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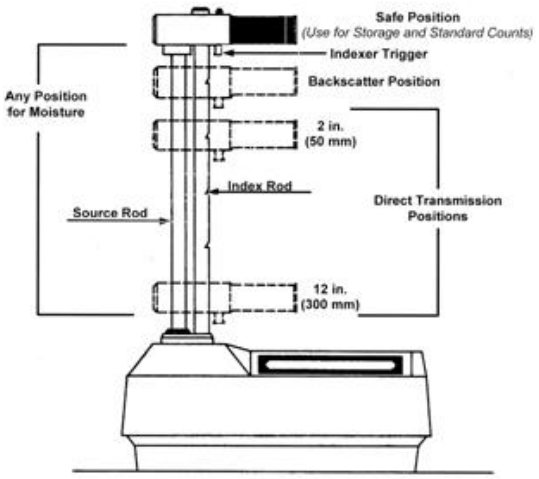

RADIATION SAFETY CERTIFICATION COURSE

VERSION 18.4

Division of Materials and Tests 2018

TDOT Radiation Safety Certification

Why are you here?

- Operators must be trained as required by Federal and State law
- TDOT nuclear gauge policies
- Proper testing practices
- SAFETY of operators, co-workers and the public.

Radiation Safety Course

- Radioactivity Awareness
- Nuclear Gauge Uses
- Nuclear Gauge Storage
- Transportation Requirements
- Standard Count
- Asphalt Test Strip and Correction Factors
- Testing on Asphalt, Soil, Aggregate

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Instructors

- Matthew Chandler
  Matthew.Chandler@tn.gov
- Ulises Martinez
  Ulises.Martinez@tn.gov
- Jimmy Britt
  Jimmy.Britt@tn.gov
- Rocky Kelley
  Rocky.Kelley@tn.gov

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Class Organization

- Classroom and Demo
- Test:
  - **25** questions
  - Open book/notes
  - To Pass: Must get 70% overall on written exam

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ADA Notice of Requirements

- Can be found at the following website:
  - http://www.tn.gov/tdot/topic/transportation-americans-with-disabilities-notice
- To be in compliance with TDOTs requirements listed on the website above, it is our goal to provide reasonable accommodations to those who identify themselves as having a disability and request such accommodations.
- Please feel free to bring it to any of the course instructors and accommodations will be administered as discretely as possible.

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No Tobacco Related Product Inside Building!!!!!!!!!!!!!!

No Electronic Cigarette
No Chewing Tobacco Allowed
Spitting into a bottle disturbs others

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Radiation Safety Officers

Headquarters Radiation Safety Officer (RSO):
Rocky Kelley
(615)-924-6254

Regional RSOs

Region 1: Billy Goins	(865) 806-1935
Region 2: Jeff Yarworth	(423) 322-0649
Region 3: Mark Hand	(615) 806-9123
Region 4: Marc Turner	(731) 352-5327

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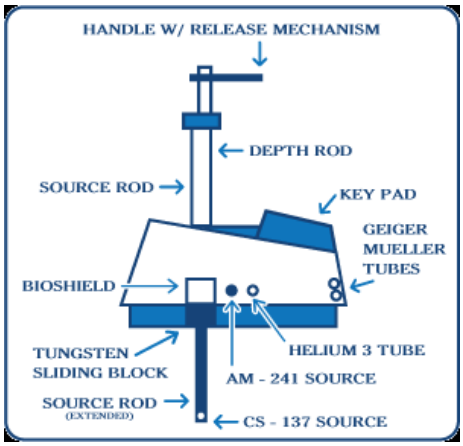
The Basics of any Gauge



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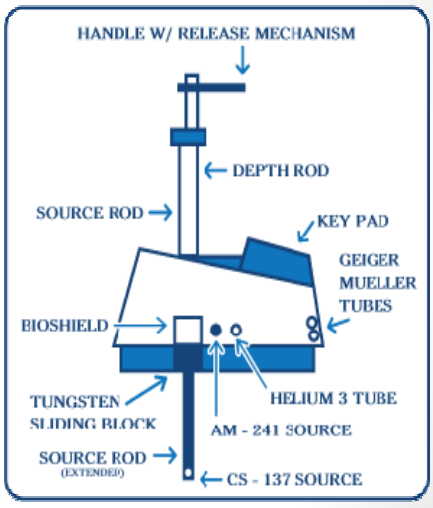
Radioactivity

