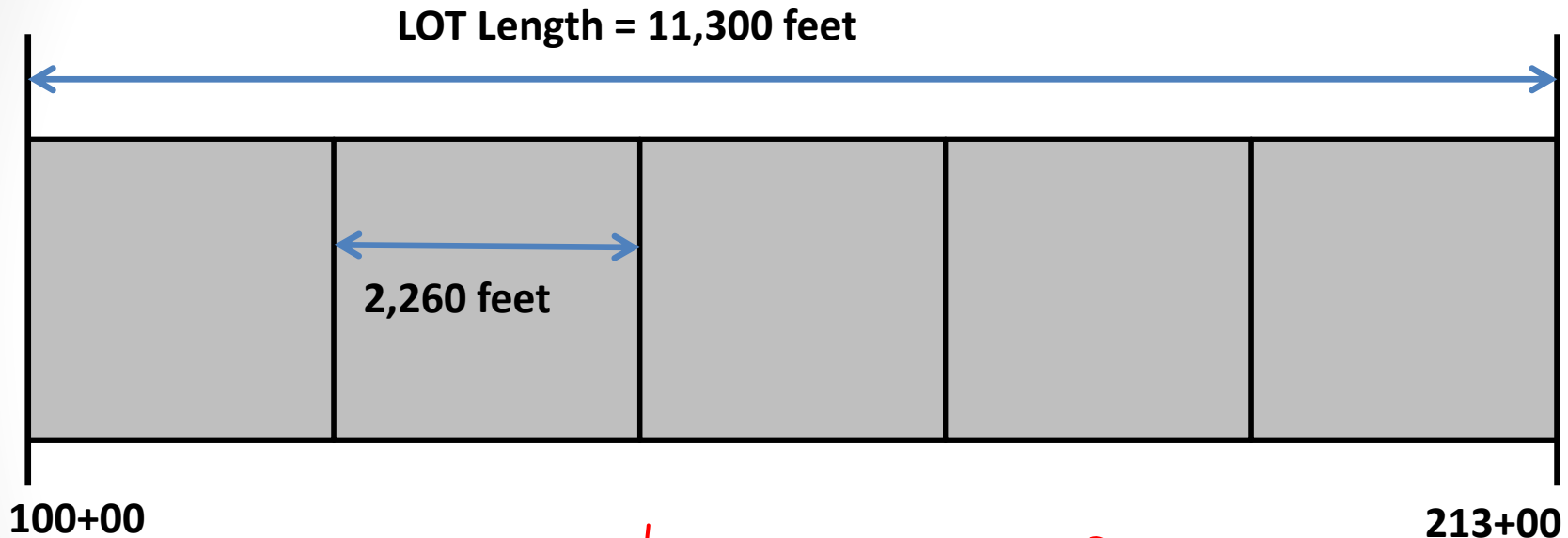


# Example Problem (cont.)

- STEP 1- Determine Lot Length
  - 1,000 Ton lot
  - 132.5 lb/yd<sup>2</sup>
  - 12-feet wide
  - Begin Station = 100+00
- From Table
  - Lot Length = 11,300 feet
  - Sublot Length = 2,260 feet



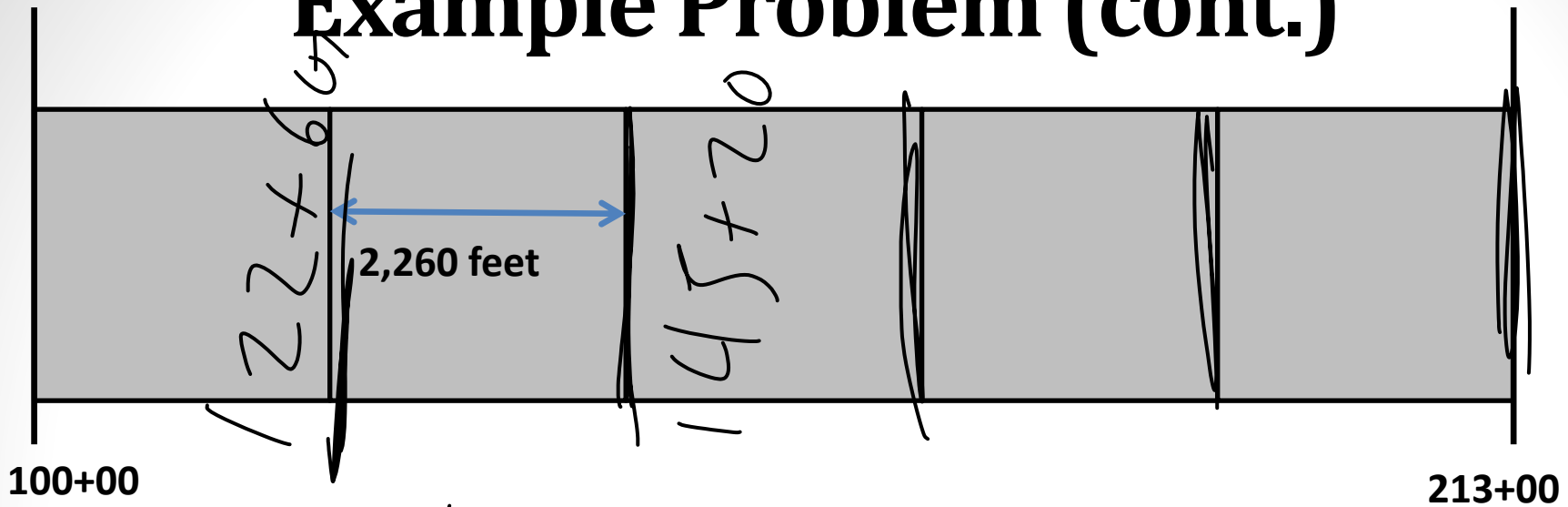
# Example Problem (cont.)



$$\begin{array}{r} 10000 \\ + 11300 \\ \hline 21300 \end{array}$$



# Example Problem (cont.)



$$\begin{array}{r} 12260 \\ + 2260 \\ \hline 14520 \end{array}$$



# Example Problem (cont.)

- **STEP 1-**

LOT= **11,300'** SUB-LOT=2,260'

- **STEP 2- (Beginning Station 100+00)**

- $[100+00]+2,260 = 10,000+2,260 = 12,260 = 122+60$
- $[122+60]+2,260 = 12,260+2,260 = 14,520 = 145+20$
- $[145+20]+2,260 = 14,520+2,260 = 167+80$
- $[167+80]+2,260 = 190+40$
- $[190+40]+2,260 = 213+00$
- $[100+00]+\mathbf{11,300} = 213+00$

} **End of Lot**



# Example Problem (cont.)

- **STEP 3-** Using a random number table, select 5 numbers

|            |            |            |            |            |            |            |            |            |            |
|------------|------------|------------|------------|------------|------------|------------|------------|------------|------------|
| <b>.20</b> | <b>.68</b> | <b>.98</b> | <b>.30</b> | <b>.27</b> | <b>.84</b> | <b>.54</b> | <b>.31</b> | <b>.05</b> | <b>.88</b> |
| <b>.61</b> | <b>.17</b> | <b>.38</b> | <b>.62</b> | <b>.55</b> | <b>.59</b> | <b>.67</b> | <b>.73</b> | <b>.43</b> | <b>.23</b> |
| <b>.27</b> | <b>.38</b> | <b>.84</b> | <b>.99</b> | <b>.72</b> | <b>.51</b> | <b>.48</b> | <b>.81</b> | <b>.77</b> | <b>.76</b> |
| <b>.24</b> | <b>.38</b> | <b>.40</b> | <b>.34</b> | <b>.76</b> | <b>.87</b> | <b>.60</b> | <b>.75</b> | <b>.49</b> | <b>.56</b> |
| <b>.88</b> | <b>.52</b> | <b>.25</b> | <b>.51</b> | <b>.79</b> | <b>.41</b> | <b>.33</b> | <b>.08</b> | <b>.32</b> | <b>.47</b> |
| <b>.62</b> | <b>.36</b> | <b>.97</b> | <b>.61</b> | <b>.28</b> | <b>.50</b> | <b>.81</b> | <b>.29</b> | <b>.75</b> | <b>.82</b> |
| <b>.94</b> | <b>.83</b> | <b>.35</b> | <b>.66</b> | <b>.42</b> | <b>.70</b> | <b>.44</b> | <b>.30</b> | <b>.54</b> | <b>.45</b> |

Random Number Table



# Example Problem (cont.)

- **STEP 4-** Determine the distance within each subplot that each test will be located using both the subplot length and a random number.
  - Round to the nearest whole number.
  - Sublot #1 =  $(2,260' \times 0.38) = \mathbf{859 \text{ feet}}$
  - Sublot #2 =  $(2,260' \times 0.50) = \mathbf{1,130 \text{ feet}}$
  - Sublot #3 =  $(2,260' \times 0.61) = \mathbf{1,379 \text{ feet}}$
  - Sublot #4 =  $(2,260' \times 0.76) = \mathbf{1,718 \text{ feet}}$
  - Sublot #5 =  $(2,260' \times 0.20) = \mathbf{452 \text{ feet}}$



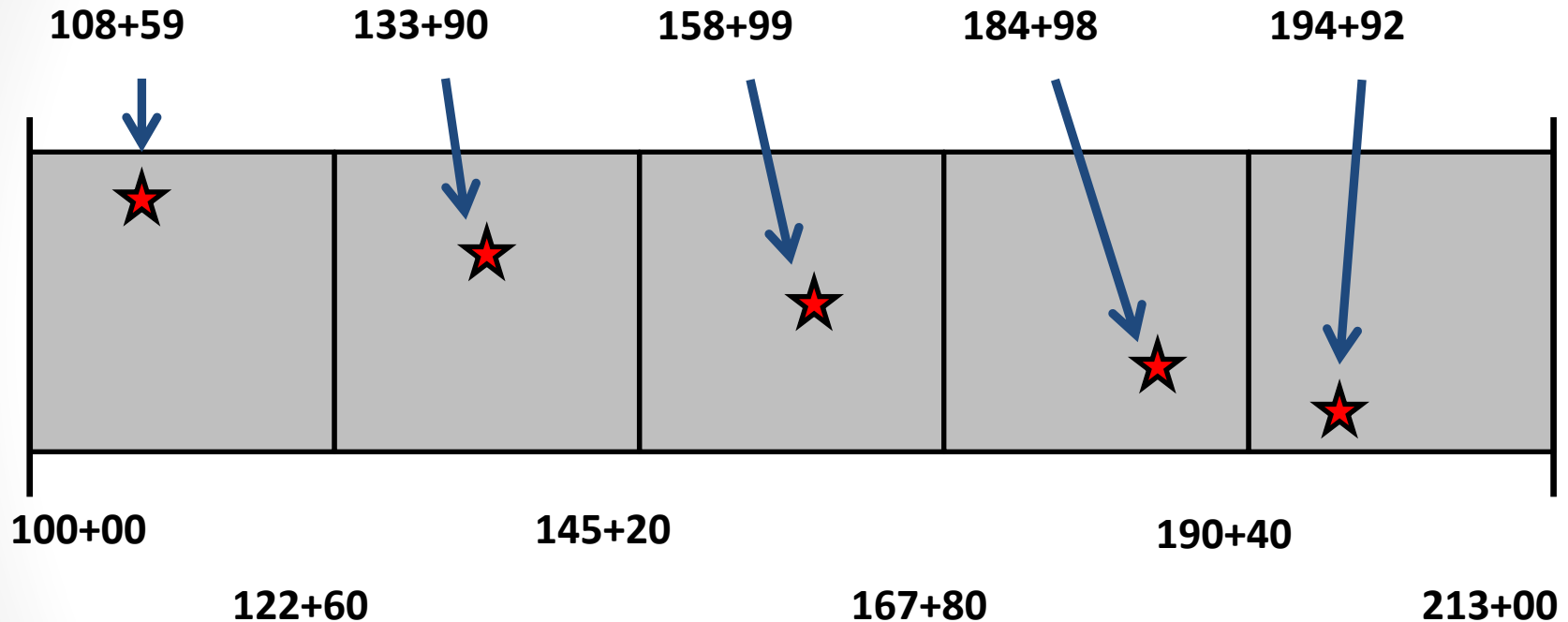
# Example Problem (cont.)

- **STEP 5-** Determine where the gauge reading will be taken by adding each length to the start of each subplot.

- Sublot #1 =  $(10,000') + 859' = 10,859' = \mathbf{108+59}$
- Sublot #2 =  $(12,260') + 1,130' = 13,390' = \mathbf{133+90}$
- Sublot #3 =  $(14,520') + 1,379' = 15,899' = \mathbf{158+99}$
- Sublot #4 =  $(16,780') + 1,718' = 18,498' = \mathbf{184+98}$
- Sublot #5 =  $(19,040') + 452' = 19,492' = \mathbf{194+92}$



# Example Problem (cont.)



# Soils/Aggregate Example Problem

## Situation

- Placing Type A Base Material
- Typical base stone cross-section is 30 Feet
- Beginning Station 100+00



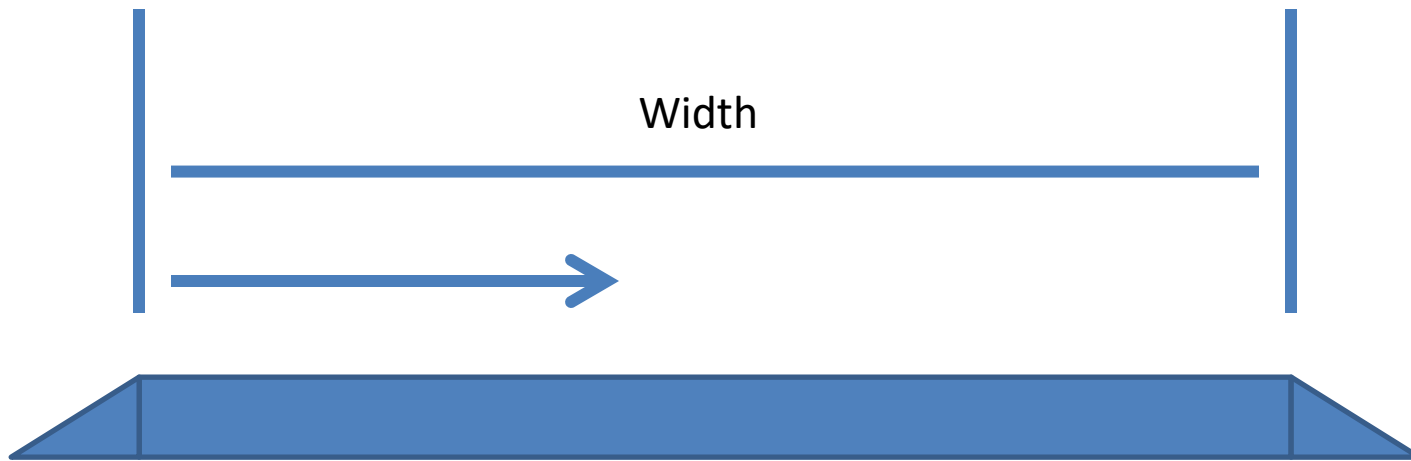
# Example Problem (Continued)

- STEP 1- (Per SOP 1-1)
  - 10,000 SY LOT
  - LOT Length:  $10,000 \text{ yd}^2 \times 9 = 90,000 \text{ ft}^2$   
 $90,000 \text{ ft}^2 / 30 \text{ ft} = \underline{3000 \text{ ft length}}$
- SUB-LOT Length:  $3000 \text{ ft} / 5 = \underline{600 \text{ ft}}$



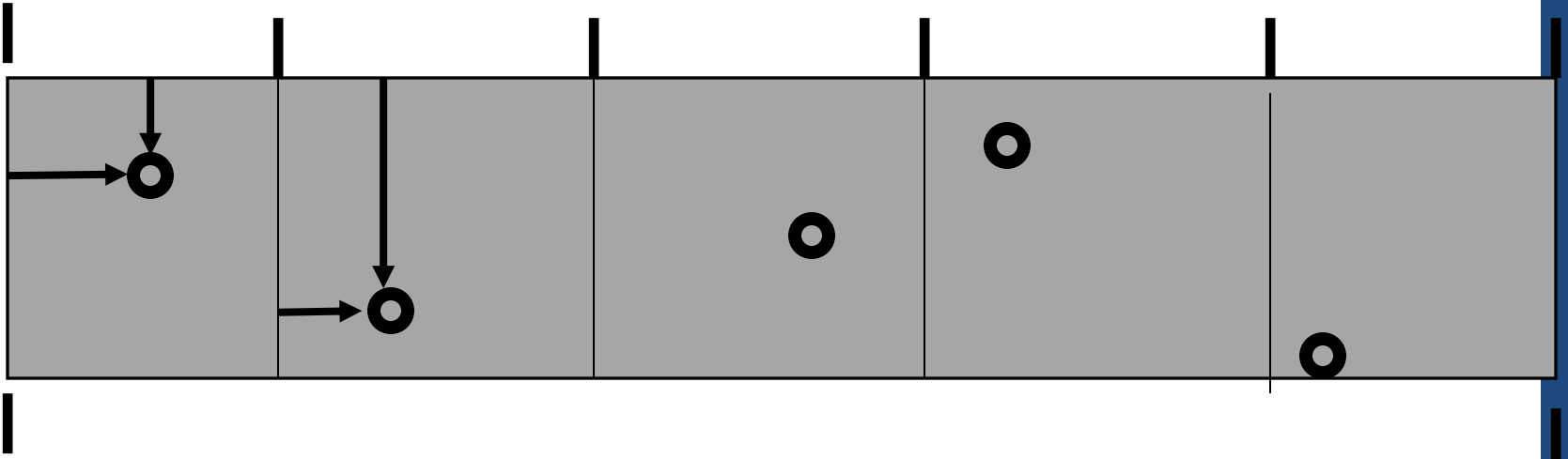
# Soils/Aggregate Continued

- Transverse location must also be random



Transverse Location = Width X Random Number







## Part Four: Using Random Numbers for Sampling and Testing (With Examples and Random Number Tables)

### Significance

The selection of test locations is critical in ensuring control of materials and construction work. If the results from the test locations conform to specified tests, the rest of the work is likely to conform as well; therefore, test site locations shall be random and representative of the material in its entirety.

The procedures outlined below will help you to select random and representative test locations using random number tables, a random number function on a calculator, a spreadsheet program, etc.

### Selecting Random Numbers

Randomness in transportation construction inspection indicates unpredictability in the time or location of sampling and testing of a material or procedure in a construction phase.

Random numbers occur in no pattern or sequence. When you review a series of random numbers, you do not know what number may come next; there is no particular order in which random numbers occur.