- A small amount of radioactive material is embedded at the end of the detection rod of these gauges 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



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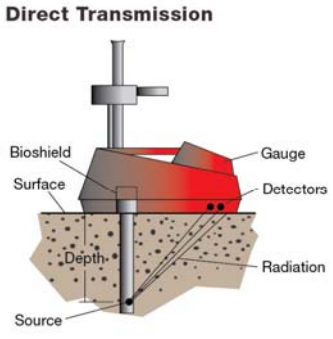
What are they used for?

Moisture Density Gauge



Measuring in place density of embankment and base stone…

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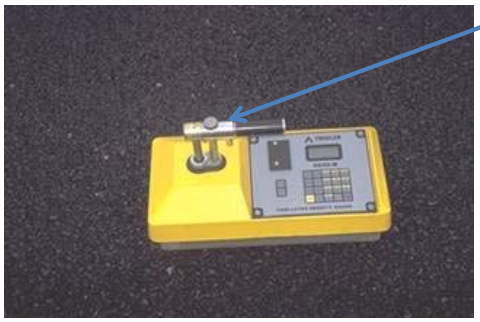
What are they used for?



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

… and in place density of Asphalt Pavements

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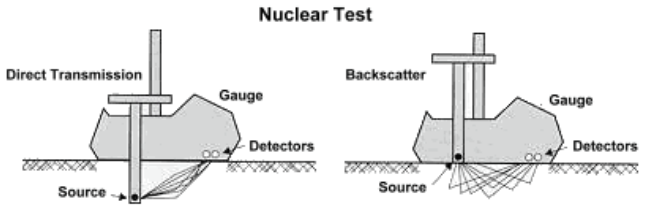
Direct Transmission vs. Backscatter Modes



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Radiation Awarness Training

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Radioactivity

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

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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.

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Radioactivity

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 limits
3. The specified annual dose limit to the eye is 15 rems.
4. UNLESS…

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Radioactivity

Declared Pregnant Workers shall be limited to 0.5 rems of exposure during the pregnancy

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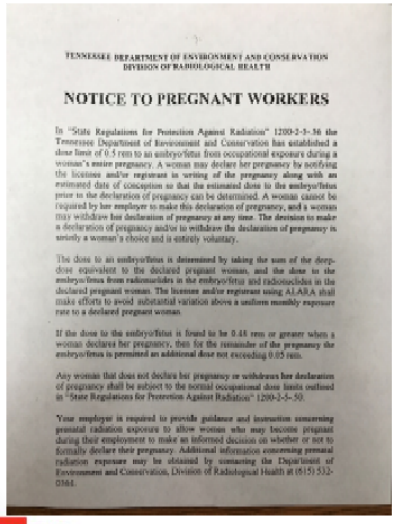
Radioactivity



TENNESSEE DEPARTMENT OF ENVIRONMENT AND CONSERVATION
DIVISION OF RADIOLOGICAL HEALTH

NOTICE TO PREGNANT WORKERS

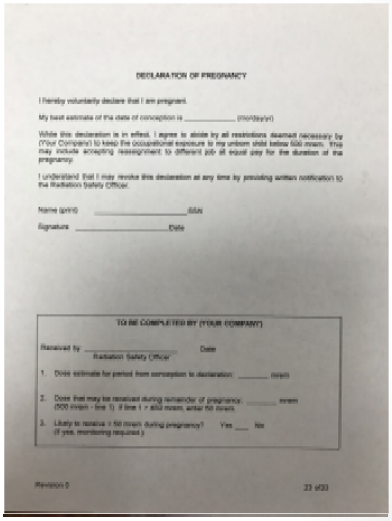
In "State Regulations for Protection Against Radiation" 1200-2-3-.06 the Tennessee Department of Environment and Conservation has established a dose limit of 0.5 rem to an embryo/fetus from occupational exposure during a woman's entire pregnancy. A woman may declare her pregnancy by notifying the licensee and/or registrant in writing of the pregnancy along with an estimated date of conception so that the estimated dose to the embryo/fetus prior to the declaration of pregnancy can be determined. A woman cannot be required by her employer to make this declaration of pregnancy, and a woman may withdraw her declaration of pregnancy at any time. The decision to make a declaration of pregnancy and/or to withdraw the declaration of pregnancy is strictly a woman's choice and is entirely voluntary.