A sample random-number table is shown below.

|   | A     |       | B     |       | C     |       | D     |       | E     |       |   |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|
| 1 | 0.814 | 0.759 | 0.651 | 0.947 | 0.965 | 0.994 | 0.581 | 0.877 | 0.500 | 0.208 | 1 |
|   | 0.105 | 0.015 | 0.323 | 0.630 | 0.223 | 0.616 | 0.070 | 0.469 | 0.672 | 0.931 |   |
|   | 0.035 | 0.841 | 0.590 | 0.184 | 0.488 | 0.794 | 0.909 | 0.940 | 0.062 | 0.031 |   |
|   | 0.741 | 0.336 | 0.346 | 0.926 | 0.237 | 0.967 | 0.385 | 0.657 | 0.521 | 0.921 |   |
|   | 0.278 | 0.697 | 0.423 | 0.365 | 0.010 | 0.210 | 0.264 | 0.745 | 0.378 | 0.337 |   |
| 2 | 0.834 | 0.355 | 0.952 | 0.924 | 0.591 | 0.003 | 0.280 | 0.363 | 0.175 | 0.254 | 2 |
|   | 0.204 | 0.159 | 0.006 | 0.006 | 0.764 | 0.020 | 0.768 | 0.209 | 0.959 | 0.147 |   |
|   | 0.426 | 0.860 | 0.160 | 0.009 | 0.978 | 0.033 | 0.394 | 0.445 | 0.682 | 0.600 |   |
|   | 0.990 | 0.330 | 0.581 | 0.946 | 0.129 | 0.047 | 0.384 | 0.363 | 0.038 | 0.275 |   |
|   | 0.837 | 0.658 | 0.140 | 0.344 | 0.189 | 0.047 | 0.675 | 0.923 | 0.101 | 0.122 |   |
| 3 | 0.537 | 0.505 | 0.909 | 0.794 | 0.249 | 0.339 | 0.850 | 0.326 | 0.510 | 0.961 | 3 |
|   | 0.286 | 0.447 | 0.286 | 0.975 | 0.458 | 0.484 | 0.992 | 0.078 | 0.947 | 0.756 |   |
|   | 0.492 | 0.633 | 0.262 | 0.660 | 0.451 | 0.511 | 0.255 | 0.439 | 0.185 | 0.712 |   |
|   | 0.428 | 0.126 | 0.884 | 0.203 | 0.199 | 0.222 | 0.638 | 0.492 | 0.062 | 0.967 |   |
|   | 0.443 | 0.927 | 0.626 | 0.542 | 0.746 | 0.683 | 0.822 | 0.242 | 0.481 | 0.077 |   |
| 4 | 0.343 | 0.529 | 0.955 | 0.122 | 0.692 | 0.721 | 0.393 | 0.774 | 0.986 | 0.485 | 4 |
|   | 0.070 | 0.948 | 0.408 | 0.338 | 0.921 | 0.355 | 0.252 | 0.916 | 0.255 | 0.456 |   |
|   | 0.832 | 0.666 | 0.385 | 0.337 | 0.918 | 0.098 | 0.209 | 0.163 | 0.921 | 0.241 |   |
|   | 0.858 | 0.470 | 0.756 | 0.923 | 0.799 | 0.250 | 0.101 | 0.615 | 0.891 | 0.120 |   |
|   | 0.153 | 0.773 | 0.722 | 0.819 | 0.626 | 0.393 | 0.340 | 0.202 | 0.120 | 0.793 |   |
| 5 | 0.142 | 0.636 | 0.217 | 0.005 | 0.597 | 0.628 | 0.994 | 0.150 | 0.375 | 0.969 | 5 |
|   | 0.882 | 0.905 | 0.272 | 0.637 | 0.201 | 0.768 | 0.002 | 0.568 | 0.176 | 0.702 |   |
|   | 0.369 | 0.985 | 0.930 | 0.070 | 0.891 | 0.835 | 0.340 | 0.283 | 0.863 | 0.566 |   |
|   | 0.423 | 0.658 | 0.311 | 0.795 | 0.174 | 0.419 | 0.909 | 0.600 | 0.885 | 0.145 |   |
|   | 0.461 | 0.878 | 0.363 | 0.644 | 0.890 | 0.278 | 0.219 | 0.312 | 0.585 | 0.923 |   |
|   | A     |       | B     |       | C     |       | D     |       | E     |       |   |

Lot sizes vary depending on the type of construction and the material. For example, a lot for earthwork construction is defined by the width and length of roadway, while concrete tests for bridge decks (slump, temperature, and air content) are determined by the volume of concrete delivered to the site.

Determine the lot size and the number of samples and tests required per lot from the Sampling and Testing (S&T) Guide and Schedule (SOP 1-1).

Knowing the type of construction and the material to be tested, use the S&T Schedule to determine the type of test and frequency of testing.

**Example 1:** Moisture and density must be measured on a lift of soil for subgrade preparation of a roadbed. The proposed roadway is 48-feet wide.

According to the Sampling and Testing Schedule (SOP 1-1, Part 2, shown below), five tests for moisture and density are required for every 10,000 square-yard lot of soil placed.

|                      |      |                                    |                   |                                                        |                                                                                             |                                            |
|----------------------|------|------------------------------------|-------------------|--------------------------------------------------------|---------------------------------------------------------------------------------------------|--------------------------------------------|
| Subgrade Preparation | Soil | Proctor Density & Optimum Moisture | Project Inspector | As required by material changes                        | May be sampled before grading construction or after grading prior to sub-grade preparation. | Submit 50-75 pound sample to Regional M&T. |
|                      |      | Density, Moisture                  |                   | Five tests per 10,000 square-yard lot for top 6 inches | Immediately before placing pavement structure                                               |                                            |

Since the project is 48 feet wide, the lot length will be, *at most*,

$$\frac{10000 \text{ yd}^2 \text{ area of aggregate} \times 9 \frac{\text{ft}^2}{\text{yd}^2}}{48 \text{ feet wide}} = 1875 \text{ feet per lot}$$

We decide to use 1000 linear feet of roadway as our designated lot since this is shorter than the allowable lot length of 1875 feet.

If using the random number table shown below, we randomly choose a block of numbers, say, block C2.

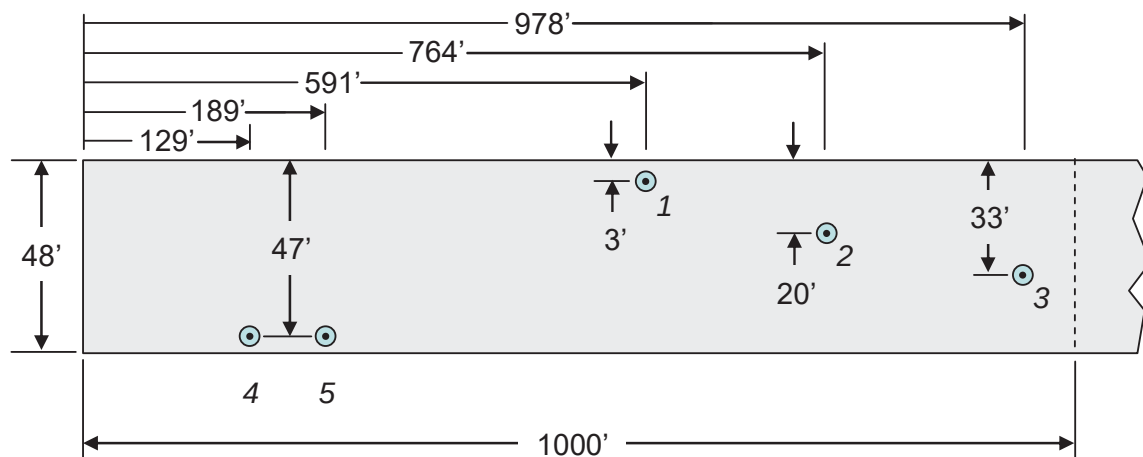
|   | A     |       | B     |       | C     |       | D     |       | E     |       |   |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|
| 1 | 0.271 | 0.584 | 0.674 | 0.883 | 0.379 | 0.976 | 0.555 | 0.083 | 0.967 | 0.812 | 1 |
|   | 0.185 | 0.905 | 0.686 | 0.491 | 0.424 | 0.566 | 0.724 | 0.582 | 0.393 | 0.176 |   |
|   | 0.283 | 0.202 | 0.692 | 0.475 | 0.436 | 0.304 | 0.375 | 0.660 | 0.731 | 0.384 |   |
|   | 0.567 | 0.800 | 0.642 | 0.205 | 0.827 | 0.129 | 0.598 | 0.216 | 0.124 | 0.787 |   |
|   | 0.703 | 0.621 | 0.893 | 0.063 | 0.755 | 0.194 | 0.133 | 0.110 | 0.795 | 0.824 |   |
| 2 | 0.103 | 0.338 | 0.620 | 0.594 | 0.591 | 0.069 | 0.639 | 0.203 | 0.313 | 0.733 | 2 |
|   | 0.536 | 0.826 | 0.362 | 0.321 | 0.764 | 0.408 | 0.487 | 0.515 | 0.591 | 0.676 |   |
|   | 0.017 | 0.218 | 0.365 | 0.209 | 0.978 | 0.688 | 0.546 | 0.490 | 0.795 | 0.241 |   |
|   | 0.840 | 0.594 | 0.341 | 0.006 | 0.129 | 0.986 | 0.350 | 0.437 | 0.927 | 0.782 |   |
|   | 0.161 | 0.720 | 0.366 | 0.219 | 0.189 | 0.985 | 0.899 | 0.501 | 0.793 | 0.889 |   |
| 3 | 0.251 | 0.496 | 0.741 | 0.314 | 0.014 | 0.839 | 0.124 | 0.209 | 0.292 | 0.099 | 3 |
|   | 0.380 | 0.901 | 0.262 | 0.180 | 0.459 | 0.843 | 0.640 | 0.720 | 0.131 | 0.132 |   |
|   | 0.637 | 0.274 | 0.959 | 0.050 | 0.924 | 0.773 | 0.314 | 0.390 | 0.819 | 0.410 |   |
|   | 0.310 | 0.324 | 0.111 | 0.760 | 0.706 | 0.165 | 0.930 | 0.515 | 0.639 | 0.116 |   |
|   | 0.568 | 0.379 | 0.600 | 0.362 | 0.697 | 0.006 | 0.080 | 0.680 | 0.028 | 0.206 |   |
| 4 | 0.378 | 0.392 | 0.910 | 0.202 | 0.512 | 0.156 | 0.336 | 0.465 | 0.813 | 0.471 | 4 |
|   | 0.805 | 0.641 | 0.118 | 0.878 | 0.932 | 0.196 | 0.018 | 0.094 | 0.419 | 0.211 |   |
|   | 0.830 | 0.106 | 0.643 | 0.706 | 0.720 | 0.299 | 0.252 | 0.598 | 0.955 | 0.021 |   |
|   | 0.367 | 0.538 | 0.050 | 0.448 | 0.896 | 0.669 | 0.968 | 0.984 | 0.890 | 0.117 |   |
|   | 0.274 | 0.509 | 0.848 | 0.645 | 0.890 | 0.998 | 0.389 | 0.611 | 0.586 | 0.137 |   |
| 5 | 0.566 | 0.802 | 0.283 | 0.151 | 0.399 | 0.316 | 0.559 | 0.684 | 0.318 | 0.516 | 5 |
|   | 0.078 | 0.505 | 0.541 | 0.962 | 0.868 | 0.007 | 0.192 | 0.610 | 0.255 | 0.081 |   |
|   | 0.458 | 0.811 | 0.454 | 0.476 | 0.156 | 0.385 | 0.198 | 0.102 | 0.762 | 0.372 |   |
|   | 0.486 | 0.345 | 0.786 | 0.759 | 0.465 | 0.222 | 0.487 | 0.355 | 0.935 | 0.223 |   |
|   | 0.783 | 0.432 | 0.275 | 0.218 | 0.942 | 0.054 | 0.641 | 0.278 | 0.957 | 0.778 |   |
|   | A     |       | B     |       | C     |       | D     |       | E     |       |   |

Using block C2, we have 10 random numbers that range between 0 and 1 carried to the thousandth decimal place. We will use these as multiplication factors to determine our test locations in the following table. The left-hand column of numbers in block C2 will be used to determine the longitudinal coordinates (length of the proposed roadway) by multiplying the lot length by the random number, then rounding to the nearest whole number. The right-hand column of numbers in block C2 will be used to determine the lateral coordinates (perpendicular to the proposed roadway) by multiplying the lot width by the random number, then rounding to the nearest whole number.

| SAMPLE NO. | LENGTH | RANDOM NO. | LONGITUDINAL<br>COORDINATE |
|------------|--------|------------|----------------------------|
| 1          | 1000   | 0.591      | 591                        |
| 2          | 1000   | 0.764      | 764                        |
| 3          | 1000   | 0.978      | 978                        |
| 4          | 1000   | 0.129      | 129                        |
| 5          | 1000   | 0.189      | 189                        |

| SAMPLE NO. | WIDTH | RANDOM NO. | LATERAL<br>COORDINATE |
|------------|-------|------------|-----------------------|
| 1          | 48    | 0.069      | 3                     |
| 2          | 48    | 0.408      | 20                    |
| 3          | 48    | 0.688      | 33                    |
| 4          | 48    | 0.986      | 47                    |
| 5          | 48    | 0.985      | 47                    |

Now, we simply match the first longitudinal coordinate with the first lateral coordinate to locate the first test location. Then, we match the remainder of the longitudinal and lateral coordinates to determine the remaining 4 test locations. The figure below shows the locations of the tests on the roadbed.



PLAN VIEW OF TEST AREA  
(NOT TO SCALE)

**Example 2:** Nuclear gauge tests of density on 3.5 inches of Grading 307-A asphalt pavement that is 12 feet wide. The spread rate for 3.5 inches is 402.5 lbs/yd<sup>2</sup>.

According to the Sampling and Testing Schedule (SOP 1-1, Part 2, shown below), five tests for density are required for every 1,000 ton lot of asphalt placed.

|                             |                                                                       |         |                   |                  |                                       |                                                                                               |
|-----------------------------|-----------------------------------------------------------------------|---------|-------------------|------------------|---------------------------------------|-----------------------------------------------------------------------------------------------|
| Asphalt Plant Mix Pavements | Plant Mix Asphalt Gratings A, B, BM, BM2, C, CW, D, E, and E Shoulder | Density | Project Inspector | Every 1,000 tons | As soon as practical after compaction | Each lot shall be divided into 5 equal sub-lots, and one test shall be performed per sub-lot. |
|-----------------------------|-----------------------------------------------------------------------|---------|-------------------|------------------|---------------------------------------|-----------------------------------------------------------------------------------------------|

Since the lot size is 1,000 tons, the maximum lot size will be,

$$\frac{1,000 \text{ tons} \times 2,000 \frac{\text{lb}}{\text{ton}}}{402.5 \frac{\text{lb}}{\text{yd}^2}} = 4,969 \text{ square yards}$$

Converting this into square feet,

$$4,969 \text{ yd}^2 \times 9 \frac{\text{ft}^2}{\text{yd}^2} = 44,721 \text{ ft}^2$$

Since the project is 12 feet wide, the maximum lot will be,

$$44,721 \text{ ft}^2 \div 12 \text{ ft wide} = 3,726.8 \text{ ft}$$

Dividing this lot into five equal sub-lots,  $3727 \text{ ft} \div 5 = 745 \text{ feet per sub-lot}$

| LOT SIZE<br>(yd <sup>2</sup> ) |                | LANE WIDTH (ft) |      |      |      |
|--------------------------------|----------------|-----------------|------|------|------|
|                                |                | 10              | 11   | 12   | 13   |
| 5,000                          | LOT LENGTH     | 4500            | 4091 | 3750 | 3462 |
|                                | SUB-LOT LENGTH | 900             | 818  | 750  | 692  |
| 10,000                         | LOT LENGTH     | 9000            | 8182 | 7500 | 6923 |
|                                | SUB-LOT LENGTH | 1800            | 1636 | 1500 | 1385 |

Using the table of random numbers shown below, we randomly choose a block of numbers, say, block D5.

|   | A     | B     | C     | D     | E     |       |       |       |       |       |   |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|
| 1 | 0.781 | 0.437 | 0.811 | 0.662 | 0.105 | 0.135 | 0.509 | 0.792 | 0.137 | 0.779 | 1 |
|   | 0.311 | 0.114 | 0.878 | 0.378 | 0.984 | 0.741 | 0.177 | 0.558 | 0.725 | 0.807 |   |
|   | 0.746 | 0.926 | 0.294 | 0.674 | 0.952 | 0.597 | 0.559 | 0.685 | 0.891 | 0.909 |   |
|   | 0.381 | 0.729 | 0.057 | 0.378 | 0.166 | 0.332 | 0.807 | 0.034 | 0.628 | 0.090 |   |
|   | 0.954 | 0.130 | 0.447 | 0.548 | 0.199 | 0.658 | 0.897 | 0.349 | 0.396 | 0.742 |   |
| 2 | 0.265 | 0.732 | 0.808 | 0.566 | 0.484 | 0.163 | 0.114 | 0.631 | 0.992 | 0.934 | 2 |
|   | 0.769 | 0.313 | 0.280 | 0.451 | 0.035 | 0.787 | 0.223 | 0.994 | 0.111 | 0.777 |   |
|   | 0.729 | 0.963 | 0.946 | 0.178 | 0.198 | 0.252 | 0.085 | 0.630 | 0.677 | 0.055 |   |
|   | 0.140 | 0.111 | 0.712 | 0.641 | 0.576 | 0.558 | 0.407 | 0.384 | 0.653 | 0.181 |   |
|   | 0.923 | 0.316 | 0.508 | 0.284 | 0.406 | 0.228 | 0.920 | 0.875 | 0.403 | 0.503 |   |
| 3 | 0.602 | 0.516 | 0.251 | 0.954 | 0.268 | 0.197 | 0.809 | 0.004 | 0.769 | 0.678 | 3 |
|   | 0.138 | 0.246 | 0.819 | 0.198 | 0.418 | 0.126 | 0.835 | 0.187 | 0.680 | 0.855 |   |
|   | 0.178 | 0.399 | 0.550 | 0.565 | 0.071 | 0.916 | 0.560 | 0.219 | 0.537 | 0.856 |   |
|   | 0.613 | 0.157 | 0.218 | 0.001 | 0.535 | 0.576 | 0.146 | 0.010 | 0.215 | 0.190 |   |
|   | 0.097 | 0.155 | 0.388 | 0.403 | 0.252 | 0.987 | 0.775 | 0.596 | 0.365 | 0.231 |   |
| 4 | 0.373 | 0.974 | 0.929 | 0.104 | 0.447 | 0.449 | 0.447 | 0.147 | 0.424 | 0.195 | 4 |
|   | 0.880 | 0.803 | 0.036 | 0.846 | 0.058 | 0.834 | 0.010 | 0.314 | 0.011 | 0.621 |   |
|   | 0.749 | 0.231 | 0.217 | 0.206 | 0.869 | 0.810 | 0.804 | 0.426 | 0.157 | 0.881 |   |
|   | 0.020 | 0.048 | 0.404 | 0.368 | 0.917 | 0.374 | 0.444 | 0.214 | 0.432 | 0.827 |   |
|   | 0.052 | 0.601 | 0.318 | 0.016 | 0.766 | 0.513 | 0.623 | 0.065 | 0.409 | 0.816 |   |
| 5 | 0.777 | 0.941 | 0.140 | 0.401 | 0.171 | 0.139 | 0.353 | 0.481 | 0.209 | 0.735 | 5 |
|   | 0.406 | 0.017 | 0.252 | 0.730 | 0.476 | 0.188 | 0.347 | 0.656 | 0.945 | 0.149 |   |
|   | 0.044 | 0.413 | 0.782 | 0.032 | 0.459 | 0.856 | 0.838 | 0.594 | 0.322 | 0.654 |   |
|   | 0.980 | 0.185 | 0.574 | 0.166 | 0.025 | 0.962 | 0.588 | 0.134 | 0.198 | 0.704 |   |
|   | 0.237 | 0.162 | 0.155 | 0.373 | 0.673 | 0.104 | 0.665 | 0.070 | 0.849 | 0.957 |   |
|   | A     | B     | C     | D     | E     |       |       |       |       |       |   |

Using block D5, we have 10 random numbers that range between 0 and 1 carried to the thousandth decimal place. We will use the multiplication factors in the left-hand column to determine our longitudinal test locations. Transverse locations are determined randomly with one test 12" off each edge, one test in each wheel path, and one test in the center of the lane.

The distances into each subplot,

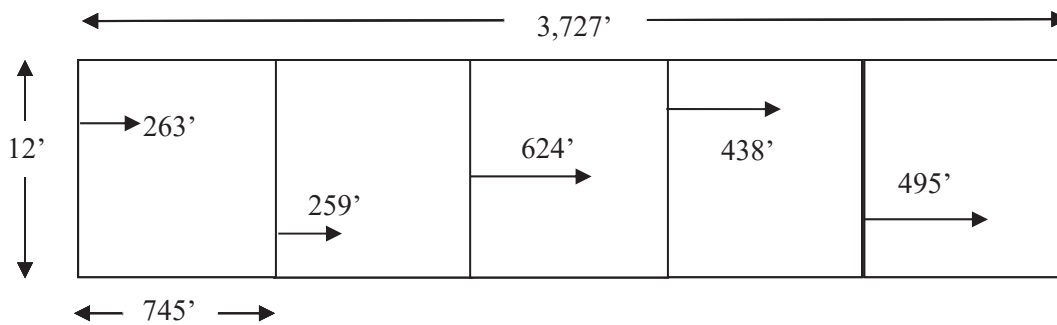
$$745 \text{ ft} * 0.353 = 263 \text{ ft}$$

$$745 \text{ ft} * 0.347 = 259 \text{ ft}$$

$$745 \text{ ft} * 0.588 = 438 \text{ ft}$$

$$745 \text{ ft} * 0.838 = 624 \text{ ft}$$

$$745 \text{ ft} * 0.665 = 495 \text{ ft}$$



If we wanted to know the total distance into the 3750' lot for each test:

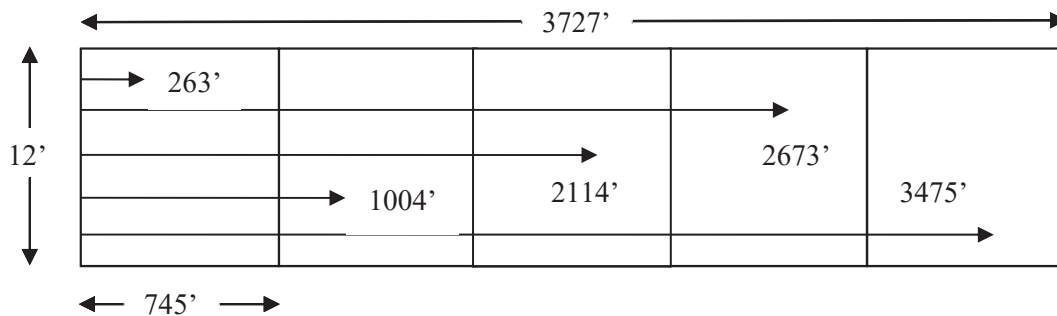
Test 1 = 263 ft

Test 2 = 745 ft + 259 ft = 1004 ft

Test 3 = 745 ft + 745 ft + 624 ft = 2114 ft

Test 4 = 745 ft + 745 ft + 745 ft + 438 ft = 2673 ft

Test 5 = 745 ft + 745 ft + 745 ft + 745 ft + 495 ft = 3475 ft



**Example 3:** Slump, temperature, and air content of concrete from mixing trucks delivering concrete to a bridge deck pour that is expected to use 1300 cubic yards of concrete.

According to the Sampling and Testing Schedule (SOP 1-1, Part 2, shown below), one complete set of tests for air content, slump, and temperature are required for the first three loads of concrete delivered.

One pair of cylinders must be cast from one of the three passing loads. For each additional 50 cubic yards of concrete, a pair of cylinders must be made and tests for air content, slump, and temperature must be performed.

|                                                                                                |                |                                                           |                   |                                                                                                                                                                        |                |                                                               |
|------------------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---------------------------------------------------------------|
| Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Polymer Modified, Prestressed | Class D, DS, L | Cylinders (28-day), Slump, Air Content, & Mix Temperature | Project Inspector | Test first three loads and every 50 cubic yards thereafter per day per structure<br><br>One pair of cylinders shall be cast from one of the first three passing loads. | Placement site | Refer to SOP 4-1 for acceptance of concrete for bridge decks. |
|------------------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------|-------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------|---------------------------------------------------------------|

Now we'll use the random number tables in a different way. We must decide which loads of concrete to test. First, we'll assume each truck is hauling 10 cubic yards of concrete. Subsequent to the first 30 cubic yards, we'll test from truck loads by first choosing a random block of numbers from the following table. We'll choose block A3.

|   | A     | B     | C     | D     | E     |       |       |       |       |       |   |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|
| 1 | 0.818 | 0.696 | 0.758 | 0.117 | 0.827 | 0.567 | 0.974 | 0.487 | 0.874 | 0.665 | 1 |
|   | 0.565 | 0.826 | 0.141 | 0.229 | 0.996 | 0.003 | 0.783 | 0.079 | 0.145 | 0.827 |   |
|   | 0.926 | 0.785 | 0.743 | 0.669 | 0.411 | 0.702 | 0.949 | 0.460 | 0.434 | 0.201 |   |
|   | 0.776 | 0.529 | 0.397 | 0.450 | 0.851 | 0.569 | 0.157 | 0.571 | 0.097 | 0.556 |   |
| 2 | 0.333 | 0.996 | 0.810 | 0.562 | 0.053 | 0.975 | 0.122 | 0.055 | 0.702 | 0.609 | 2 |
|   | 0.626 | 0.783 | 0.145 | 0.210 | 0.591 | 0.003 | 0.493 | 0.136 | 0.036 | 0.223 |   |
|   | 0.291 | 0.607 | 0.048 | 0.788 | 0.764 | 0.020 | 0.991 | 0.719 | 0.948 | 0.727 |   |
|   | 0.950 | 0.570 | 0.324 | 0.232 | 0.978 | 0.033 | 0.803 | 0.534 | 0.367 | 0.897 |   |
| 3 | 0.521 | 0.642 | 0.912 | 0.464 | 0.129 | 0.047 | 0.359 | 0.497 | 0.382 | 0.993 | 3 |
|   | 0.235 | 0.611 | 0.262 | 0.783 | 0.189 | 0.047 | 0.241 | 0.252 | 0.706 | 0.886 |   |
|   | 0.537 | 0.505 | 0.557 | 0.919 | 0.939 | 0.579 | 0.351 | 0.525 | 0.304 | 0.092 |   |
|   | 0.286 | 0.447 | 0.366 | 0.025 | 0.454 | 0.643 | 0.647 | 0.958 | 0.887 | 0.702 |   |
| 4 | 0.492 | 0.633 | 0.937 | 0.229 | 0.556 | 0.078 | 0.468 | 0.850 | 0.233 | 0.009 | 4 |
|   | 0.428 | 0.126 | 0.767 | 0.250 | 0.740 | 0.976 | 0.835 | 0.280 | 0.808 | 0.401 |   |
|   | 0.443 | 0.465 | 0.666 | 0.947 | 0.372 | 0.412 | 0.408 | 0.589 | 0.170 | 0.211 |   |
|   | 0.970 | 0.183 | 0.800 | 0.534 | 0.702 | 0.508 | 0.295 | 0.397 | 0.391 | 0.421 |   |
| 5 | 0.198 | 0.464 | 0.847 | 0.596 | 0.228 | 0.450 | 0.671 | 0.787 | 0.169 | 0.648 | 5 |
|   | 0.727 | 0.087 | 0.544 | 0.353 | 0.630 | 0.454 | 0.687 | 0.320 | 0.852 | 0.593 |   |
|   | 0.272 | 0.647 | 0.553 | 0.886 | 0.761 | 0.396 | 0.059 | 0.207 | 0.014 | 0.331 |   |
|   | 0.284 | 0.210 | 0.344 | 0.355 | 0.060 | 0.158 | 0.536 | 0.940 | 0.365 | 0.546 |   |
|   | 0.027 | 0.134 | 0.910 | 0.121 | 0.186 | 0.452 | 0.081 | 0.231 | 0.400 | 0.598 |   |
|   | 0.818 | 0.052 | 0.867 | 0.848 | 0.497 | 0.386 | 0.485 | 0.976 | 0.283 | 0.388 |   |
|   | 0.010 | 0.387 | 0.919 | 0.694 | 0.693 | 0.272 | 0.859 | 0.959 | 0.613 | 0.065 |   |
|   | 0.112 | 0.245 | 0.158 | 0.294 | 0.690 | 0.704 | 0.273 | 0.389 | 0.075 | 0.676 |   |
|   | 0.949 | 0.172 | 0.810 | 0.381 | 0.307 | 0.129 | 0.552 | 0.162 | 0.016 | 0.047 |   |
|   | A     | B     | C     | D     | E     |       |       |       |       |       |   |

The table below shows one way to determine, using the random numbers above, the truck numbers from which samples will be taken.

| SAMPLE NO. | DELIVERED<br>CONCRETE<br>(yd <sup>3</sup> ) | TOTAL<br>AMOUNT OF<br>CONCRETE<br>(yd <sup>3</sup> ) | TOTAL<br>LOADS OF<br>CONCRETE<br>(A) | RANDOM NO.<br>(B) | LOAD NUMBER<br>[(A <sub>n</sub> -A <sub>n-1</sub> )×B]+A <sub>n-1</sub> |
|------------|---------------------------------------------|------------------------------------------------------|--------------------------------------|-------------------|-------------------------------------------------------------------------|
| 1          | 10                                          | 10                                                   | 1                                    | NA                | 1                                                                       |
| 2          | 10                                          | 20                                                   | 2                                    | NA                | 2                                                                       |
| 3          | 10                                          | 30                                                   | 3                                    | NA                | 3                                                                       |
| 4          | 50                                          | 80                                                   | 8                                    | 0.492             | 5                                                                       |
| 5          | 50                                          | 130                                                  | 13                                   | 0.428             | 10                                                                      |
| 6          | 50                                          | 180                                                  | 18                                   | 0.443             | 15                                                                      |
| 7          | 50                                          | 230                                                  | 23                                   | 0.505             | 21                                                                      |
| 8          | 50                                          | 280                                                  | 28                                   | 0.447             | 25                                                                      |
| 9          | 50                                          | 330                                                  | 33                                   | 0.633             | 31                                                                      |
| 10         | 50                                          | 380                                                  | 38                                   | 0.126             | 34                                                                      |

**Example 4:** Slump, temperature, and air content of concrete from mixing trucks delivering concrete to a structural footing that is expected to use 550 cubic yards of concrete.

According to the Sampling and Testing Schedule (SOP 1-1, Part 2, shown below), one complete set of tests for air content, slump, and temperature are required for the first load of concrete delivered each day for quality control/informational purposes. For each additional 100 cubic yards of concrete, a pair of cylinders must be made and tests for air content, slump, and temperature must be performed.

|                                                                                                |                         |                                                                                                                                                                               |                   |                                                                                              |                |  |
|------------------------------------------------------------------------------------------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|----------------------------------------------------------------------------------------------|----------------|--|
| Ready Mix, Closure Pour, Grout, Pre-Packaged Mix, Flowable Fill, Polymer Modified, Prestressed | Class A, A Paving, S, X | Cylinders (28-day), Slump, Air Content, & Mix Temperature<br><br>Complete set of tests shall be performed on the initial load for informational purposes, not for acceptance. | Project Inspector | Every 100 cubic yards placed per day per structure unless otherwise specified (i.e. Class X) | Placement site |  |
|------------------------------------------------------------------------------------------------|-------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------|----------------------------------------------------------------------------------------------|----------------|--|

Now we'll use the random number tables in a different way. We must decide which loads of concrete to test. First, we'll assume each truck is hauling 10 cubic yards of concrete. Subsequent to the first 10 cubic yards, we'll test from truck loads by first choosing a random block of numbers from the following table. We'll choose block C1.

|   | A     | B     | C     | D     | E     |       |       |       |       |       |   |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|
| 1 | 0.815 | 0.125 | 0.006 | 0.653 | 0.614 | 0.455 | 0.968 | 0.103 | 0.150 | 0.154 | 1 |
|   | 0.872 | 0.226 | 0.619 | 0.637 | 0.585 | 0.566 | 0.331 | 0.028 | 0.369 | 0.751 |   |
|   | 0.685 | 0.964 | 0.937 | 0.948 | 0.969 | 0.454 | 0.194 | 0.425 | 0.852 | 0.500 |   |
|   | 0.427 | 0.348 | 0.222 | 0.129 | 0.690 | 0.911 | 0.996 | 0.115 | 0.681 | 0.569 |   |
|   | 0.181 | 0.115 | 0.519 | 0.715 | 0.508 | 0.308 | 0.525 | 0.584 | 0.694 | 0.427 |   |
| 2 | 0.917 | 0.628 | 0.054 | 0.928 | 0.817 | 0.812 | 0.264 | 0.776 | 0.756 | 0.610 | 2 |
|   | 0.759 | 0.891 | 0.311 | 0.612 | 0.247 | 0.044 | 0.668 | 0.389 | 0.953 | 0.931 |   |
|   | 0.510 | 0.632 | 0.371 | 0.037 | 0.667 | 0.681 | 0.730 | 0.638 | 0.965 | 0.925 |   |
|   | 0.836 | 0.525 | 0.342 | 0.752 | 0.638 | 0.403 | 0.687 | 0.245 | 0.403 | 0.785 |   |
|   | 0.669 | 0.875 | 0.824 | 0.842 | 0.565 | 0.756 | 0.401 | 0.371 | 0.576 | 0.689 |   |
| 3 | 0.931 | 0.450 | 0.955 | 0.323 | 0.696 | 0.790 | 0.021 | 0.127 | 0.753 | 0.550 | 3 |
|   | 0.771 | 0.631 | 0.896 | 0.968 | 0.870 | 0.312 | 0.764 | 0.665 | 0.113 | 0.610 |   |
|   | 0.855 | 0.525 | 0.056 | 0.255 | 0.921 | 0.282 | 0.301 | 0.401 | 0.775 | 0.246 |   |
|   | 0.897 | 0.753 | 0.246 | 0.763 | 0.259 | 0.293 | 0.613 | 0.154 | 0.743 | 0.574 |   |
|   | 0.393 | 0.878 | 0.401 | 0.459 | 0.134 | 0.655 | 0.433 | 0.323 | 0.393 | 0.038 |   |
| 4 | 0.965 | 0.130 | 0.181 | 0.909 | 0.940 | 0.399 | 0.200 | 0.724 | 0.673 | 0.397 | 4 |
|   | 0.745 | 0.233 | 0.460 | 0.361 | 0.935 | 0.018 | 0.405 | 0.945 | 0.183 | 0.576 |   |
|   | 0.204 | 0.623 | 0.771 | 0.120 | 0.859 | 0.314 | 0.880 | 0.447 | 0.680 | 0.938 |   |
|   | 0.804 | 0.213 | 0.903 | 0.488 | 0.425 | 0.685 | 0.584 | 0.676 | 0.717 | 0.220 |   |
|   | 0.526 | 0.018 | 0.323 | 0.978 | 0.407 | 0.197 | 0.827 | 0.102 | 0.641 | 0.302 |   |
| 5 | 0.620 | 0.343 | 0.587 | 0.878 | 0.922 | 0.977 | 0.162 | 0.523 | 0.011 | 0.409 | 5 |
|   | 0.558 | 0.383 | 0.880 | 0.541 | 0.422 | 0.466 | 0.186 | 0.004 | 0.457 | 0.446 |   |
|   | 0.128 | 0.893 | 0.685 | 0.864 | 0.349 | 0.413 | 0.273 | 0.971 | 0.970 | 0.311 |   |
|   | 0.455 | 0.032 | 0.141 | 0.835 | 0.705 | 0.898 | 0.958 | 0.945 | 0.095 | 0.779 |   |
|   | 0.790 | 0.312 | 0.258 | 0.518 | 0.141 | 0.448 | 0.185 | 0.599 | 0.546 | 0.751 |   |
|   | A     | B     | C     | D     | E     |       |       |       |       |       |   |

The table below shows one way to determine, using the random numbers above, the truck numbers from which samples will be taken for acceptance.

| SAMPLE NO. | TOTAL AMOUNT OF CONCRETE (yd <sup>3</sup> ) | TOTAL LOADS OF CONCRETE (A) | RANDOM NO. (B) | LOAD NUMBER [(A <sub>n</sub> -A <sub>n-1</sub> ) x B]+A <sub>n-1</sub> |
|------------|---------------------------------------------|-----------------------------|----------------|------------------------------------------------------------------------|
| 1          | 0-100                                       | 10                          | 0.273          | 3                                                                      |
| 2          | 101-200                                     | 20                          | 0.614          | 16                                                                     |
| 3          | 201-300                                     | 30                          | 0.585          | 26                                                                     |
| 4          | 301-400                                     | 40                          | 0.969          | 40                                                                     |
| 5          | 401-500                                     | 50                          | 0.690          | 47                                                                     |
| 6          | 501-550                                     | 55                          | 0.383          | 52                                                                     |

**Example 5:** Assume the contractor is paving 411-D mix at 132.50 lbs/square yard at 12 feet wide. How long is the average lot and subplot?

In order to find those lengths, view the following table:

| Spread<br>(lb/SY) | Lot/<br>Sublot | Mat Width (Feet) |       |       |       |       |       |       |      |      |      |
|-------------------|----------------|------------------|-------|-------|-------|-------|-------|-------|------|------|------|
|                   |                | 4                | 6     | 8     | 9     | 10    | 11    | 12    | 14   | 15   | 16   |
| 132.50            | Lot            | 34000            | 22600 | 17000 | 15100 | 13600 | 12300 | 11300 | 9700 | 9100 | 8500 |
|                   | Sublot         | 6800             | 4520  | 3400  | 3020  | 2720  | 2460  | 2260  | 1940 | 1820 | 1700 |
| 154.50            | Lot            | 29100            | 19400 | 14600 | 12900 | 11700 | 10600 | 9700  | 8300 | 7800 | 7300 |
|                   | Sublot         | 5820             | 3880  | 2920  | 2580  | 2340  | 2120  | 1940  | 1660 | 1560 | 1460 |
| 226.00            | Lot            | 19900            | 13300 | 10000 | 8800  | 8000  | 7200  | 6600  | 5700 | 5300 | 5000 |
|                   | Sublot         | 3980             | 2660  | 2000  | 1760  | 1600  | 1440  | 1320  | 1140 | 1060 | 1000 |
| 254.25            | Lot            | 17700            | 11800 | 8800  | 7900  | 7100  | 6400  | 5900  | 5100 | 4700 | 4400 |
|                   | Sublot         | 3540             | 2360  | 1760  | 1580  | 1420  | 1280  | 1180  | 1020 | 940  | 880  |
| 282.50            | Lot            | 15900            | 10600 | 8000  | 7100  | 6400  | 5800  | 5300  | 4600 | 4200 | 4000 |
|                   | Sublot         | 3180             | 2120  | 1600  | 1420  | 1280  | 1160  | 1060  | 920  | 840  | 800  |
| 310.75            | Lot            | 14500            | 9700  | 7200  | 6400  | 5800  | 5300  | 4800  | 4100 | 3900 | 3600 |
|                   | Sublot         | 2900             | 1940  | 1440  | 1280  | 1160  | 1060  | 960   | 820  | 780  | 720  |
| 345.00            | Lot            | 13000            | 8700  | 6500  | 5800  | 5200  | 4700  | 4300  | 3700 | 3500 | 3300 |
|                   | Sublot         | 2600             | 1740  | 1300  | 1160  | 1040  | 940   | 860   | 740  | 700  | 660  |
| 460.00            | Lot            | 9800             | 6500  | 4900  | 4300  | 3900  | 3600  | 3300  | 2800 | 2600 | 2400 |
|                   | Sublot         | 1960             | 1300  | 980   | 860   | 780   | 720   | 660   | 560  | 520  | 480  |

Find the row with the spread rate on the plans and follow it over to the column with the appropriate mat width. Where the row and column meet the lot/sublot lengths will be listed. For our example, find the row for 132.50 lbs/square yard and the column for 12 feet wide lanes. The values are **11,300 feet/2,260 feet** for the lot/sublot respectively.

**Example 6:** Assume the final lot is 500 tons. No matter how small, all lots will still require five equal sublots and five density tests. Instead of testing 500 tons five times consider combining the final two lots and halving the tonnage between the two lots. This will result in two lots of 750 tons.

You may still use the above table to find your lot and sublots. First locate the lot and subplot length for a 1000 ton lot based on the spread rate and lane width. For this example, use a spread rate of 132.5 lbs/square yard at 12 feet wide.

This would yield a Standard Lot of 11,300 feet and 2,260 feet respectively, but this needs to be modified based on the shorter lot.