The dose to an embryo/fetus is determined by taking the sum of the deep-dose equivalent to the declared pregnant woman, and the dose to the embryo/fetus from radionuclides in the embryo/fetus and radionuclides in the declared pregnant woman. The licensee and/or registrant using ALARA shall make efforts to avoid substantial variation above a uniform monthly exposure rate to a declared pregnant woman.

If the dose to the embryo/fetus is found to be 0.45 rem or greater when a woman declares her pregnancy, then for the remainder of the pregnancy the embryo/fetus is permitted an additional dose not exceeding 0.05 rem.

Any woman that does not declare her pregnancy or withdraws her declaration of pregnancy shall be subject to the normal occupational dose limits outlined in "State Regulations for Protection Against Radiation" 1200-2-3-.50.

Your employer is required to provide guidance and instruction concerning prenatal radiation exposure to allow women who may become pregnant during their employment to make an informed decision on whether or not to formally declare their pregnancy. Additional information concerning prenatal radiation exposure may be obtained by contacting the Department of Environment and Conservation, Division of Radiological Health at (615) 532-0364.



DECLARATION OF PREGNANCY

I hereby voluntarily declare that I am pregnant.

My best estimate of the date of conception is _____ (month/day/yr)

While this declaration is in effect, I agree to abide by all restrictions deemed necessary by (Your Company) to keep the occupational exposure to my unborn child below 500 mrem. This may include accepting reassignment to different job of equal pay for the duration of the pregnancy.

I understand that I may revoke this declaration at any time by providing written notification to the Radiation Safety Officer.

Name (print) _____ date

Signature _____ Date

TO BE COMPLETED BY (YOUR COMPANY)

Received by _____ Date
Radiation Safety Officer

1. Dose estimate for period from conception to declaration: _____ mrem
2. Dose that may be received during remainder of pregnancy: _____ mrem (500 mrem - line 1). If line 1 > 500 mrem, enter 50 mrem.
3. Likely to receive > 50 mrem during pregnancy? Yes ___ No ___
(If yes, monitoring required.)

Revision 0

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Radioactivity

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

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) Plane (3000 mile flight)	.0003rem 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

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Personal Dosimetry Film Badges

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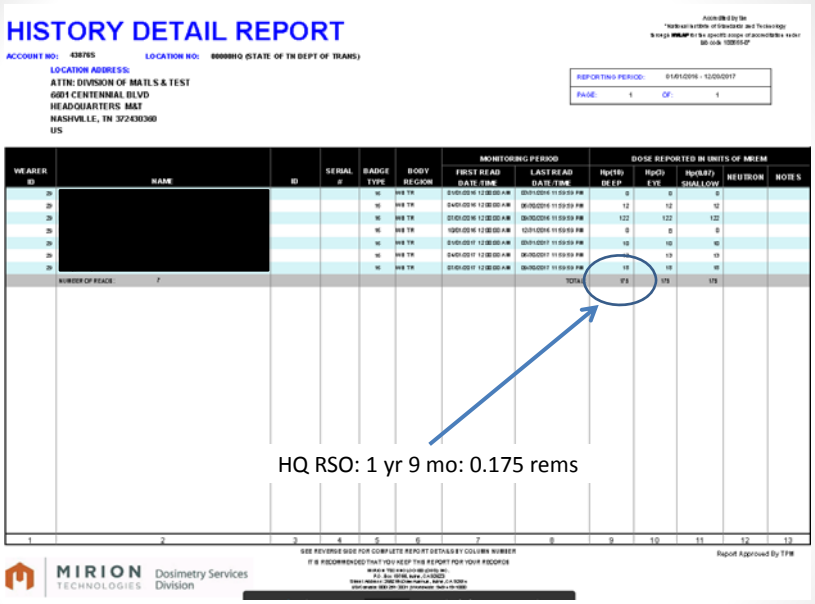

The ALARA Philosophy

- As Low as Reasonably Achievable –
- 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 shielding and in a stored position when not using the gauge.
  - Distance – Always maintain your distance when the gauge is taking a test.

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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 should wear “personal dosimetry film badges” which help monitor whether technicians are absorbing radiation.

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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
- This license lists all radioactive sources owned and maintained by TDOT and dictates how they will be transported and monitored.
- This license is owned and operated by personnel within the HQ Materials and Tests Field Operations Section.

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Storing the Gauge

- The handle shall be locked and the gauge stored in its transport case.
- The transport case shall be locked.
- 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 RADIOACTIVE MATERIALS" (can be obtained from HQ RSO).

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Storage Site

- **Do not store a nuclear gauge in a motor vehicle except:**
  - The actively working on a project. Overnight is okay between days where nuclear gauge readings will be taken.
- **A log of all gauges stored at the site will be maintained at the storage site. All gauges must be checked in when stored and checked out by the operator when in use.**
- Storage site must be enclosed (four walls and a roof) and it must protect gauges from the elements.
- 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 storaged site.

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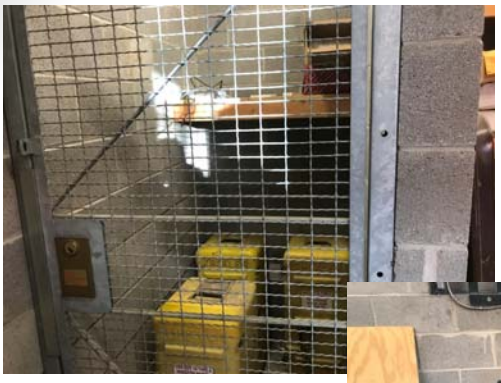

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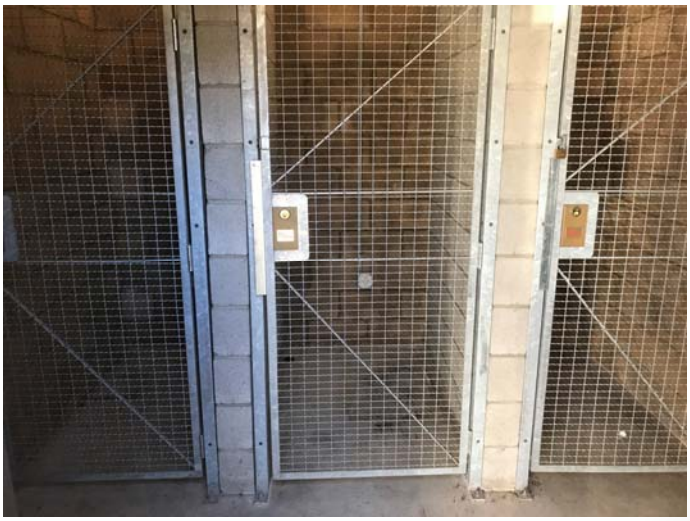

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Transporting the Gauge

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Gauge Inspection

- 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.
- Do not store or transport the gauge unless the sliding block is completely closed. Increased radiation levels may violate transportation regulations and cause excessive personal radiation exposure.

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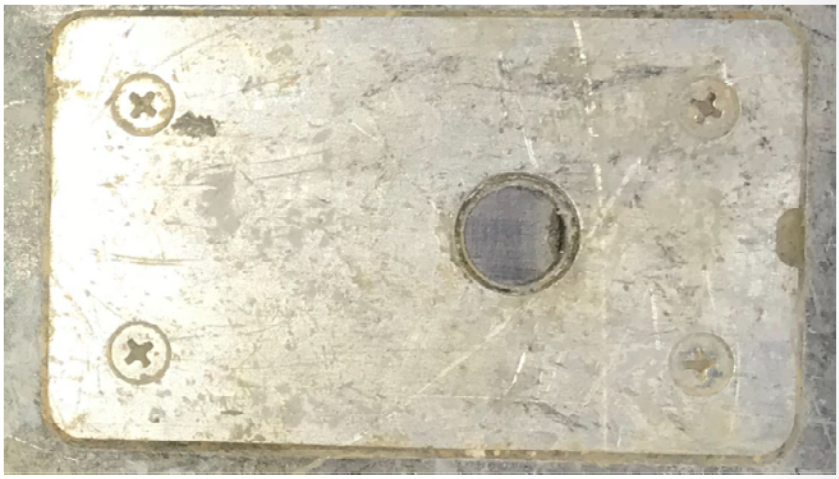