Now that all of the givens are known, use the following equation to solve for the final lot/sublot lengths:

$$\left( \frac{\text{Lot Tonnage}}{1,000 \text{ tons}} \right) \times (\text{Standard Lot Length, in feet}) = \text{Lot Length, in feet}$$

$$\left( \frac{750 \text{ tons}}{1,000 \text{ tons}} \right) \times (11,300 \text{ feet}) = 8,475 \text{ feet} \sim \mathbf{8,500 \text{ feet}}$$

Once the lot length is determined for 750 tons, divide the new lot length by 5 for equal subplot lengths:

$$\left( \frac{8500 \text{ feet}}{5 \text{ sublots}} \right) = \mathbf{1,700 \text{ feet/sublot}}$$

These values are the new lot/sublot lengths. These values may be rounded to the nearest 100' for simplicity.

|   | A     |       | B     |       | C     |       | D     |       | E     |       |   |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|
| 1 | 0.678 | 0.694 | 0.141 | 0.441 | 0.836 | 0.182 | 0.274 | 0.829 | 0.365 | 0.881 | 1 |
|   | 0.023 | 0.158 | 0.948 | 0.763 | 0.555 | 0.741 | 0.157 | 0.869 | 0.811 | 0.789 |   |
|   | 0.504 | 0.635 | 0.730 | 0.899 | 0.719 | 0.357 | 0.284 | 0.140 | 0.644 | 0.082 |   |
|   | 0.704 | 0.941 | 0.361 | 0.863 | 0.882 | 0.404 | 0.704 | 0.933 | 0.667 | 0.571 |   |
|   | 0.830 | 0.617 | 0.154 | 0.081 | 0.109 | 0.741 | 0.503 | 0.974 | 0.301 | 0.911 |   |
| 2 | 0.247 | 0.737 | 0.402 | 0.169 | 0.871 | 0.830 | 0.069 | 0.276 | 0.998 | 0.499 | 2 |
|   | 0.710 | 0.346 | 0.012 | 0.836 | 0.233 | 0.885 | 0.077 | 0.341 | 0.607 | 0.719 |   |
|   | 0.205 | 0.290 | 0.040 | 0.804 | 0.638 | 0.987 | 0.353 | 0.539 | 0.208 | 0.676 |   |
|   | 0.980 | 0.629 | 0.424 | 0.081 | 0.002 | 0.761 | 0.185 | 0.940 | 0.997 | 0.568 |   |
|   | 0.360 | 0.766 | 0.117 | 0.032 | 0.588 | 0.049 | 0.407 | 0.388 | 0.535 | 0.464 |   |
| 3 | 0.120 | 0.852 | 0.163 | 0.852 | 0.201 | 0.487 | 0.713 | 0.696 | 0.914 | 0.080 | 3 |
|   | 0.413 | 0.327 | 0.839 | 0.949 | 0.724 | 0.728 | 0.508 | 0.471 | 0.327 | 0.850 |   |
|   | 0.955 | 0.924 | 0.285 | 0.028 | 0.299 | 0.064 | 0.953 | 0.791 | 0.437 | 0.745 |   |
|   | 0.131 | 0.616 | 0.223 | 0.213 | 0.027 | 0.024 | 0.484 | 0.030 | 0.533 | 0.552 |   |
|   | 0.037 | 0.500 | 0.803 | 0.546 | 0.093 | 0.401 | 0.750 | 0.189 | 0.417 | 0.078 |   |
| 4 | 0.096 | 0.483 | 0.713 | 0.576 | 0.935 | 0.281 | 0.506 | 0.994 | 0.014 | 0.491 | 4 |
|   | 0.818 | 0.855 | 0.950 | 0.195 | 0.142 | 0.392 | 0.380 | 0.786 | 0.063 | 0.423 |   |
|   | 0.689 | 0.685 | 0.742 | 0.863 | 0.906 | 0.966 | 0.617 | 0.375 | 0.908 | 0.685 |   |
|   | 0.443 | 0.857 | 0.239 | 0.770 | 0.181 | 0.241 | 0.982 | 0.373 | 0.150 | 0.316 |   |
|   | 0.020 | 0.898 | 0.158 | 0.365 | 0.497 | 0.139 | 0.864 | 0.937 | 0.392 | 0.026 |   |
| 5 | 0.245 | 0.510 | 0.670 | 0.082 | 0.483 | 0.403 | 0.524 | 0.338 | 0.387 | 0.406 | 5 |
|   | 0.658 | 0.596 | 0.690 | 0.737 | 0.899 | 0.567 | 0.655 | 0.231 | 0.508 | 0.374 |   |
|   | 0.107 | 0.682 | 0.077 | 0.763 | 0.593 | 0.877 | 0.094 | 0.929 | 0.268 | 0.973 |   |
|   | 0.057 | 0.478 | 0.230 | 0.623 | 0.339 | 0.942 | 0.239 | 0.839 | 0.074 | 0.854 |   |
|   | 0.312 | 0.193 | 0.428 | 0.947 | 0.185 | 0.197 | 0.642 | 0.537 | 0.590 | 0.876 |   |
|   | A     |       | B     |       | C     |       | D     |       | E     |       |   |

|   | A     |       | B     |       | C     |       | D     |       | E     |       |   |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|
| 1 | 0.439 | 0.107 | 0.450 | 0.340 | 0.181 | 0.794 | 0.186 | 0.814 | 0.350 | 0.112 | 1 |
|   | 0.460 | 0.661 | 0.706 | 0.123 | 0.648 | 0.988 | 0.750 | 0.968 | 0.955 | 0.196 |   |
|   | 0.631 | 0.799 | 0.355 | 0.746 | 0.842 | 0.268 | 0.445 | 0.942 | 0.430 | 0.324 |   |
|   | 0.398 | 0.177 | 0.993 | 0.666 | 0.377 | 0.609 | 0.533 | 0.840 | 0.271 | 0.270 |   |
|   | 0.258 | 0.732 | 0.905 | 0.314 | 0.200 | 0.640 | 0.736 | 0.970 | 0.804 | 0.352 |   |
| 2 | 0.099 | 0.586 | 0.938 | 0.597 | 0.883 | 0.855 | 0.489 | 0.003 | 0.290 | 0.397 | 2 |
|   | 0.024 | 0.789 | 0.120 | 0.111 | 0.274 | 0.627 | 0.731 | 0.654 | 0.482 | 0.637 |   |
|   | 0.536 | 0.280 | 0.146 | 0.968 | 0.044 | 0.326 | 0.097 | 0.326 | 0.228 | 0.370 |   |
|   | 0.087 | 0.955 | 0.770 | 0.328 | 0.492 | 0.940 | 0.554 | 0.913 | 0.888 | 0.758 |   |
|   | 0.192 | 0.771 | 0.968 | 0.688 | 0.247 | 0.770 | 0.194 | 0.621 | 0.847 | 0.848 |   |
| 3 | 0.183 | 0.040 | 0.020 | 0.172 | 0.625 | 0.262 | 0.170 | 0.501 | 0.930 | 0.626 | 3 |
|   | 0.605 | 0.948 | 0.688 | 0.893 | 0.686 | 0.840 | 0.799 | 0.047 | 0.936 | 0.752 |   |
|   | 0.924 | 0.795 | 0.113 | 0.148 | 0.316 | 0.956 | 0.536 | 0.701 | 0.440 | 0.702 |   |
|   | 0.569 | 0.213 | 0.626 | 0.960 | 0.240 | 0.823 | 0.196 | 0.335 | 0.663 | 0.630 |   |
|   | 0.799 | 0.128 | 0.560 | 0.843 | 0.951 | 0.600 | 0.609 | 0.256 | 0.292 | 0.681 |   |
| 4 | 0.597 | 0.815 | 0.412 | 0.439 | 0.189 | 0.094 | 0.782 | 0.515 | 0.809 | 0.303 | 4 |
|   | 0.014 | 0.033 | 0.240 | 0.170 | 0.824 | 0.248 | 0.118 | 0.570 | 0.344 | 0.203 |   |
|   | 0.916 | 0.958 | 0.802 | 0.089 | 0.958 | 0.677 | 0.515 | 0.843 | 0.127 | 0.868 |   |
|   | 0.989 | 0.291 | 0.184 | 0.927 | 0.089 | 0.780 | 0.214 | 0.277 | 0.105 | 0.138 |   |
|   | 0.545 | 0.849 | 0.884 | 0.192 | 0.617 | 0.416 | 0.763 | 0.558 | 0.027 | 0.098 |   |
| 5 | 0.227 | 0.322 | 0.069 | 0.477 | 0.984 | 0.112 | 0.207 | 0.110 | 0.196 | 0.615 | 5 |
|   | 0.342 | 0.472 | 0.531 | 0.716 | 0.337 | 0.880 | 0.593 | 0.881 | 0.195 | 0.188 |   |
|   | 0.059 | 0.058 | 0.688 | 0.504 | 0.418 | 0.197 | 0.894 | 0.298 | 0.843 | 0.959 |   |
|   | 0.056 | 0.926 | 0.214 | 0.016 | 0.050 | 0.692 | 0.256 | 0.966 | 1.000 | 0.084 |   |
|   | 0.033 | 0.489 | 0.768 | 0.354 | 0.855 | 0.839 | 0.670 | 0.853 | 0.934 | 0.012 |   |
|   | A     |       | B     |       | C     |       | D     |       | E     |       |   |

|   | A     |       | B     |       | C     |       | D     |       | E     |       |   |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|
| 1 | 0.001 | 0.411 | 0.562 | 0.371 | 0.511 | 0.010 | 0.189 | 0.340 | 0.529 | 0.991 | 1 |
|   | 0.095 | 0.690 | 0.070 | 0.561 | 0.412 | 0.123 | 0.060 | 0.580 | 0.614 | 0.151 |   |
|   | 0.742 | 0.355 | 0.526 | 0.217 | 0.848 | 0.774 | 0.923 | 0.542 | 0.653 | 0.385 |   |
|   | 0.914 | 0.676 | 0.912 | 0.868 | 0.085 | 0.281 | 0.924 | 0.704 | 0.371 | 0.600 |   |
|   | 0.257 | 0.536 | 0.951 | 0.713 | 0.939 | 0.987 | 0.637 | 0.536 | 0.129 | 0.917 |   |
| 2 | 0.586 | 0.163 | 0.710 | 0.254 | 0.744 | 0.846 | 0.979 | 0.344 | 0.333 | 0.481 | 2 |
|   | 0.271 | 0.577 | 0.487 | 0.484 | 0.408 | 0.704 | 0.901 | 0.347 | 0.850 | 0.286 |   |
|   | 0.480 | 0.538 | 0.017 | 0.074 | 0.427 | 0.225 | 0.452 | 0.049 | 0.233 | 0.846 |   |
|   | 0.967 | 0.187 | 0.657 | 0.775 | 0.251 | 0.877 | 0.169 | 0.977 | 0.879 | 0.635 |   |
|   | 0.471 | 0.416 | 0.107 | 0.334 | 0.565 | 0.735 | 0.549 | 0.763 | 0.850 | 0.113 |   |
| 3 | 0.398 | 0.095 | 0.496 | 0.726 | 0.650 | 0.498 | 0.266 | 0.727 | 0.355 | 0.209 | 3 |
|   | 0.265 | 0.801 | 0.509 | 0.718 | 0.181 | 0.286 | 0.928 | 0.200 | 0.588 | 0.881 |   |
|   | 0.937 | 0.348 | 0.446 | 0.688 | 0.955 | 0.834 | 0.796 | 0.045 | 0.292 | 0.019 |   |
|   | 0.999 | 0.804 | 0.217 | 0.945 | 0.601 | 0.122 | 0.897 | 0.535 | 0.170 | 0.606 |   |
|   | 0.871 | 0.270 | 0.269 | 0.056 | 0.555 | 0.907 | 0.732 | 0.709 | 0.224 | 0.424 |   |
| 4 | 0.550 | 0.650 | 0.779 | 0.280 | 0.914 | 0.303 | 0.377 | 0.896 | 0.428 | 0.791 | 4 |
|   | 0.262 | 0.325 | 0.785 | 0.248 | 0.748 | 0.291 | 0.552 | 0.560 | 0.806 | 0.450 |   |
|   | 0.194 | 0.754 | 0.700 | 0.244 | 0.521 | 0.673 | 0.196 | 0.495 | 0.227 | 0.995 |   |
|   | 0.484 | 0.315 | 0.295 | 0.267 | 0.637 | 0.202 | 0.082 | 0.750 | 0.626 | 0.107 |   |
|   | 0.925 | 0.002 | 0.940 | 0.406 | 0.756 | 0.942 | 0.745 | 0.665 | 0.398 | 0.519 |   |
| 5 | 0.769 | 0.126 | 0.227 | 0.521 | 0.395 | 0.853 | 0.606 | 0.467 | 0.716 | 0.376 | 5 |
|   | 0.786 | 0.339 | 0.246 | 0.850 | 0.310 | 0.413 | 0.966 | 0.387 | 0.222 | 0.035 |   |
|   | 0.121 | 0.278 | 0.807 | 0.006 | 0.872 | 0.081 | 0.317 | 0.163 | 0.942 | 0.763 |   |
|   | 0.794 | 0.721 | 0.766 | 0.883 | 0.285 | 0.936 | 0.363 | 0.154 | 0.021 | 0.304 |   |
|   | 0.138 | 0.381 | 0.875 | 0.566 | 0.802 | 0.077 | 0.888 | 0.634 | 0.880 | 0.916 |   |
|   | A     |       | B     |       | C     |       | D     |       | E     |       |   |

|   | A     |       | B     |       | C     |       | D     |       | E     |       |   |
|---|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|
| 1 | 0.213 | 0.416 | 0.998 | 0.713 | 0.003 | 0.826 | 0.353 | 0.763 | 0.835 | 0.398 | 1 |
|   | 0.761 | 0.812 | 0.959 | 0.598 | 0.771 | 0.105 | 0.414 | 0.251 | 0.305 | 0.385 |   |
|   | 0.071 | 0.848 | 0.185 | 0.978 | 0.881 | 0.329 | 0.822 | 0.690 | 0.779 | 0.126 |   |
|   | 0.745 | 0.888 | 0.662 | 0.041 | 0.589 | 0.145 | 0.125 | 0.617 | 0.474 | 0.200 |   |
|   | 0.619 | 0.972 | 0.230 | 0.780 | 0.224 | 0.463 | 0.846 | 0.098 | 0.541 | 0.002 |   |
| 2 | 0.770 | 0.801 | 0.055 | 0.852 | 0.289 | 0.381 | 0.023 | 0.911 | 0.736 | 0.387 | 2 |
|   | 0.794 | 0.193 | 0.499 | 0.827 | 0.235 | 0.046 | 0.168 | 0.789 | 0.543 | 0.594 |   |
|   | 0.768 | 0.053 | 0.915 | 0.063 | 0.541 | 0.687 | 0.848 | 0.742 | 0.891 | 0.091 |   |
|   | 0.752 | 0.363 | 0.172 | 0.583 | 0.183 | 0.234 | 0.105 | 0.650 | 0.456 | 0.330 |   |
|   | 0.746 | 0.920 | 0.088 | 0.285 | 0.125 | 0.514 | 0.795 | 0.366 | 0.144 | 0.758 |   |
| 3 | 0.676 | 0.579 | 0.181 | 0.237 | 0.249 | 0.376 | 0.805 | 0.306 | 0.050 | 0.951 | 3 |
|   | 0.524 | 0.502 | 0.975 | 0.401 | 0.741 | 0.518 | 0.312 | 0.284 | 0.444 | 0.002 |   |
|   | 0.408 | 0.575 | 0.505 | 0.360 | 0.774 | 0.546 | 0.635 | 0.758 | 0.440 | 0.299 |   |
|   | 0.875 | 0.176 | 0.145 | 0.011 | 0.174 | 0.516 | 0.317 | 0.560 | 0.775 | 0.488 |   |
|   | 0.045 | 0.320 | 0.449 | 0.079 | 0.726 | 0.455 | 0.934 | 0.341 | 0.912 | 0.963 |   |
| 4 | 0.589 | 0.945 | 0.644 | 0.339 | 0.984 | 0.115 | 0.517 | 0.414 | 0.834 | 0.261 | 4 |
|   | 0.338 | 0.428 | 0.777 | 0.803 | 0.755 | 0.264 | 0.481 | 0.030 | 0.186 | 0.953 |   |
|   | 0.034 | 0.715 | 0.499 | 0.896 | 0.934 | 0.827 | 0.601 | 0.527 | 0.282 | 0.758 |   |
|   | 0.642 | 0.976 | 0.896 | 0.449 | 0.361 | 0.777 | 0.297 | 0.484 | 0.949 | 0.629 |   |
|   | 0.864 | 0.440 | 0.059 | 0.265 | 0.072 | 0.879 | 0.779 | 0.421 | 0.657 | 0.146 |   |
| 5 | 0.979 | 0.318 | 0.153 | 0.682 | 0.066 | 0.806 | 0.003 | 0.163 | 0.249 | 0.012 | 5 |
|   | 0.253 | 0.995 | 0.678 | 0.459 | 0.166 | 0.223 | 0.132 | 0.558 | 0.377 | 0.663 |   |
|   | 0.922 | 0.764 | 0.313 | 0.247 | 0.330 | 0.167 | 0.098 | 0.416 | 0.378 | 0.585 |   |
|   | 0.711 | 0.516 | 0.731 | 0.061 | 0.387 | 0.520 | 0.865 | 0.596 | 0.456 | 0.745 |   |
|   | 0.341 | 0.350 | 0.431 | 0.984 | 0.583 | 0.321 | 0.142 | 0.508 | 0.040 | 0.741 |   |
|   | A     |       | B     |       | C     |       | D     |       | E     |       |   |

|   |  | A     |       | B     |       | C     |       | D     |       | E     |       |   |  |
|---|--|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|--|
| 1 |  | 0.764 | 0.375 | 0.774 | 0.880 | 0.109 | 0.349 | 0.121 | 0.861 | 0.612 | 0.200 | 1 |  |
|   |  | 0.614 | 0.527 | 0.172 | 0.266 | 0.018 | 0.374 | 0.036 | 0.623 | 0.341 | 0.427 |   |  |
|   |  | 0.017 | 0.694 | 0.456 | 0.638 | 0.812 | 0.271 | 0.423 | 0.329 | 0.644 | 0.041 |   |  |
|   |  | 0.823 | 0.132 | 0.112 | 0.039 | 0.319 | 0.312 | 0.565 | 0.634 | 0.124 | 0.199 |   |  |
|   |  | 0.001 | 0.938 | 0.180 | 0.639 | 0.207 | 0.918 | 0.905 | 0.490 | 0.938 | 0.019 |   |  |
| 2 |  | 0.281 | 0.761 | 0.733 | 0.457 | 0.424 | 0.063 | 0.159 | 0.247 | 0.546 | 0.975 | 2 |  |
|   |  | 0.503 | 0.360 | 0.556 | 0.533 | 0.829 | 0.490 | 0.527 | 0.286 | 0.557 | 0.078 |   |  |
|   |  | 0.689 | 0.948 | 0.589 | 0.816 | 0.370 | 0.794 | 0.913 | 0.324 | 0.529 | 0.041 |   |  |
|   |  | 0.260 | 0.313 | 0.841 | 0.771 | 0.752 | 0.282 | 0.669 | 0.749 | 0.420 | 0.451 |   |  |
|   |  | 0.204 | 0.118 | 0.165 | 0.209 | 0.865 | 0.429 | 0.366 | 0.493 | 0.509 | 0.945 |   |  |
| 3 |  | 0.546 | 0.394 | 0.643 | 0.855 | 0.104 | 0.120 | 0.201 | 0.987 | 0.640 | 0.240 | 3 |  |
|   |  | 0.230 | 0.569 | 0.865 | 0.696 | 0.044 | 0.494 | 0.030 | 0.699 | 0.204 | 0.105 |   |  |
|   |  | 0.808 | 0.107 | 0.645 | 0.308 | 0.094 | 0.288 | 0.391 | 0.885 | 0.069 | 0.994 |   |  |
|   |  | 0.423 | 0.022 | 0.370 | 0.008 | 0.125 | 0.774 | 0.091 | 0.523 | 0.700 | 0.599 |   |  |
|   |  | 0.819 | 0.415 | 0.405 | 0.856 | 0.065 | 0.079 | 0.408 | 0.541 | 0.723 | 0.309 |   |  |
| 4 |  | 0.212 | 0.347 | 0.045 | 0.359 | 0.420 | 0.422 | 0.720 | 0.767 | 0.983 | 0.589 | 4 |  |
|   |  | 0.444 | 0.389 | 0.427 | 0.634 | 0.055 | 0.337 | 0.519 | 0.444 | 0.644 | 0.703 |   |  |
|   |  | 0.224 | 0.571 | 0.271 | 0.859 | 0.636 | 0.175 | 0.255 | 0.080 | 0.027 | 0.877 |   |  |
|   |  | 0.840 | 0.401 | 0.917 | 0.099 | 0.600 | 0.715 | 0.332 | 0.335 | 0.405 | 0.983 |   |  |
|   |  | 0.233 | 0.580 | 0.966 | 0.419 | 0.092 | 0.243 | 0.175 | 0.179 | 0.743 | 0.611 |   |  |
| 5 |  | 0.668 | 0.678 | 0.304 | 0.650 | 0.646 | 0.623 | 0.290 | 0.246 | 0.680 | 0.359 | 5 |  |
|   |  | 0.430 | 0.392 | 0.388 | 0.807 | 0.455 | 0.004 | 0.586 | 0.442 | 0.179 | 0.162 |   |  |
|   |  | 0.309 | 0.373 | 0.239 | 0.392 | 0.490 | 0.549 | 0.773 | 0.695 | 0.917 | 0.797 |   |  |
|   |  | 0.681 | 0.901 | 0.637 | 0.195 | 0.392 | 0.093 | 0.091 | 0.642 | 0.389 | 0.492 |   |  |
|   |  | 0.134 | 0.119 | 0.276 | 0.503 | 0.096 | 0.319 | 0.135 | 0.225 | 0.953 | 0.169 |   |  |
|   |  | A     |       | B     |       | C     |       | D     |       | E     |       |   |  |