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Transporting Gauge to Project

- The handle for the gauge shall be locked into the safe position during transport.
- The nuclear gauge shall be locked inside the transport case during transport.
- Transport the nuclear gauge in the rearmost part of the bed of a truck inside either:
  - A locked bed cover with the device secured in place with heavy chain to prevent the case from moving or
  - A mounted transportation box, specifically designed for the nuclear gauge case.
- No one other than the operator of the nuclear gauge is allowed in the vehicle while the nuclear gauge is in the vehicle.

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Transporting Gauge to Project

- While in transit the following paperwork must be in the vehicle and readily accessible by the driver:
  - Nuclear gauge bill of lading (BOL),
  - Operator's nuclear safety certificate,
  - Nuclear gauge shipping paper,
  - TDOT Radiation Safety Plan (SOP 7-2),
- At any time the vehicle is parked while the gauge is stowed for transit, the shipping paper must be place face up in the driver's seat.

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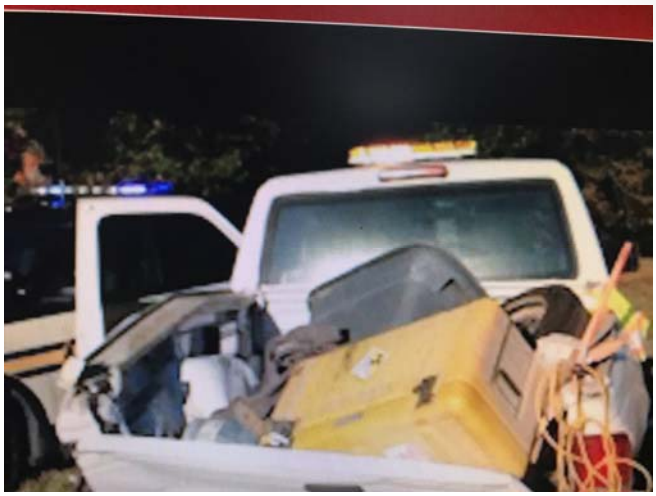

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While Using the Gauge

- Follow SOP 7-1 for use (later)
- Remove Gauge only while in use.
- Anytime Gauge is out of the case, shall be in the possession of the operator

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While Using the Gauge

- Don’t run gauge within 30’ of another gauge.
- Don’t run the gauge within 10’ of a large object.
- Non-badged personnel shall be 30’ from gauge while in use.

While Using the Gauge

- Once operator has set the gauge to read, step away.
- Can use truck to move gauge on site, but gauge must be placed back into case and in bed of truck, but do not have to lock case

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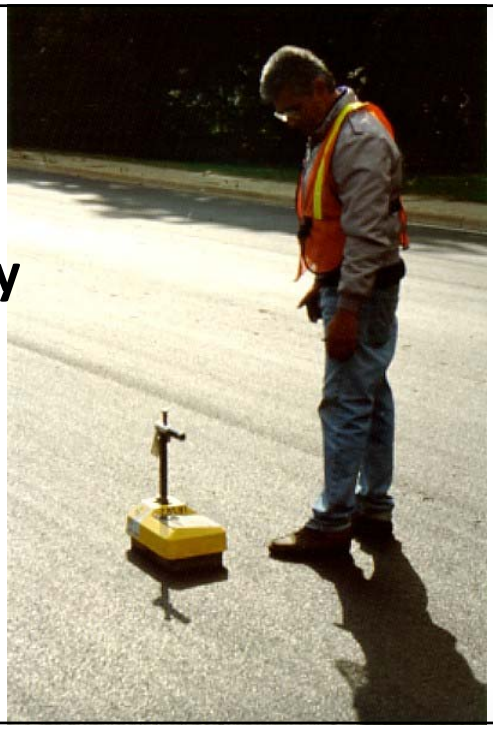
Nothing to see here, step away until it beeps



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Name 3 things bad

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EMERGENCY RESPONSE PLAN

- An Accident Happened.
- What now?