|   |  | A     |       | B     |       | C     |       | D     |       | E     |       |   |  |
|---|--|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|--|
| 1 |  | 0.772 | 0.571 | 0.975 | 0.511 | 0.489 | 0.398 | 0.089 | 0.964 | 0.379 | 0.313 | 1 |  |
|   |  | 0.838 | 0.849 | 0.592 | 0.814 | 0.914 | 0.928 | 0.438 | 0.875 | 0.712 | 0.507 |   |  |
|   |  | 0.447 | 0.478 | 0.176 | 0.084 | 0.317 | 0.169 | 0.755 | 0.741 | 0.821 | 0.134 |   |  |
|   |  | 0.960 | 0.192 | 0.970 | 0.442 | 0.856 | 0.621 | 0.500 | 0.912 | 0.814 | 0.895 |   |  |
|   |  | 0.941 | 0.780 | 0.393 | 0.912 | 0.252 | 0.713 | 0.386 | 0.158 | 0.941 | 0.599 |   |  |
| 2 |  | 0.819 | 0.432 | 0.555 | 0.447 | 0.866 | 0.737 | 0.363 | 0.382 | 0.615 | 0.705 | 2 |  |
|   |  | 0.937 | 0.970 | 0.331 | 0.751 | 0.633 | 0.711 | 0.234 | 0.174 | 0.518 | 0.644 |   |  |
|   |  | 0.408 | 0.983 | 0.714 | 0.499 | 0.782 | 0.417 | 0.849 | 0.013 | 0.325 | 0.064 |   |  |
|   |  | 0.848 | 0.718 | 0.096 | 0.035 | 0.021 | 0.484 | 0.146 | 0.233 | 0.744 | 0.090 |   |  |
|   |  | 0.814 | 0.540 | 0.268 | 0.199 | 0.913 | 0.387 | 0.614 | 0.335 | 0.493 | 0.194 |   |  |
| 3 |  | 0.373 | 0.229 | 0.458 | 0.544 | 0.138 | 0.753 | 0.825 | 0.441 | 0.521 | 0.304 | 3 |  |
|   |  | 0.748 | 0.235 | 0.421 | 0.304 | 0.568 | 0.329 | 0.098 | 0.348 | 0.371 | 0.646 |   |  |
|   |  | 0.365 | 0.098 | 0.826 | 0.053 | 0.931 | 0.166 | 0.835 | 0.384 | 0.716 | 0.951 |   |  |
|   |  | 0.711 | 0.021 | 0.531 | 0.549 | 0.727 | 0.539 | 0.111 | 0.627 | 0.036 | 0.867 |   |  |
|   |  | 0.111 | 0.106 | 0.980 | 0.418 | 0.757 | 0.475 | 0.157 | 0.525 | 0.793 | 0.326 |   |  |
| 4 |  | 0.171 | 0.226 | 0.276 | 0.734 | 0.265 | 0.190 | 0.452 | 0.998 | 0.520 | 0.857 | 4 |  |
|   |  | 0.749 | 0.458 | 0.832 | 0.004 | 0.218 | 0.492 | 0.375 | 0.428 | 0.966 | 0.285 |   |  |
|   |  | 0.074 | 0.807 | 0.868 | 0.560 | 0.526 | 0.077 | 0.236 | 0.430 | 0.861 | 0.112 |   |  |
|   |  | 0.463 | 0.256 | 0.120 | 0.567 | 0.237 | 0.012 | 0.136 | 0.075 | 0.617 | 0.974 |   |  |
|   |  | 0.903 | 0.948 | 0.531 | 0.315 | 0.050 | 0.839 | 0.977 | 0.882 | 0.196 | 0.982 |   |  |
| 5 |  | 0.611 | 0.524 | 0.293 | 0.749 | 0.367 | 0.958 | 0.348 | 0.109 | 0.780 | 0.254 | 5 |  |
|   |  | 0.438 | 0.791 | 0.982 | 0.027 | 0.170 | 0.127 | 0.820 | 0.943 | 0.075 | 0.887 |   |  |
|   |  | 0.973 | 0.410 | 0.313 | 0.035 | 0.949 | 0.848 | 0.720 | 0.672 | 0.530 | 0.799 |   |  |
|   |  | 0.382 | 0.458 | 0.800 | 0.781 | 0.242 | 0.564 | 0.019 | 0.139 | 0.338 | 0.176 |   |  |
|   |  | 0.751 | 0.263 | 0.344 | 0.467 | 0.941 | 0.795 | 0.019 | 0.880 | 0.515 | 0.415 |   |  |
|   |  | A     |       | B     |       | C     |       | D     |       | E     |       |   |  |

|   |  | A     |       | B     |       | C     |       | D     |       | E     |       |   |  |  |
|---|--|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|---|--|--|
| 1 |  | 0.975 | 0.023 | 0.046 | 0.500 | 0.806 | 0.260 | 0.202 | 0.319 | 0.813 | 0.862 | 1 |  |  |
|   |  | 0.600 | 0.130 | 0.373 | 0.995 | 0.048 | 0.501 | 0.552 | 0.519 | 0.846 | 0.403 |   |  |  |
|   |  | 0.536 | 0.018 | 0.935 | 0.372 | 0.090 | 0.931 | 0.311 | 0.579 | 0.466 | 0.979 |   |  |  |
|   |  | 0.567 | 0.042 | 0.182 | 0.483 | 0.143 | 0.473 | 0.838 | 0.578 | 0.894 | 0.070 |   |  |  |
|   |  | 0.956 | 0.913 | 0.130 | 0.915 | 0.895 | 0.415 | 0.558 | 0.554 | 0.975 | 0.636 |   |  |  |
| 2 |  | 0.348 | 0.419 | 0.682 | 0.262 | 0.536 | 0.984 | 0.886 | 0.878 | 0.009 | 0.877 | 2 |  |  |
|   |  | 0.141 | 0.217 | 0.422 | 0.261 | 0.384 | 0.716 | 0.326 | 0.212 | 0.353 | 0.610 |   |  |  |
|   |  | 0.625 | 0.370 | 0.164 | 0.966 | 0.722 | 0.236 | 0.548 | 0.137 | 0.851 | 0.053 |   |  |  |
|   |  | 0.357 | 0.688 | 0.676 | 0.757 | 0.630 | 0.527 | 0.817 | 0.041 | 0.235 | 0.790 |   |  |  |
|   |  | 0.114 | 0.741 | 0.129 | 0.805 | 0.802 | 0.800 | 0.615 | 0.417 | 0.741 | 0.455 |   |  |  |
| 3 |  | 0.515 | 0.566 | 0.935 | 0.755 | 0.055 | 0.412 | 0.083 | 0.253 | 0.174 | 0.826 | 3 |  |  |
|   |  | 0.557 | 0.484 | 0.163 | 0.242 | 0.221 | 0.150 | 0.397 | 0.763 | 0.868 | 0.113 |   |  |  |
|   |  | 0.787 | 0.758 | 0.735 | 0.302 | 0.391 | 0.540 | 0.043 | 0.991 | 0.537 | 0.459 |   |  |  |
|   |  | 0.111 | 0.507 | 0.695 | 0.634 | 0.251 | 0.587 | 0.386 | 0.533 | 0.585 | 0.449 |   |  |  |
|   |  | 0.824 | 0.682 | 0.521 | 0.056 | 0.088 | 0.302 | 0.128 | 0.562 | 0.334 | 0.244 |   |  |  |
| 4 |  | 0.597 | 0.828 | 0.318 | 0.337 | 0.736 | 0.029 | 0.891 | 0.709 | 0.700 | 0.134 | 4 |  |  |
|   |  | 0.768 | 0.644 | 0.400 | 0.481 | 0.528 | 0.573 | 0.928 | 0.824 | 0.537 | 0.445 |   |  |  |
|   |  | 0.778 | 0.664 | 0.687 | 0.607 | 0.493 | 0.515 | 0.269 | 0.363 | 0.662 | 0.947 |   |  |  |
|   |  | 0.833 | 0.812 | 0.289 | 0.346 | 0.923 | 0.478 | 0.941 | 0.580 | 0.976 | 0.509 |   |  |  |
|   |  | 0.635 | 0.995 | 0.723 | 0.558 | 0.349 | 0.432 | 0.155 | 0.276 | 0.129 | 0.326 |   |  |  |
| 5 |  | 0.880 | 0.025 | 0.952 | 0.801 | 0.596 | 0.565 | 0.407 | 0.303 | 0.620 | 0.153 | 5 |  |  |
|   |  | 0.624 | 0.276 | 0.934 | 0.715 | 0.372 | 0.111 | 0.823 | 0.740 | 0.650 | 0.676 |   |  |  |
|   |  | 0.084 | 0.459 | 0.616 | 0.230 | 0.955 | 0.787 | 0.486 | 0.817 | 0.420 | 0.599 |   |  |  |
|   |  | 0.028 | 0.943 | 0.707 | 0.336 | 0.442 | 0.751 | 0.009 | 0.025 | 0.406 | 0.638 |   |  |  |
|   |  | 0.257 | 0.953 | 0.580 | 0.071 | 0.474 | 0.137 | 0.481 | 0.277 | 0.533 | 0.292 |   |  |  |
|   |  | A     |       | B     |       | C     |       | D     |       | E     |       |   |  |  |

|   |  | A     |       | B     |       | C     |       | D     |       | E     |       |  |  |
|---|--|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--|--|
| 1 |  | 0.817 | 0.093 | 0.254 | 0.779 | 0.563 | 0.409 | 0.263 | 0.244 | 0.026 | 0.340 |  |  |
|   |  | 0.267 | 0.817 | 0.444 | 0.908 | 0.830 | 0.238 | 0.270 | 0.990 | 0.287 | 0.607 |  |  |
|   |  | 0.287 | 0.574 | 0.016 | 0.879 | 0.159 | 0.232 | 0.440 | 0.553 | 0.799 | 0.461 |  |  |
|   |  | 0.416 | 0.330 | 0.913 | 0.890 | 0.426 | 0.746 | 0.078 | 0.374 | 0.190 | 0.396 |  |  |
|   |  | 0.116 | 0.197 | 0.178 | 0.223 | 0.794 | 0.327 | 0.401 | 0.499 | 0.666 | 0.475 |  |  |
| 2 |  | 0.554 | 0.784 | 0.841 | 0.113 | 0.606 | 0.687 | 0.319 | 0.268 | 0.793 | 0.461 |  |  |
|   |  | 0.777 | 0.671 | 0.420 | 0.990 | 0.215 | 0.825 | 0.222 | 0.591 | 0.264 | 0.230 |  |  |
|   |  | 0.215 | 0.696 | 0.455 | 0.127 | 0.976 | 0.774 | 0.761 | 0.437 | 0.664 | 0.164 |  |  |
|   |  | 0.174 | 0.315 | 0.788 | 0.300 | 0.037 | 0.258 | 0.464 | 0.286 | 0.575 | 0.581 |  |  |
|   |  | 0.262 | 0.845 | 0.246 | 0.789 | 0.815 | 0.539 | 0.766 | 0.646 | 0.034 | 0.860 |  |  |
| 3 |  | 0.372 | 0.973 | 0.530 | 0.319 | 0.021 | 0.337 | 0.755 | 0.423 | 0.182 | 0.877 |  |  |
|   |  | 0.696 | 0.264 | 0.848 | 0.895 | 0.963 | 0.121 | 0.620 | 0.738 | 0.446 | 0.657 |  |  |
|   |  | 0.551 | 0.612 | 0.469 | 0.596 | 0.767 | 0.900 | 0.050 | 0.859 | 0.210 | 0.652 |  |  |
|   |  | 0.940 | 0.828 | 0.328 | 0.224 | 0.861 | 0.612 | 0.640 | 0.783 | 0.952 | 0.292 |  |  |
|   |  | 0.493 | 0.163 | 0.854 | 0.979 | 0.858 | 0.562 | 0.690 | 0.143 | 0.796 | 0.904 |  |  |
| 4 |  | 0.963 | 0.877 | 0.075 | 0.714 | 0.414 | 0.351 | 0.829 | 0.246 | 0.447 | 0.060 |  |  |
|   |  | 0.441 | 0.183 | 0.880 | 0.986 | 0.755 | 0.034 | 0.642 | 0.540 | 0.393 | 0.665 |  |  |
|   |  | 0.558 | 0.228 | 0.709 | 0.238 | 0.572 | 0.599 | 0.504 | 0.971 | 0.698 | 0.744 |  |  |
|   |  | 0.811 | 0.758 | 0.092 | 0.848 | 0.312 | 0.436 | 0.017 | 0.438 | 0.916 | 0.304 |  |  |
|   |  | 0.017 | 0.260 | 0.953 | 0.564 | 0.947 | 0.011 | 0.425 | 0.468 | 0.083 | 0.789 |  |  |
| 5 |  | 0.178 | 0.881 | 0.468 | 0.731 | 0.604 | 0.324 | 0.398 | 0.753 | 0.278 | 0.130 |  |  |
|   |  | 0.979 | 0.811 | 0.476 | 0.125 | 0.423 | 0.314 | 0.456 | 0.090 | 0.189 | 0.066 |  |  |
|   |  | 0.057 | 0.136 | 0.483 | 0.100 | 0.712 | 0.204 | 0.372 | 0.385 | 0.918 | 0.405 |  |  |
|   |  | 0.717 | 0.633 | 0.348 | 0.744 | 0.255 | 0.781 | 0.433 | 0.625 | 0.300 | 0.705 |  |  |
|   |  | 0.305 | 0.247 | 0.661 | 0.493 | 0.889 | 0.764 | 0.577 | 0.169 | 0.261 | 0.398 |  |  |
|   |  | A     |       | B     |       | C     |       | D     |       | E     |       |  |  |

## **Tennessee Department of Transportation Division of Materials and Tests**

### **Nuclear Density Testing (SOP 7-1)**

Purpose: The purpose of this document is to provide guidance for conducting nuclear density tests on hot mix asphalt, backfill, soil, aggregate base, embankments, and other materials requiring density tests in accordance with SOP 1-1.

Discussion: Many compacted materials on TDOT projects are accepted by means of testing with nuclear density gauges. This document intends to provide guidance and define best practices for operation of these gauges to unify testing operations statewide. Testing details of common concern include proper setup of gauge information, depth of test probes, time length of tests, and recording of data.

Basic Procedure: All test procedures shall be in accordance with AASHTO T310, "*In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)*" and ASTM D2950, "*Standard Test Method for Density of Bituminous Concrete In-Place by Nuclear Methods*" except as revised herein.

Specific instructions on conducting standard counts, entering maximum specific gravity values, offsets, correction factors, and proctor information can be found in the users' manuals corresponding to the make and model of the gauge in use.

Instructions on conducting standard counts can be found in Part Three of this SOP. You can also find specific information in the users' manual for the gauge being used.

### **PART ONE – ACCEPTANCE TESTING**

#### **For All Asphalt Mixtures That Require Density Testing**

Step 1: Conduct Standard Count in accordance with Part Three.

Step 2: Enter maximum specific gravity (Gmm) value from asphalt mix design.

Step 3: Enter gauge correction factor from test strip. See Part Two for determining correction factors. (Note: testing may be done prior to obtaining the correction factor, however all tests done during this time must be corrected as soon as possible and prior to finalizing the records for acceptance or assurance tests.)

Step 4: Set gauge setting to Backscatter.

Step 5: Place gauge in location to be tested.

**Footnote 1:** For guidance on testing frequencies, random numbers, and selecting test locations, see [SOP 1-1](#).

Step 6: Activate a test. When collecting a density test, the following approach **shall** be used:

- o “*Four Nineties*” Test: Four tests shall be conducted at a single location, rotating around the test location 90 degrees at a time, as shown in Figure 1. The four test results will then be averaged to obtain a single test value for that location. Test counts for this approach shall be 15 seconds or longer.

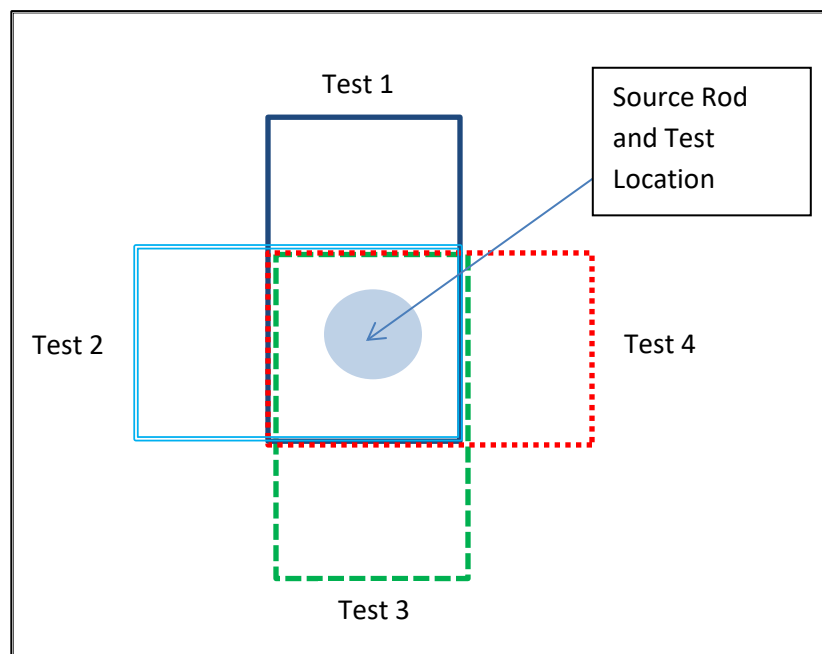


Figure 1. Testing at four 90° locations

Step 7: Record the test value into the appropriate paperwork.

- o DT-0315, Daily Asphalt Density Report
- o SiteManager D2950 – Density of Bituminous Concrete in Place

## Soil and Aggregate Materials

*Materials: Backfill (Earth retaining structures), Select granular backfill (Earth retaining structures), Embankments, Subgrade preparation, Lime-treated subgrade, Soil-Cement Base, Mineral Aggregate Base and Surface, Aggregate for Underdrains, Aggregate-Cement base course, Aggregate Lime fly ash base course, & Conditioned mineral aggregate base.*

Step 1: Conduct Standard Count in accordance with Part Three.

Step 2: Enter maximum dry density and optimum moisture content from Proctor Density report.

Step 3: Select Test location. Create a test hole using the scraper plate, drill rod, and extraction tool provided with the gauge. **Take caution to not expand the test hole when extracting the drill rod.**

**Footnote 2:** For guidance on selecting test locations, see [SOP 1-1](#).

Step 4: Set gauge setting to Direct Transmission at a depth reasonably close to one half the depth of the compacted lift.

Step 5: Place gauge in location to be tested and insert test probe into test hole at a depth reasonably close to one half the depth of the compacted lift. Pull gauge back to ensure probe makes contact with material being tested.

Step 6: Activate a test. When collecting a density test, the following approach shall be used:

*Single Count Test:* A single test shall be conducted at any test location, given that the **test count is equal to 60 seconds.**

Step 7: Record the test value into the appropriate paperwork.

- o DT-0298, Daily Report on Soil and Aggregate Stabilization
- o DT-0304, Daily Report on Embankment
- o DT-0307, Daily Report on Mineral Aggregate Base
- o DT-0314, Density Worksheet – Nuclear Method (Aggregate, Soil)
- o **SiteManager T310 – Nuclear Density/ Moisture of Soil and Aggregate**

## PART TWO – DETERMINATION OF ASPHALT CALIBRATION FACTORS

- Conduct test strips in accordance with most current version of TDOT Standard specifications, subsection 407.15. Nuclear Gauge readings are not valid on Asphalt until the gauge is correlated to the mix and project location. A new test strip shall be required for each project and each mix design used on the project (for mix types that require density testing as noted above). Uncorrelated gauges shall not be used for acceptance or assurance testing.
- Test strips are required for all asphalt mixtures that require density testing.
- The minimum size of a single test strip is 400 yd<sup>2</sup>, but a larger area is recommended. The following roadway lengths provide an area of 400 yd<sup>2</sup> :
  - o 9' wide= 400' long
  - o 10' wide= 360' long
  - o 11' wide= 330' long
  - o 12' wide= 300' long
- Compaction of the test strip shall commence immediately after placement of the bituminous mixture.
- TDOT form DT-0316, Density and Roller Pattern Test Strip

Step 1: Compact test strip area

Step 2: Layout ten test strip test locations such that the full length and width of the test strip is covered. Mark test location and test number on pavement with spray paint. **DO NOT spray base of gauge with marking paint.**

Step 3: Conduct and record ten sets of uncorrected density (4 90s test method) tests on the compacted test strip area and record test information

Step 4: Cores shall be cut at same locations as nuclear density tests and tested by TDOT Plant Technician for laboratory density in accordance with AASHTO T166. (NOTE: The contractor's technician shall not conduct this testing)

**Footnote 3:** Only Method A of T166 shall apply when testing test strip cores for density. Cores shall be COMPLETELY DRY before testing. Accelerated drying in accordance with ASTM D 7227 (core drying device) is permitted.

Step 5: The nuclear gauge correction factor shall be the difference between the average of ten nuclear gauge readings and the average of ten core density values.

### **Additional notes on test strips and correction factors:**

- Nuclear gauges are specific to an individual gauge, mix, and project. DO NOT develop a correction factor with a different gauge unit than the one to be used during mainline acceptance testing.
- Developing correction factors based on cores that were not allowed to dry completely will influence results in a manner that can mislead test results into appearing as if they are higher than they actually are. In other words, wet cores appear heavier or denser than they actually are.
- In accordance with TDOT Specifications, a new test strip is required when:
  - There is a change in job mix formulas
  - A change in the source of materials occurs
  - A change in the material from the same source is observed
  - There is reason to believe that the test strip density is not representative of the mixture being placed. For example, test results are consistently above 100% density or test results have been consistent for a steady number of days and had suddenly changed significantly.
  - A change in paving or compaction equipment occurs.

### **PART THREE – TAKING THE STANDARD COUNT**

- Keep a log of your standard counts.
- Standard counts provide a quick reference check to ensure that the gauge is operating correctly.
- A standard count must be taken daily on the reference standard block.
- Max Density and Moisture Variation: **1%** for density and **2%** for moisture.

#### **Preparatory steps before taking the standard count:**

1. Turn the gauge on and let it **warm up for a minimum of 10 minutes** (Troxler & Instron only).
2. The base of the gauge and the top of the standard block must be clean and debris free.
3. Place the reference block on the material you will be performing the density test.
4. Troxler & Instron gauges, ensure the source rod is placed at the opposite end of the butt plate.
5. Humboldt gauges, ensure the source rod is placed toward the standard block handle.
6. Make sure to slide the gauge towards and up against the butt plate (Troxler & Instron) or handle (Humboldt) on the standard count block.

7. Make sure the source rod is in the safe locked position before taking the standard test.
8. Make sure there are no other gauges within 30 feet.
9. Make sure to take the test in an area away from any large vertical objects including walls, vehicles and people.
10. **DO NOT** warm up the gauge or take a standard count on the tailgate of the truck.

If any one of these apply: (Does not apply to Humboldt gauges. Refer to chapter 3.2 in users manual)

- **A standard count log has NOT been kept**
- **The standard count fails**
- **The gauge hasn't been used in the last 30 days**

Do the following: (Does not apply to Humboldt gauges. Refer to chapter 3.2 in users manual)

Step 1: Take five new counts

Step 2: Average the first four

Step 3: Compare with the 5th reading using the equation below:

$$\% \text{ DIFFERENCE} = \frac{\text{AVERAGE} - 5\text{TH READING}}{\text{AVERAGE}} \times 100$$

Step 4: Check if the reading is within the required limits.

**Max Density and Moisture Variation:** 1% for density and 2% for moisture. If the standard count still fails, call your Regional RSO.

**Tennessee Department of Transportation  
Division of Materials and Tests  
Standard Operating Procedure 7-2  
Nuclear Gauge Safety Plan**

**Purpose** - The purpose of this document is to establish guidelines on nuclear density gauge storage, gauge usage, gauge transportation, and outline an Emergency Response Plan for TDOT Radiation Safety Technicians. A TDOT Radiation Safety Technician is an individual who has successfully completed the TDOT Radiation Safety training and demonstrated a basic understanding of radiation safety and compliance, nuclear density gauge operation, testing procedures, and maintenance.

**Background**- Tennessee Radioactive Material License No. R-19017-K26 requires that TDOT technicians attend the appropriate training to operate and transport nuclear density gauges. The license also requires TDOT to have a radiation safety emergency response plan.

Each **Materials & Tests Field Services Office** has a Radiation Safety Officer (RSO) as well as the Statewide TDOT RSO located in Nashville at Headquarters Materials and Tests. **Each gauge operator is responsible for knowing the current contact information of their Field Services RSO. Each operator is also responsible for knowing how to transport and handle the nuclear density gauge according to Federal and State Laws and per SOP 7-2. Not following the below statements could result in TDOT and the operator receiving fines and loss of our Radioactive Materials License.**

**1 Storage Site:**

- 1.1 Storage site must be enclosed (four walls and a roof) and it must protect gauges from the elements. **All storage sites will adhere to the two security barrier requirements. Gauges will need to be secured with a lock and chain/cable or inside the cage of the storage building.**
- 1.2 The storage area shall be marked with a radiation sign that reads **"CAUTION RADIATION AREA, RADIOACTIVE MATERIALS, AUTHORIZED PERSONNEL WITH PERSONAL MONITORING DEVICE ONLY "** on or near storage site entrance. Contact the TDOT RSO for signage.
- 1.3 **Storage site shall also display "Notice to Employees" and "Notice to Pregnant Worker" information signage on or near storage site entrance. Contact the TDOT RSO for signage.**
- 1.4 A log of all gauges stored at the site will be maintained at the storage site. The gauge must be signed in when stored and signed out by the operator when in use.
- 1.5 The storage sites will maintain a **SIGN IN/OUT LOG** with name of operator, signature of operator, date signed out/in, and time signed out/in, contract number/ location of test site. This log will be maintained by storage site manager and will be readily available for inspection. **Additional** sign in/out log sheets will be provided by the TDOT RSO as needed.
- 1.6 The gauge handle trigger shall be locked, and the gauge stored in its transportation case. Troxler/InstroTek gauge handle trigger shall be locked with a Master Lock P-581 or P-812. Humboldt gauge handle trigger shall be locked with the American Series 1100 only.
- 1.7 The transport case shall be locked with a LSDA 801 Lock only.
- 1.8 **Keys to the transportation case and gauge shall not be stored with the gauge or in the storage building.**
- 1.9 The gauge and transport case shall be stored at least 15ft (5 m) from work areas, in a locked storage area in a dry location (indoors).
- 1.10 Do not store a nuclear gauge in a motor vehicle.
- 1.11 **If the gauge will be used for an extended period on a project, then the operator will need to sign the gauge in and back out each Monday until the project is completed.**

- 1.12 Only nuclear gauges are allowed to be stored inside the storage site. No tools/equipment/debris of any kind is allowed to be placed inside the storage site. **(Unless approved by TDOT RSO)**

## 2 Inspections:

- 2.1 Before transporting you are required to inspect the gauge to ensure proper operation of all safety features as follows:

- 2.1.1 Push the source rod down into the backscatter position, and then raise it back to the SAFE (shielded) position. The source rod opening in the bottom of the gauge is equipped with a spring-loaded tungsten sliding block that shuts when the source rod is in the SAFE position. Turn the gauge over and verify that the sliding block is completely shut. **If any portion of the opening is uncovered, notify your Field Services RSO or TDOT RSO immediately. DO NOT REMOVE THE BOTTOM PLATE TO REPAIR.**
- 2.1.2 **DO NOT TRANSPORT** the gauge unless the sliding block is completely closed. **If you are unsure contact your Field Services RSO or the TDOT RSO for guidance.** Increased radiation levels will violate our transportation regulations and cause excessive personal radiation exposure.

## 2.2 Validation, Inspection, Inventory, and Leak Testing:

- 2.2.1 All nuclear density gauges shall be leak tested every March and September.
- 2.2.2 The TDOT RSO will assist the Field Services RSO with the 'swipe' testing of their region's gauges.
- 2.2.3 The TDOT RSO will login each test sample and submit all samples to the lab for testing.
- 2.2.4 In conjunction with the 'swipe' test in March, the TDOT RSO and the Field Services RSO will conduct the annual Validation requirement.
- 2.2.5 The Field Services RSO will schedule each office in their perspective region to have the gauges at the Regional Office on Tuesday, Wednesday, or Thursday between 0900-1100 hrs. on their scheduled week. A complete inventory and condition of all gauges, including required documentation, will also be performed at this time.
- Region 1 First week in March
  - Region 2 Second Week in March
  - Region 4 Third week in March
  - Region 3 Fourth week in March
- 2.2.6 The September leak test will consist of another complete inventory of gauge, tools and required documentation. The Field Services RSO will schedule each office in their perspective region to have the gauges at the Regional Office on Tuesday or Wednesday between 0900-100 hrs. on their schedule week.
- Region 1 First week in September
  - Region 2 Second week in September
  - Region 4 Third week in September
  - Region 3 Fourth week in September
- 2.2.7 Any documentation out of date or missing will be replaced at the time of the inspection. Any tools assigned to the gauge that are missing will be investigated by the TDOT RSO.

## 3 Operator Certification and Monitoring:

- 3.1 All TDOT personnel that are required to operate a nuclear density gauge will need to possess a TDOT Hazmat Certificate.
- 3.2 TDOT Hazmat Certificate is only valid for 3 years. It is the responsibility of the individual to ensure their certification is valid.

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- 3.3 All TDOT operators will be assigned a Bluetooth monitoring dosimeter badge for their duration as a nuclear density gauge operator. The operator must wear their assigned dosimeter badge while operating and/or transporting the nuclear gauge. Dosimeter badges may not be shared between individuals and may only be used by the person who is named on the dosimeter badge.
- 3.4 Any TDOT personnel that will be near a nuclear density gauge will need to be assigned a dosimeter badge. They will also need to possess a TDOT Hazmat Certificate.
- 3.5 It is the responsibility of the operator to keep up with their assigned dosimeter badge. In the event their dosimeter badge has become lost or damaged, it will be the operator's responsibility to notify their **Field Services** RSO immediately.
- 3.6 All badge personnel are to ensure their Bluetooth badge connects to the server every Monday to download readings. The following two options will be available to connect to the server.
  - 3.6.1 **Install the Instadose Mobile App and perform a manual download every Monday morning.**
  - 3.6.2 Connect via Intralinks Hotspot located inside the local office. **Badges will need to be stored within 25' of the Instralink Hotspot. Ensure the badge is not stored in a metal desk or cabinet so it can connect to the hotspot. Recommend storing the badge as close to the hotspot as possible to ensure proper download.**
- 3.7 **Field Services RSOs are required to monitor weekly downloads on their assigned badge to ensure all badges downloaded per design. Recommend checking this every Thursday morning.**
- 3.8 **Field Services RSOs are required to monitor** and notify any personnel with an abnormal weekly radiation exposure reading greater than 50 millirems. TDOT's annual whole body exposure dose limit is 5 rems.

#### **4 Transporting Nuclear Gauge to Project:**

- 4.1 Inspect the tungsten slide block to ensure it is properly closed (see section 2 Inspections above).
- 4.2 The gauge handle trigger shall be locked in the safe position with the specific lock covered in 1.1.
- 4.3 The nuclear gauge shall be placed inside the transportation case and the transportation case shall be locked with an **LSDA LOCK** only.
- 4.4 Operator will ensure the transportation case is packaged per the manufacturers closure instructions before transporting gauge. (See "TYPE A EVALUATION/CERTIFICATION" in gauge red shipping folder)
- 4.5 **Check to ensure the gauge has a current leak test form in the red folder that is not older than 6 months. Contact your Field Services or TDOT RSO if the leak test is out of date. DO NOT TRANSPORT GAUGE**
- 4.6 **All gauge tools** (drill rod, scraper plate and standard block) **must be** stored in the transportation case.
- 4.7 Inspect transportation case to ensure the case is not damaged (holes, cracks, missing handles, broken or missing latches, etc.). If damaged, **DO NOT USE gauge and report damage to your Field Services RSO.**
- 4.8 Inspect transportation case to ensure all labels are undamaged, readable, and in their proper place. **DO NOT** transport gauge with missing or damaged labels. If labels are missing or damaged notify your **Field Services** RSO.
  - There should be one red and white "USA DOT 7A TYPE A" label on top of the transportation case.
  - One red and white "USA DOT 7A TYPE A" label and one yellow and black "RADIOACTIVE II" label on the hinge side of the transportation case.
  - One yellow and black "RADIOACTIVE II" label on the latch side of the case.
  - Ensure the "TRANSPORT INDEX" number is readable and correct for the gauge.
    - Troxler = 0.3
    - Instrotek = 0.5
    - Humboldt = 0.2
- 4.9 Transport the nuclear gauge in the rearmost part of the bed of a truck either:

- 4.9.1 Under a **locked** bed cover with the device secured in place with heavy chain to prevent the case from being easily removed and to prevent the case from moving more than ½ inch in any direct. Chain will be secured to the bed of the truck through both side handles and top handle, if present, to prevent the case from being opened and gauge being removed while secured, OR
- 4.9.2 A mounted transportation box, specifically designed for the nuclear gauge case or one that has been approved by your RSO with two forms of locks. In either case, ensure the gauge will not move more than a ½ inch in any direction while being transported.
- 4.9.3 The bed cover and/or mounted transportation box shall be **LOCKED** at all times while the gauge is being transported.
- 4.9.4 TDOT is required to have a **minimum** of 2 forms of security barriers while transporting a gauge in our trucks.
- 4.9.5 The transportation case lock **IS NOT** a form of security barrier.
- 4.9.6 Transporting the gauge any other way will violate our transportation license agreement.
- 4.9.7 Gauges are not allowed to be permanently stored in a vehicle. The gauge must be returned and signed back to its permanent storage building once the project(s) testing it was signed out for is completed.
  - 4.9.7.1 In the event the gauge will be used for multiple projects in a given day/week, it must be returned to its permanent storage building and signed in when the last test is completed for the work week.
  - 4.9.7.2 At no time will any gauge be stored inside or at an employee/operator home of residence.
- 4.10 No one other than **DOSIMETER BADGE WEARER with HAZMAT TRAINING** is allowed in the vehicle while the nuclear gauge is in the vehicle.
- 4.11 While in transit, the following paperwork must be in the vehicle and readily accessible by the driver:  
(within arm's reach)
  - Nuclear gauge shipping paper (Red & White BOL)
  - Proof of Operator's Hazmat Certification (Accessible electronic copy is acceptable)
- 4.12 The following will be maintained in the red folder assigned to the gauge and updated as required:
  - TDOT Radiation Safety Plan (SOP 7-2)
  - IAEA Certificate
  - Current Leak Test (No more than 6 months old)
  - Manufacturers Closure Report
- 4.13 At any time the vehicle is parked while the gauge is stowed for transit, the shipping paper must be placed face up in the driver's seat or drivers' side dashboard.
- 4.14 Gauge must be removed from the vehicle and signed back into its storage facility when the vehicle is turned in for service or repair.

## 5 Operating Nuclear Gauge at the Project:

- 5.1 See SOP 7-1 for instructions on how to calibrate and run tests.
- 5.2 Only remove the nuclear gauge from the transportation case when testing.
- 5.3 If the gauge is unsecured (i.e., not stored for transport per section 4 or stored per section 1), it shall be in the possession of the operator. The nuclear gauge must never be left unattended.
- 5.4 If it becomes necessary to move between locations inside the project, lock the handle into the SAFE position and place the nuclear gauge into the transport case and place in the rear of truck bed. At no time will the nuclear gauge be placed into the cab of the truck.
- 5.5 When the nuclear gauge is in operation/testing only the gauge operator will be near the gauge. All other personnel must be a minimum of 30' away from the gauge when testing. Only exception to this will be the RSO, the RSO may be with the operator while testing.

- 5.6 Once the operator has set the gauge and it is reading, the operator must be a minimum distance of 3' away from the gauge.

**6 Emergency Response Plan: In the event of a Missing, Stolen, Vehicle Accident, or Damaged Nuclear Gauge adhere to the following procedure:**

**6.1 In the event of a missing gauge:**

- 6.1.1 Call the **Field Services** RSO and TDOT RSO.
- 6.1.2 **Field Services** RSO will start an investigation immediately.
- 6.1.3 TDOT RSO will contact the regulatory agency.

**6.2 In the event of a stolen gauge:**

- 6.2.1 Call the police to file a report.
- 6.2.2 Call the **Field Services** RSO and TDOT RSO.
- 6.2.3 **Field Services** RSO will start an investigation immediately.
- 6.2.4 TDOT RSO will contact the regulatory agency.

**6.3 In the event of a non-injury vehicle accident while transporting a nuclear density gauge:**

- 6.3.1 Call First Responders as needed and required per TDOT.
- 6.3.2 Check gauge to ensure it is still secure and not damaged.
- 6.3.3 Take pictures of gauge and transportation case.
- 6.3.4 Call **Field Services** RSO.
- 6.3.5 **Field Services** RSO will provide a written report to the TDOT RSO with pictures, gauge serial number, and any damage that occurred to the gauge or case within 72 hrs. of accident.

**6.4 In the event the gauge operator is incapacitated in a major vehicle accident while transporting a nuclear density gauge: (After first responders are notified)**

- 6.4.1 Operators' supervisor will secure the gauge.
- 6.4.2 Supervisor will need to take pictures of the gauge and transportation case.
- 6.4.3 Supervisor will notify **Field Services** RSO and report any damage to the gauge or transportation case.
- 6.4.4 **Field Services** RSO will direct supervisor on what to do next and will go to the scene of the accident.
- 6.4.5 **Field Services** RSO will notify the TDOT RSO immediately of any major damage of the gauge or transportation case.
- 6.4.6 **Field Services** RSO will provide a detailed written report to the TDOT RSO with pictures, gauge serial number and any damage that occurred to the gauge or case within two weeks after the date of the accident.

**6.5 In the event of physical damage to the gauge at the worksite:**

**6.5.1 Priority Response Actions To Be Taken By Gauge Operator:**

- 6.5.1.1 Render aid as necessary for lifesaving, first aid, control of fire and other hazards. (Note: Radiation presents minimal risks to lives of persons during transportation accidents. Packages identified as "Type A" by markings on the shipping containers contain only non-life endangering amounts of radioactive materials.
- 6.5.1.2 Visually inspect gauge for damage, including visual inspection of source rod.
- 6.5.1.3 Determine if sources are or can be placed in their shielded positions.
- 6.5.1.4 Locate sources if separated from the gauge. **DO NOT TOUCH OR MOVE RADIOACTIVE SOURCES.** Locate, mark, and secure but do not pick up with bare hands.
- 6.5.1.5 Secure Area – Evacuate an area of at least a 15 ft. radius around the damaged gauge and/or radioactive sources. (Note: if a source cannot be located,

evacuate and secure an area large enough to include any possible locations where the source might be located).

- 6.5.1.6 Prevent entry by all unauthorized persons into the evacuated area.
- 6.5.1.7 If a vehicle or construction equipment is involved in the incident, detain the equipment until it is determined that there is no contamination.
- 6.5.1.8 As soon as possible notify your **Field Services** RSO of the incident.
- 6.5.1.9 Describe in detail the incident, condition of the gauge, and actions taken.
- 6.5.1.10 Follow any additional instructions given by the RSO as soon as possible.