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EMERGENCY RESPONSE PLAN

- First Priority
  - If someone is critically injured
    - Help them
  - If something is on fire
    - Put it out/control if possible
  - Nuclear Gauge is a minimum radiation hazard in a transportation accident

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EMERGENCY RESPONSE PLAN

- If not immediate threat to life or property:
  - Visually inspect gauge for damage
  - Locate source rod if missing
  - Secure Area, if gauge is damaged or source rod is unshielded. Evacuate everyone to min 15' radius.
  - If can't find source: evacuate larger area

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EMERGENCY RESPONSE PLAN

- If not immediate threat to life or property:
  - If vehicle/construction equipment is involved in incident, detain it until it can be inspected for contamination
  - ASAP after the above actions contact your regional RSO/HQ RSO

NOTE: Copy of these instructions are in the transportation papers.

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TESTING

- Standard Count: Calibration check
- Determining Correction Factor (Asphalt)
- Gmm or Proctor
- Running Tests on Soil/Aggregate or Asphalt

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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 should be taken daily on the reference standard block.
- Max Variation: 1% for density and 2% for moisture.
- Place the reference standard block on the surface you are about to test.

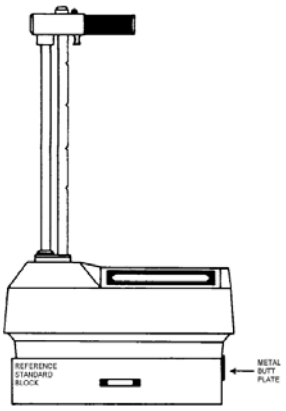

Figure 3-3. Standard Count Position

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Standard Count

Conducting a Standard Count:

1. Ensure source rod is in the SAFE position
2. Make sure to place reference blocks on dry, flat surface
3. Press the <STD> key, then the <YES> key.
4. Press <START> to begin the 4 minute count
5. Record the standard count

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Standard Count

Example:
Old Count Moisture 112.0 - Density 135.0
New Count Moisture 112.5 - Density 136.0

Take the difference: For Moisture 112.5-112.0 = 0.5
For Density 136.0-135.0 = 1.0

Divide by your last Standard Count and multiply by 100:
For Moisture (0.5/112.0) x 100 = 0.45%
For Density (1.0/135.0) x 100 = 0.74%

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Standard Count

- If a standard count log has not been kept, four new counts will need to be obtained, averaged, and compared with a 5th reading to make sure the gauge is working properly. If standard count fails, see manual for further details or call HQ RSO.

Where:
- DS=Density Standard Count
- MS=Moisture Standard Count

Standard Count:
DS=xxxx MS=xxxx

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Standard Count

- Do the following if a Standard Count Log has not been kept or first standard count comparison does not meet the 1% for density and 2% for moister. If standard count fails after taking these five counts, contact your regional RSO and DON'T USE THE GUAGE.

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Standard Count

- Example:
- Count 1: Density – 160.0 Moister – 120.0
- Count 2: Density – 165.0 Moister – 123.0
- Count 3: Density – 162.0 Moister – 120.0
- Count 4: Density – 159.0 Moister – 125.0
- Count 5: Density – 154.0 Moister – 119.0

Average 161.5

Average 122.0

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Density = (161.5-154.0)/161.5 x 100 = 4.6%
Moister = (122.0-119.0)/122.0 x 100 = 2.5%

Test Strip

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Test Strip Calibration (Asphalt)

- 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.