**6.6 Actions to Be Taken by the **Field Services** RSO:**

- 6.6.1 Give additional advice to gauge operator (if needed).
- 6.6.2 Notify the police, fire, or other emergency agencies as needed or required.
- 6.6.3 Notify the TDOT RSO Rocky Kelley 615-924-6254.
- 6.6.4 **Travel to the accident site and perform the following:**
  - 6.6.4.1 Confirm the actions taken by the operator to be correct.
  - 6.6.4.2 Conduct a visual inspection of the gauge, shielding, and source rod to determine if radioactive sources are still in the gauge.
- 6.6.5 **If radioactive sources are found to be missing, or damage to the shielding is suspected:**
  - 6.6.5.1 Use survey meter to conduct a radiation survey of the gauge to assess the integrity of the source encapsulation and shielding. Compare the survey radiation levels to the gauge radiation profile. If the reading is greater than the listed values, you can suspect that the source shielding has been violated.
  - 6.6.5.2 If source(s) are not present in the gauge, perform the necessary surveys to locate and properly secure the source(s). (Note: DO NOT pick up radioactive sources with your hands. Use tongs or pliers to place the source in a properly shielded container. Container may be a source "pig". The source may also be returned to the gauge shielding if uncompromised).
  - 6.6.5.3 Perform a leak test on the gauge and source rod.
  - 6.6.5.4 With gauge sources at least 30 feet away, check leak test filters with a survey meter and proceed as follows: If the wipe shows a reading greater than background reading, STOP all other actions. Leave any suspected contaminated material in the secured area and notify the appropriate regulatory agency. Increase the secured area and maintain security until proper authorities arrive.
  - 6.6.5.5 If no contamination is found, notify the TDOT RSO and request permission to transport the gauge. Once gauge has been approved for transporting, any involved vehicle or equipment may be released and the secure area re-opened.
  - 6.6.5.6 Document all actions taken, or not taken, and provide sketches and/or photos.

**6.7 Follow Up Actions Taken by TDOT Radiation Safety Officer:**

- 6.7.1 TDOT RSO will notify the Tennessee Department of Environmental Conservation Division of Radiological Health (TDEC) at (615) 532-0364.
- 6.7.2 The TDOT RSO will notify the following as needed or if required:
  - TEMA: 1 (800) 262-3300
  - Troxler 24-Hour Hazmat Emergency: (919) 549-9539
  - Humboldt 24-Hour Hazmat Emergency: 1 (800) 535-5053
  - Instro-Tek 24-Hour Hazmat Emergency: 1 (800) 535-5053 #83301
  - U.S. DOT: 1 (800) 424-8802
- 6.7.3 Take photos of the damaged gauge prior to shipping for repairs or disposal.

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- 6.7.4 Place gauge in secure storage location until approved for shipment to manufacturer if needed.
- 6.7.5 Notify the gauge manufacturer of gauge damage and accident.
- 6.7.6 Send photos of the gauge along with leak test info to the manufacturer for clearance and shipping instructions.
- 6.7.7 Document any actions and instructions given for records.
- 6.7.8 Notify by telephone or mail/email ALL regulatory agencies as required of post-accident corrective actions and safety precautions taken.
- 6.7.9 Ship the damaged gauge to manufacturer per instructions given. (Note: NEVER ship a damaged nuclear gauge until it has been leaked tested and the wipe cleared).
- 6.7.10 Review accident causes and measures taken.
- 6.7.11 Review guidelines to prevent similar future occurrences.

**407.15 Compaction****A. General**

After spreading and striking-off the bituminous mixture and adjusting surface irregularities, thoroughly compact the mixture using methods approved by the Engineer and that are capable of achieving the specified density while the material is in a workable condition. When no density requirements are specified, use a system of compaction for roadway pavements that has previously produced the required bituminous pavement densities. The Engineer may require a control strip and random density samples to evaluate the system.

In general, accomplish compaction using a combination of the equipment specified in **407.07**. As a minimum, meet the following roller requirements, but increase the number of rollers if the required results are not being obtained.

1. Except as noted below, each paving train shall consist of a minimum of three rollers meeting **407.07**. The intermediate roller in each train shall be a pneumatic type. If the surface course contains a latex or polymer additive, the Contractor may use a steel wheel type roller for intermediate rolling instead of a pneumatic type provided the surface course meets density requirements.
2. Provide a minimum of two rollers when placing 307 CS, 411 TL, or 411 TLD mixtures. Perform breakdown rolling, as soon as possible and while the mixture is sufficiently hot, using a pneumatic tire roller having a minimum contact pressure of 85 pounds per square inch. Do not substitute a combination roller for a pneumatic roller when placing CS mix. Regulate the paver speed so rollers can maintain proper compaction of the mixture as determined by the Engineer.
3. With the Engineer's approval, the Contractor may reduce the minimum number of rollers listed above to one roller of either the steel-wheel or vibratory type on the following types of construction and projects:
  - a. Shoulder construction,

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- b. Incidental construction such as bridge approaches and driveways, and
  - c. Projects containing less than 10,000 square yards of bituminous pavement.
4. Compaction of 411-OGFC mixtures shall consist of a minimum of two passes with a steel double drum asphalt roller with minimum weight of 10 tons, before the material temperature has fallen below 185 °F. Provide a minimum of two roller units so as to accomplish the compaction promptly following the placement of the material. At no time shall a pneumatic tire roller be used or a steel wheel roller be used in vibratory mode. If the roller begins to break the aggregate, immediately stop rolling.

Unless otherwise directed by the Engineer, begin rolling at the low side and proceed longitudinally parallel to the road centerline. When paving in echelon or abutting a previously placed lane, roll the longitudinal joint first, followed by the regular rolling procedure. When paving in echelon, rollers shall not compact within 6 inches of an edge where an adjacent lane is to be placed. Operate rollers at a slow uniform speed with the drive wheels nearer the paver, and keep the rollers as nearly as possible in continuous operation. Continue rolling until all roller marks are eliminated. Do not park rollers on the bituminous pavement.

To prevent adhesion of the mixture to the rollers, keep the wheels properly moistened with water or water mixed with very small quantities of detergent or other approved material. Limit excess use of liquid.

Do not refuel rollers on bituminous pavements.

Along forms, curbs, headers, walls and other places not accessible to the rollers, compact the mixture thoroughly using hot hand tampers, smoothing irons, or with mechanical tampers. On depressed areas, the Contractor may use a trench roller to compact the mix.

#### **B. Density Requirements**

Meet the applicable density requirements specified in Tables 407.15-1 to 407.15-4.

**Table 407.15-1: Density Requirements for ADT 1,000 or less**

| <b>Mix Type</b> | <b>% of Maximum Theoretical Density (Average)</b> | <b>No Single Test Less Than, %</b> |
|-----------------|---------------------------------------------------|------------------------------------|
| A               | 90                                                | 87                                 |
| B, BM & BM2     | 90                                                | 87                                 |
| C & CW          | 90                                                | 87                                 |
| D               | 90                                                | 87                                 |
| E               | 90                                                | 87                                 |

**Table 407.15-2: Density Requirements for ADT 1,000 to 3,000**

| <b>Mix Type</b> | <b>% of Maximum Theoretical Density (Average)</b> | <b>No Single Test Less Than, %</b> |
|-----------------|---------------------------------------------------|------------------------------------|
| A               | 91                                                | 89                                 |
| B, BM & BM2     | 91                                                | 89                                 |
| C & CW          | 91                                                | 89                                 |
| D               | 91                                                | 89                                 |
| E               | 91                                                | 89                                 |

**Table 407.15-3: Density Requirements for ADT 3,000 or greater**

| <b>Mix Type</b> | <b>% of Maximum Theoretical Density (Average)</b> | <b>No Single Test Less Than, %</b> |
|-----------------|---------------------------------------------------|------------------------------------|
| A               | 92                                                | 90                                 |
| B, BM & BM2     | 92                                                | 90                                 |
| C & CW          | 92                                                | 90                                 |
| D               | 92                                                | 90                                 |
| E               | 92                                                | 90                                 |

**Table 407.15-4: Density Requirements for any ADT**

| <b>Mix Type</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | <b>% of Maximum Theoretical Density (Average)</b> | <b>No Single Test Less Than, %</b> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|------------------------------------|
| Shoulder Mix (B, BM, BM2, D or E)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 88                                                | 85                                 |
| AS and A-CRL                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | None <sup>(1)</sup>                               | None                               |
| CS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | None <sup>(1)</sup>                               | None                               |
| TL, TLD, and OGFC                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | None                                              | None                               |
| <sup>(1)</sup> The Department will waive density requirements on Bituminous Plant Mix Base Grading ACRL, Grading AS and Bituminous Plant Mix Leveling Course, Grading CS; however, the Contractor shall use a system of compaction for roadway pavements that has been approved by the Engineer. When placing Bituminous Plant Mix Base Grading ACRL and Grading AS, the Contractor may replace the specified intermediate roller (pneumatic tire) with a steel-wheel type if irreparable damage to the pavement is occurring. |                                                   |                                    |

Correct base or surface course that tests below the minimum density so that the density of the area is equal to or above the minimum, at which point it can be used to determine the average density of the lot. Do not place any successive layers until the area has been corrected. As necessary to determine the classification of open graded or dense graded mixes and to measure segregation, use AASHTO T 269 or ASTM D3203.

Repair or replace defective mixture to the satisfaction of the Engineer and at no cost to the Department.

The Department will perform density testing in accordance with **407.20.B.5**.

### **C. Test Strips**

Construct test strips for all A, B, BM, BM2, C, CW, D, and E mixes to establish rolling patterns, to calibrate nuclear gauges, to verify that the base course or surface course meets the density requirements of the specifications, and for mix design and production verification as required.

Before constructing the test strip, obtain the Engineer's approval of the underlying base or other pavement course. Compact the test strip using equipment as specified in this subsection and **407.07**.

Construct the test strip at the beginning of work on the pavement course. Prepare new test strips when:

1. A change in the JMF is necessary;
2. A change in the source of materials occurs;
3. A change in the material from the same source is observed;
4. There is reason to believe that the test strip density is not representative of the bituminous mixture being placed; and when
5. A change in paving or compaction equipment occurs.

With the approval of the Engineer, the Contractor may construct additional test strips.

Construct each test strip with approved bituminous mixture. The test strip shall remain in place as a section of the completed work. Construct each test strip to be 1 paver width wide, with an area of at least 400 square yards and of the depth specified for the pavement course concerned.

Immediately after placing the bituminous mixture, begin compacting the test strip. Perform compaction in a continuous and uniform manner over the entire test strip.

Continue compacting the test strip until additional roller coverage will produce no appreciable increase in density (1 pound per cubic foot), as measured using a nuclear gauge. Use the roller coverage necessary to obtain this maximum density as the rolling pattern for the remainder of the project.

Take cores on the test strip at ten randomly selected locations as designated by the Engineer. Do not take cores within 2 feet of the longitudinal edges for calibration. Provide these cores to the Department for use in calibrating the nuclear gauge and to verify that

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the average density of the test strip meets the density requirements of the specifications. The Department will report all densities using the corrected nuclear gauge readings. Correction factors are specific to the nuclear gauges used during the test strip construction. If a different nuclear gauge needs to be used for acceptance, it will be necessary to cut new cores from the ongoing pavement construction to calibrate the new gauge.

When testing test strip cores, the Department will determine density (bulk specific gravity) in accordance with AASHTO T 166, Method A only. All core samples shall be completely dry before testing. Air drying is permitted provided core samples are weighed at 2-hour intervals until dry in accordance with AASHTO T166, Section 6.1. Cores may also be dried in accordance with ASTM D7227.

If the density of the asphaltic concrete in the test strip does not meet specification requirements, make whatever changes are necessary to obtain the specified density. Use other sources and combinations of aggregates as necessary, subject to the Engineer's approval, to produce a mix meeting the required density.

#### **407.16 Joints**

Place bituminous paving as continuously as possible. Do not pass rollers over the unprotected end of a freshly laid mixture unless approved by the Engineer. Form transverse joints by cutting back on the previous run to expose the full depth of the course. Use a brush or sprayed coat of bituminous material on contact surfaces of longitudinal and transverse joints just before placing additional mixture against the previously rolled material.

#### **407.17 Pavement Samples**

When directed, cut samples from the compacted pavement for testing by the Engineer. Take samples of the mixture for the full depth of the course at locations selected by the Engineer. Cut the samples with a power saw or core drill. Samples shall have a top surface area of at least 10 inches.

Fill holes left by taking samples with the same type mixture that was used to construct the course sampled, and compact to conform to the surrounding pavement. Cut samples and repair sample holes at no cost to the Department.

a Cold Weather Paving and Compaction Plan. All projects requiring a Cold Weather Paving and Compaction Plan shall utilize Intelligent Compaction to demonstrate proper coverage and compaction temperature at no additional cost to the Department; with the exception of small quantity projects, such as, but not limited to, bridge approaches, intersections, and temporary traffic shifts. Upon completion, the documentation showing appropriate coverage and compaction temperature shall be provided to the Department. Submit requests in writing at least one week before the anticipated need, and include a Paving and Compaction Plan for Cold Weather that meets the Department's Procedure. The plan shall identify what practices and precautions the Contractor intends to use to ensure the mixture is placed and compacted to meet the specifications. The plan shall include compaction cooling curves estimating the time available for compaction, the intended production, haul, and compaction rates, with paver and roller speeds estimated. The Contractor may consider using such practices as the addition of rollers, reduced production and paving rates, insulated truck beds, and heating the existing surface.

In no cases will a cold weather paving and compaction plan or seasonal limitation waiver be approved for 411-OGFC, 411-TL, or 411-TLD.

If the specified densities are not obtained, stop all paving operations and develop a new plan. All mixture failing to meet specifications will be subject to price adjustments or removal and replacement at no cost to the Department.

**Subsection 407.11** (pg. 332) 12-2-16; Add the following to the paragraph below Table 407.11-1:

“Minimum temperature for OGFC mixes shall be 280°.”

**Subsection 407.15, C. Test Strips.** (pg. 340-341) 11-16-15; Add the following paragraph after the 7<sup>th</sup> paragraph of the subsection:

“Take an additional 3 cores after placement of the surface layer on the tack coat test strip described in subsection **403.05.B**. Include the underlying pavement layer for shear testing. These cores will be for informational testing only. Not required for mats less than one inch thick”

**Subsection 407.15** (pg. 341) 6-27-16; remove the 2<sup>nd</sup> sentence of the 8<sup>th</sup> paragraph:

“Take cores on the test strip at ten randomly selected locations as designated by the Engineer. Provide these cores to the Department for use in calibrating the nuclear gauge and to verify that the average density of the test strip meets the density requirements of the specifications. The Department will report all densities using the corrected nuclear gauge readings. Correction factors are specific to the nuclear gauges used during the test strip construction. If a different nuclear gauge needs to be used for acceptance, it will be necessary to cut new cores from the ongoing pavement construction to calibrate the new gauge.”

**Subsection 407.15** (pg. 341) 12-2-16; remove “randomly selected” from 1<sup>st</sup> sentence of the 8<sup>th</sup> paragraph as follows:

“Take cores on the test strip at ten locations as designated by the Engineer.”

**Subsection 407.15 A. 3. c.** (pg. 337-338) 5-15-17; update 10,000 square yards to 1,000 tons:



**STATE OF TENNESSEE**  
**DEPARTMENT OF TRANSPORTATION**  
**DIVISION OF MATERIALS AND TESTS**  
6601 CENTENNIAL BLVD.  
NASHVILLE, TENNESSEE 37243-0360

**DENSITY WORKSHEET - NUCLEAR METHOD**

Project Reference No. \_\_\_\_\_ Date \_\_\_\_\_  
Project No. \_\_\_\_\_ County \_\_\_\_\_ Region \_\_\_\_\_  
Nuclear gauge no. \_\_\_\_\_ Contract No. \_\_\_\_\_  
Item Number \_\_\_\_\_

|                              |  |  |  |  |  |
|------------------------------|--|--|--|--|--|
| Lot No.                      |  |  |  |  |  |
| Test No.                     |  |  |  |  |  |
| Station                      |  |  |  |  |  |
| Offset (ft.)                 |  |  |  |  |  |
| Feet Below Grade             |  |  |  |  |  |
| Thickness                    |  |  |  |  |  |
| Moisture Standard Count      |  |  |  |  |  |
| Moisture Count               |  |  |  |  |  |
| Moisture Count Ratio         |  |  |  |  |  |
| Probe Depth                  |  |  |  |  |  |
| Density Standard Count       |  |  |  |  |  |
| Density Count                |  |  |  |  |  |
| Density Count Ratio          |  |  |  |  |  |
| Unit Weight Wet (pcf)        |  |  |  |  |  |
| Moisture (pcf)               |  |  |  |  |  |
| Unit Weight Dry (pcf)        |  |  |  |  |  |
| Percent Moisture             |  |  |  |  |  |
| Cut Station                  |  |  |  |  |  |
| Sample Number                |  |  |  |  |  |
| Proctor Density (pcf)        |  |  |  |  |  |
| Optimum Moisture, %          |  |  |  |  |  |
| Dry Weight of +4 Material    |  |  |  |  |  |
| Dry Weight of Total Material |  |  |  |  |  |
| Percent +4 Material          |  |  |  |  |  |
| Sp. Gravity of +4 Material   |  |  |  |  |  |
| Corrected Proctor Density    |  |  |  |  |  |
| Corrected Optimum Moisture   |  |  |  |  |  |
| Percent Compaction           |  |  |  |  |  |

Signature \_\_\_\_\_  
Title \_\_\_\_\_



**STATE OF TENNESSEE**  
**DEPARTMENT OF TRANSPORTATION**  
**DIVISION OF MATERIALS AND TESTS**  
6601 CENTENNIAL BLVD.  
NASHVILLE, TENNESSEE 37243-0360

Item No. \_\_\_\_\_  
Report No. \_\_\_\_\_

**ASPHALT DENSITY REPORT**

Grading \_\_\_\_\_  
Date \_\_\_\_\_  
Contract No. \_\_\_\_\_  
Region \_\_\_\_\_

Project Reference No. \_\_\_\_\_ County \_\_\_\_\_  
Project No. \_\_\_\_\_ Contractor \_\_\_\_\_

| Gauge No. | Standard Count | Theoretical or Laboratory Density | Core Correction | Percent Required Density |
|-----------|----------------|-----------------------------------|-----------------|--------------------------|
|           |                | 5.0                               |                 |                          |

| Lot No.           | From Sta. | To Sta. | Lin. M (ft.) | Width | Lift | Lane | Date | Test No | Sta No | Location      | Den. Test 1             | Den. Test 2 | Den. Test 3 | Den. Test 4 | Avg | Corrected Density | Density (%) |
|-------------------|-----------|---------|--------------|-------|------|------|------|---------|--------|---------------|-------------------------|-------------|-------------|-------------|-----|-------------------|-------------|
|                   |           |         |              |       |      |      |      |         |        | 1' From Left  |                         |             |             |             |     |                   |             |
|                   |           |         |              |       |      |      |      |         |        | Left Wheel    |                         |             |             |             |     |                   |             |
|                   |           |         |              |       |      |      |      |         |        | Center        |                         |             |             |             |     |                   |             |
|                   |           |         |              |       |      |      |      |         |        | Right Wheel   |                         |             |             |             |     |                   |             |
|                   |           |         |              |       |      |      |      |         |        | 1' From Right |                         |             |             |             |     |                   |             |
| Tons in Lot _____ |           |         |              |       |      |      |      |         |        |               | Mix Running Total _____ |             |             |             |     |                   |             |

| Lot No.           | From Sta. | To Sta. | Lin. M (ft.) | Width | Lift | Lane | Date | Test No | Sta No | Location      | Den. Test 1             | Den. Test 2 | Den. Test 3 | Den. Test 4 | Avg | Corrected Density | Density (%) |
|-------------------|-----------|---------|--------------|-------|------|------|------|---------|--------|---------------|-------------------------|-------------|-------------|-------------|-----|-------------------|-------------|
|                   |           |         |              |       |      |      |      |         |        | 1' From Left  |                         |             |             |             |     |                   |             |
|                   |           |         |              |       |      |      |      |         |        | Left Wheel    |                         |             |             |             |     |                   |             |
|                   |           |         |              |       |      |      |      |         |        | Center        |                         |             |             |             |     |                   |             |
|                   |           |         |              |       |      |      |      |         |        | Right Wheel   |                         |             |             |             |     |                   |             |
|                   |           |         |              |       |      |      |      |         |        | 1' From Right |                         |             |             |             |     |                   |             |
| Tons in Lot _____ |           |         |              |       |      |      |      |         |        |               | Mix Running Total _____ |             |             |             |     |                   |             |

| Lot No.           | From Sta. | To Sta. | Lin. M (ft.) | Width | Lift | Lane | Date | Test No | Sta No | Location      | Den. Test 1             | Den. Test 2 | Den. Test 3 | Den. Test 4 | Avg | Corrected Density | Density (%) |
|-------------------|-----------|---------|--------------|-------|------|------|------|---------|--------|---------------|-------------------------|-------------|-------------|-------------|-----|-------------------|-------------|
|                   |           |         |              |       |      |      |      |         |        | 1' From Left  |                         |             |             |             |     |                   |             |
|                   |           |         |              |       |      |      |      |         |        | Left Wheel    |                         |             |             |             |     |                   |             |
|                   |           |         |              |       |      |      |      |         |        | Center        |                         |             |             |             |     |                   |             |
|                   |           |         |              |       |      |      |      |         |        | Right Wheel   |                         |             |             |             |     |                   |             |
|                   |           |         |              |       |      |      |      |         |        | 1' From Right |                         |             |             |             |     |                   |             |
| Tons in Lot _____ |           |         |              |       |      |      |      |         |        |               | Mix Running Total _____ |             |             |             |     |                   |             |

Remarks:

Original to:  
Headquarters Materials and Tests  
Copies to:  
Regional Materials and Tests  
Project Supervisor  
Form DT-0315 (Rev. 07-17)

| lb/yd <sup>2</sup> (kg/yd <sup>2</sup> ) _____ |                |
|------------------------------------------------|----------------|
| Lot No.                                        | Avg. % Density |
|                                                |                |
|                                                |                |
|                                                |                |

Signature \_\_\_\_\_  
Title \_\_\_\_\_



**STATE OF TENNESSEE**  
**DEPARTMENT OF TRANSPORTATION**  
**DIVISION OF MATERIALS AND TESTS**  
6601 CENTENNIAL BLVD.  
NASHVILLE, TENNESSEE 37243-0360

DAILY REPORT ON SOIL AND AGGREGATE STABILIZATION

Date \_\_\_\_\_

Project Reference No. \_\_\_\_\_ County \_\_\_\_\_ Region \_\_\_\_\_  
Project No. \_\_\_\_\_ Contract No. \_\_\_\_\_  
Report No. \_\_\_\_\_ Contractor \_\_\_\_\_  
Producer \_\_\_\_\_ Producer Location \_\_\_\_\_

Item Numbers \_\_\_\_\_ Temp. Max \_\_\_\_\_ °F Min. \_\_\_\_\_ °F  
Type of Construction \_\_\_\_\_ Type of Mixing \_\_\_\_\_  
Percent Cement Design \_\_\_\_\_ Design Depth \_\_\_\_\_ Average Depth \_\_\_\_\_  
Lbs./Square Yd. Cement Design \_\_\_\_\_ Lbs./Square Yd. Cement Used \_\_\_\_\_  
From Station \_\_\_\_\_ To Station \_\_\_\_\_ Excluding Stations \_\_\_\_\_  
Linear Feet \_\_\_\_\_ Width \_\_\_\_\_ Square Yards \_\_\_\_\_  
Tons of Cement \_\_\_\_\_ Tons of Aggregate Delivered \_\_\_\_\_  
Quantity (moisture in excess of 3% of optimum moisture content has been deducted): \_\_\_\_\_ Tons

SCREEN ANALYSIS

Percent Passing Square Sieves

| 3" | 2-1/2" | 2" | 1-1/2" | 1" | 3/4" | 1/2" | 3/8" | 4 | 8 | 16 | 40 | 100 | 200 | % Moisture at Plant |
|----|--------|----|--------|----|------|------|------|---|---|----|----|-----|-----|---------------------|
|    |        |    |        |    |      |      |      |   |   |    |    |     |     |                     |
|    |        |    |        |    |      |      |      |   |   |    |    |     |     |                     |
|    |        |    |        |    |      |      |      |   |   |    |    |     |     |                     |
|    |        |    |        |    |      |      |      |   |   |    |    |     |     |                     |

COMPACTION DATA

| Lot No. | No. of Tests | STATION |    | Lane | Lift | Test Depth | Field Density | Theoretical Density | Optimum Moisture | Ave. Percent Theoretical Density |
|---------|--------------|---------|----|------|------|------------|---------------|---------------------|------------------|----------------------------------|
|         |              | From    | To |      |      |            |               |                     |                  |                                  |
|         |              |         |    |      |      |            |               |                     |                  |                                  |
|         |              |         |    |      |      |            |               |                     |                  |                                  |
|         |              |         |    |      |      |            |               |                     |                  |                                  |
|         |              |         |    |      |      |            |               |                     |                  |                                  |
|         |              |         |    |      |      |            |               |                     |                  |                                  |
|         |              |         |    |      |      |            |               |                     |                  |                                  |
|         |              |         |    |      |      |            |               |                     |                  |                                  |

Remarks:

Original to:  
Headquarters Materials and Tests  
Copies to:  
Regional Materials and Tests  
Project Supervisor  
Form DT-0298 (Rev. 11-12)

Approved:

Project Supervisor

Project Inspector

6601 CENTENNIAL BLVD.  
NASHVILLE, TENNESSEE 37243-0360

## Type of Material

County \_\_\_\_\_

[illegible]

---

Project Inspector



**STATE OF TENNESSEE**  
**DEPARTMENT OF TRANSPORTATION**  
**DIVISION OF MATERIALS AND TESTS**  
6601 CENTENNIAL BLVD.  
NASHVILLE, TENNESSEE 37243-0360

Item No. \_\_\_\_\_ DAILY REPORT ON MINERAL AGGREGATE BASE Date \_\_\_\_\_  
Report No. \_\_\_\_\_ County \_\_\_\_\_ Contract No. \_\_\_\_\_  
Project Reference No. \_\_\_\_\_ Region \_\_\_\_\_  
Project No. \_\_\_\_\_  
From Sta. \_\_\_\_\_ To Sta. \_\_\_\_\_ Lin M (ft.) \_\_\_\_\_ Width \_\_\_\_\_ Lift \_\_\_\_\_ Lane \_\_\_\_\_  
m<sup>2</sup> \_\_\_\_\_ Method of Mixing \_\_\_\_\_ Type \_\_\_\_\_ Class \_\_\_\_\_ Grading \_\_\_\_\_  
Contractor \_\_\_\_\_ Producer and Location \_\_\_\_\_  
Tons of Aggregate Delivered \_\_\_\_\_ Tonnes (Tons) \_\_\_\_\_  
Quantity (moisture in excess of 3% of optimum moisture content has been deducted): \_\_\_\_\_ Tonnes (Tons) \_\_\_\_\_

**SCREEN ANALYSIS**  
Percent Passing Square Sieve

| 75.0 mm<br>3" | 63.0 mm<br>2.5" | 50.0 mm<br>2" | 37.5 mm<br>1.5" | 25.0 mm<br>1" | 19.0 mm<br>3/4" | 12.5 mm<br>1/2" | 9.5 mm<br>3/8" | 4.75 mm<br>#4 | 2.36 mm<br>#8 | 1.18 mm<br>#16 | 0.425 mm<br>#40 | 0.15 mm<br>#100 | 0.075 mm<br>#200 | % Moisture at<br>Plant |
|---------------|-----------------|---------------|-----------------|---------------|-----------------|-----------------|----------------|---------------|---------------|----------------|-----------------|-----------------|------------------|------------------------|
|               |                 |               |                 |               |                 |                 |                |               |               |                |                 |                 |                  |                        |
|               |                 |               |                 |               |                 |                 |                |               |               |                |                 |                 |                  |                        |
|               |                 |               |                 |               |                 |                 |                |               |               |                |                 |                 |                  |                        |
|               |                 |               |                 |               |                 |                 |                |               |               |                |                 |                 |                  |                        |

Sampled from \_\_\_\_\_ Signature \_\_\_\_\_  
Title \_\_\_\_\_

**COMPACTION DATA**

| Lot No. | No. of Tests | Station |    | Lane | Lift | Test<br>Depth | Theoretical<br>Density | Average Field<br>Density | Average %<br>Theoretical |
|---------|--------------|---------|----|------|------|---------------|------------------------|--------------------------|--------------------------|
|         |              | From    | To |      |      |               |                        |                          |                          |
|         |              |         |    |      |      |               |                        |                          |                          |
|         |              |         |    |      |      |               |                        |                          |                          |
|         |              |         |    |      |      |               |                        |                          |                          |
|         |              |         |    |      |      |               |                        |                          |                          |
|         |              |         |    |      |      |               |                        |                          |                          |
|         |              |         |    |      |      |               |                        |                          |                          |

Remarks:

Original to:  
Headquarters Materials and Tests  
Copies to:  
Regional Materials and Tests  
Project Supervisor  
Form DT-0307 (Rev. 11-12)

Signature \_\_\_\_\_  
Title \_\_\_\_\_  
Approved \_\_\_\_\_

## PROCTOR DENSITY (Soils/Aggregate) or THEORETICAL MAXIMUM DENSITY(Asphalt)

- Press <MA/PR> to display Marshall for Asphalt or Proctor for soil/gravel. Make a selection. To change value PR or MA press down/up ↓↑arrow. Press <START/ENTER> to exit.
- PR value can be obtained from the Proctor Density Report.
- The Theoretical maximum Density can be obtained from the JMF for the Asphalt Mix

MA: ■■■ (↑↓)  
Change MA value?

PR: ■■ (↑↓)  
Change PR value?



1

Signal to: Headquarters Materials and Tests  
Jokes to: Regional Materials and Tests  
Project Supervisor

  
**STATE OF TENNESSEE**  
**DEPARTMENT OF TRANSPORTATION**  
**DIVISION OF MATERIALS AND TESTS**  
4601 CENTENNIAL BLVD.  
NASHVILLE, TENNESSEE 37243-4360

**PROCTOR DENSITY REPORT**

|                               |                             |          |
|-------------------------------|-----------------------------|----------|
| Project Reference No. 9405999 | County WILLIAMSON           | Region 3 |
| Project No. 94011-3243-34     | Contract No.                |          |
| Material BULK SOIL SAMPLE     | Project Supervisor R. JOHNS |          |
| Report No. 1                  | Date Sampled 11-Sep-17      |          |
| Serial No. 178308             | Date Reported 25-Oct-17     |          |
| Contractor                    | Sampled By F. RASHID        |          |
| Producer                      | Sampled From SR-96 ARNO RD  |          |

| GRADATION - TOTAL PERCENT PASSING |        |
|-----------------------------------|--------|
| Sample No.                        | B-1    |
| Station                           | 117+00 |
| Depth, ft.                        | 0-6    |
| Location, ft.                     | 69L T  |
| 2"                                |        |
| 1-1/2"                            |        |
| 1"                                |        |
| 3/4"                              |        |
| 3/8"                              |        |
| No. 4                             |        |
| No. 10                            | 90     |
| No. 16                            |        |
| No. 40                            | 90     |
| No. 100                           | 93     |
| No. 200                           | 64     |
| Silt and Clay                     |        |
| Clay                              | 33     |

| SOIL CONSTANTS   |    |
|------------------|----|
| Liquid Limit     | 32 |
| Plastic Limit    | 23 |
| Plasticity Index | 9  |
| Calculated PI    | 9  |
| Type             |    |
| Group            |    |

| CORRECTED FOR +4 MATERIAL     |       |
|-------------------------------|-------|
| Proctor Density               | 103.8 |
| Optimum Moisture              | 18.6  |
| 95 % Density                  |       |
| Moisture Range                | 11.4  |
| Moisture Range Below Subgrade | 23.1  |

**Proctor Density & Optimal Moisture**

TN TDOT Department of Transportation

2

**STATE OF TENNESSEE ASPHALT JOB MIX FORMULA**

2016 11/16

Date: 01/01/2018 Roadway Surface: No

Region: 1

Hot-mix Producer: Duracap Asphalt Paving - Knoxville Asphalt Mix

Type: BPMB-HM Mix: 307-A PG 64-22 Item: 307.01.01

Serial No.: Design No.: 1180001

| Material                                                                             | Size or Grade       | Producer and Location             | Percent Used                |
|--------------------------------------------------------------------------------------|---------------------|-----------------------------------|-----------------------------|
| #4, Soft Limestone (aka Non-Surface) from Aggregate USA - Knoxville John Sevier Hwy  |                     |                                   | 38.400                      |
| #7, Soft Limestone (aka Non-Surface) from Aggregate USA - Knoxville John Sevier Hwy  |                     |                                   | 24.000                      |
| #10, Soft Limestone (aka Non-Surface) from Aggregate USA - Knoxville John Sevier Hwy |                     |                                   | 14.400                      |
| RAP Processed -1/2, RAP from RAP - Duracap Asphalt Paving - Knoxville Asphalt Mix    |                     |                                   | 20.211                      |
| Asphalt Cement                                                                       | PG 64-22            | MARATHON PETROLEUM CO., KNOXVILLE | 2.989                       |
| Percent AC in RAP1:                                                                  | Optimum AC Content: | 4.00                              | Total 100.000               |
| Percent AC in RAP2:                                                                  | 5.0                 | Anti-Strip Supplier:              | TN-State Sand LLC           |
| Anti-Strip Additive:                                                                 | Virgin AC           | Arr Maz                           | Dosage: 0.5%                |
| AC Contribution:                                                                     | 2.99                | RAP AC                            | 1.01                        |
| Asphalt Sp. Gravity:                                                                 | 1.03                | Dust to Asphalt Ratio:            | 1.08                        |
| % Fracture Face on CA:                                                               | n/a                 | % Glassy Particles on CA:         | n/a                         |
| Theo.Gravity of RAP1:                                                                |                     | Eff. Gravity of Agg:              | 2.762                       |
| Theo.Gravity of RAP2:                                                                | 2.553               |                                   |                             |
| Theo. Gravity of Mix:                                                                | 2.588               | T.S.R.:                           | Lbs/Ft <sup>3</sup> : 161.5 |
| L.O.I.:                                                                              |                     | Ignition Oven Corr. Factor:       |                             |
|                                                                                      |                     | Warm Mix?                         |                             |

**Theoretical Maximum Density**

3

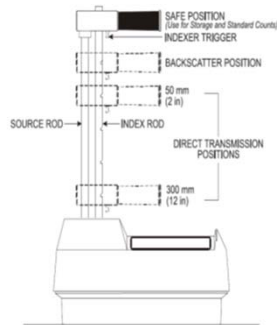
## Testing (Asphalt)

- Step 1: Conduct Standard Count
- Step 2: Enter maximum specific gravity (Gmm) value from asphalt mix design.
- Step 3: Enter gauge correction factor from test strip. See Part Two for determining correction factors. (Note: testing may be done prior to obtaining the correction factor, however all tests done during this time must be corrected as soon as possible and prior to finalizing the records for acceptance or assurance tests.)

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## Testing (Asphalt)

- Step 4: Set gauge setting to Backscatter.



- Step 5: Place gauge in location to be tested.



5

## Testing (Asphalt)

- Step 6: Activate a test. When collecting a density test, the following approach shall be used:
  - “Four Nineties” Test: Four tests shall be conducted at a single location, rotating around the test location 90 degrees at a time.
  - The four test results will then be averaged to obtain a single test value for that location.
  - Test counts for this approach shall be 15 seconds or longer.



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## Testing (Asphalt)

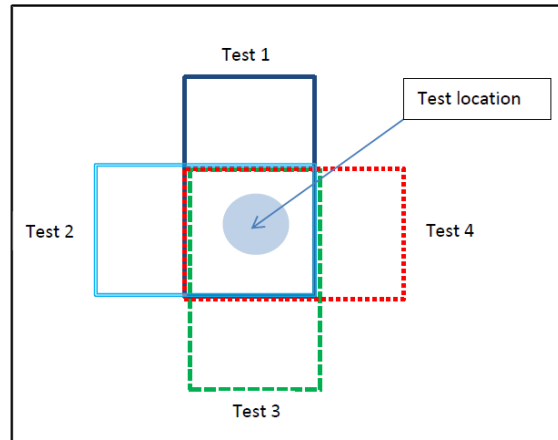


Figure 1. Testing at four 90° locations

## Testing (Asphalt)

- Step 7: Record the test value into the appropriate paperwork.
  - DT-0315, Daily Asphalt Density Report

## Taking a Measurement - Asphalt

- After the count time has elapsed, the gauge displays the measurement results in a series of six screens, as follows. Use the **down/up** ↓↑ **arrows** to scroll.
- WD: Wet Density is what you record for Asphalt.

|                  |       |
|------------------|-------|
| WD: xxxxx        | PCF   |
| % MA             | xxx % |
| DD: xxxxx        | PCF   |
| (Use ↑ & ↓ keys) |       |
| Moist: xxxxx     | PCF   |
| % Moist:         | xxx % |
| % VOIDS          | xxx % |
| 100 - % MA       | xxx % |
| MOIST CR: xxx    |       |
| DENS CR: xxx     |       |
| M Count: xxxxx   |       |
| D Count: xxxxx   |       |



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## Testing (Soil & Aggregate)

- *Step 1:* Conduct Standard Count
- *Step 2:* Enter maximum dry density and optimum moisture content from Proctor Density report.
- *Step 3:* Select Test location. Create a test hole using the scraper plate and drill rod provided with the gauge.



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## Testing (Soil & Aggregate)



- When testing on soils always prepare the ground by using the scraper plate to smooth out any obstacles or fill in any voids.
- This will reduce the chance that open pockets or protruding objects impact the reading.



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## Testing (Soil & Aggregate)



- Etch around the base of the scraper plate before picking it up, then place the gauge down inside of this etched area.
- The opening for the source rod will be positioned over the hole that was drilled.



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## Testing (Soil & Aggregate)

When using the drill rod to make a hole in the compacted material for testing, always make sure to first place the drill rod removal device – this is a mistake that will probably be made only once.



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## Testing (Soil & Aggregate)

- *Step 4:* Set gauge setting to Direct Transmission at a depth reasonably close to one half the depth of the compacted lift.
- *Step 5:* Place gauge in location to be tested and insert test probe into test hole at a depth reasonably close to one half the depth of the compacted lift. Pull gauge back to ensure probe makes contact with material being tested



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## Testing(soil & Aggregate)

- **Step 6:** Activate a test. When collecting a density test, the following approach shall be used:
  - *Single Count Test:* A single test shall be conducted at the test location, given that the test count is minimum 60 seconds.
- **Step 7:** Record the test value into the appropriate paperwork.
  - DT-0298, Daily Report on Soil and Aggregate Stabilization
  - DT-0304, Daily Report on Embankment
  - DT-0307, Daily Report on Mineral Aggregate Base
  - DT-0314, Density Worksheet – Nuclear Method (Aggregate, Soil)



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## Taking a Measurement – Soil and Aggregate Material

- After the count time has elapsed, the gauge displays the measurement results in a series of six screens, as follows. Use the **down/up ↓↑ arrows** to scroll.
- DD: Dry Density is what you record for Soil & Aggregate Material

|                                            |
|--------------------------------------------|
| WD:    xxxxx    PCF<br>(Use ↑ & ↓ keys)    |
| DD:    xxxxx    PCF<br>%PR:    xxx %       |
| Moist:    xxxxx    PCF<br>% Moist    xxx % |
| Air Void:<br>Void Ratio    xxx%            |
| MOIST CR:    xxx<br>DENS CR:    xxx        |
| M Count:    xxxxx<br>D Count:    xxxxx     |



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## After the Test

Always pull the trigger and raise the handle to the very top setting prior to moving the gauge even in backscatter mode. This locks in the lead shield around the source making the gauge safe for moving.



Never move the gauge with the source rod exposed.