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Test Strip Calibration (Asphalt)

- Test strips are required for the following mixtures:
  307-A, 307-B, 307-BM, 307-BM2, 307-C, 307-CW, 411-D, 411-Es
- The minimum size of a single test strip is 400 yd^2, but a larger area is recommended. The following roadway lengths provide an area of 400 yd^2 :
  - 9' wide= 400' long
  - 10' wide= 360' long
  - 11' wide= 330' long
  - 12' wide= 300' long

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Test Strip Calibration (Asphalt)

- Step 1: Compact test strip area

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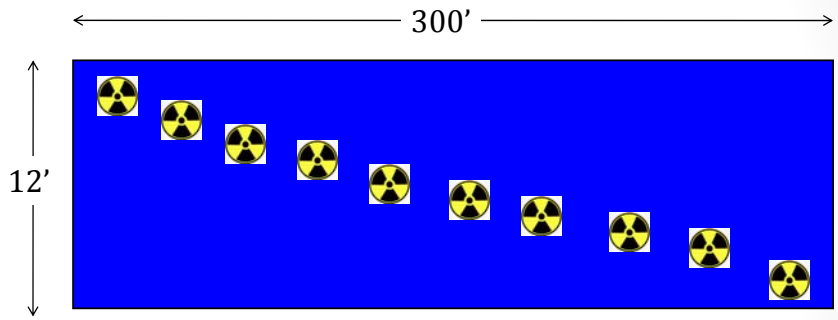
Test Strip Calibration (Asphalt)



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. Write down the density (lb/ft^3) at every location and mark the location so we can cut cores.

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Test Strip Calibration (Asphalt)

- 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

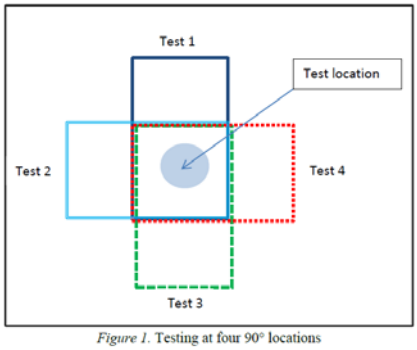

Figure 1. Testing at four 90° locations

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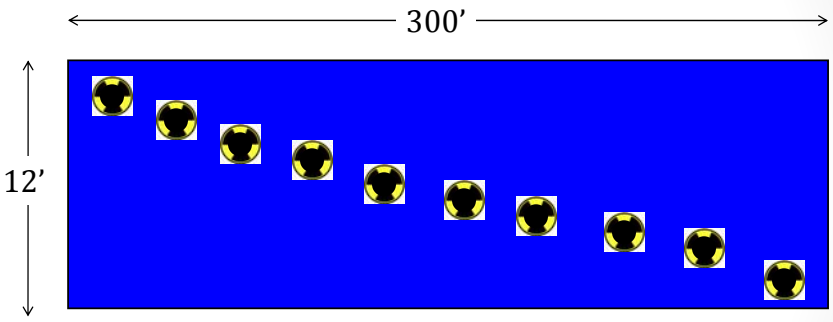
Test Strip Calibration (Asphalt)



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)

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Test Strip Calibration

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

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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.

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Test Strip Calibration

Nuclear Gauge Results:	Core Density:
• 140.5 lb/ft^3	• 142.1
• 139.7	• 142.7
• 139.3	• 142.3
• 134.3	• 139.1
• 137.8	• 141.1
• 143.1	• 141.6
• 135.4	• 140.4
• 138.1	• 141.2
• 134.1	• 137.8
• 137.6	• 140.2

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Offset/Correction Factor (Asphalt)

Density Offset

To access the *Special* functions, press ⟨**SPECIAL**⟩.

Press the down arrow key once to access the *Offset* function.
Press ⟨**START/ENTER**⟩ to display:

```
Offset: Density
(↑ ↓ or ENTER)
```

Press ⟨**START/ENTER**⟩.

```
Dens. Offset OFF
Want to Enable?
```

To enable the *Density Offset* function, press ⟨**ON/YES**⟩.

```
D off= 0.0   PCF
(↑ ↓ or ENTER)
```

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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.

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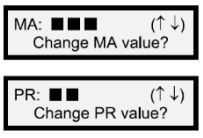
TESTING

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**



Original to:
Headquarters Materials and Tests
Copies to:
Regional Materials and Tests
Project Supervisor

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

PROCTOR DENSITY REPORT

Project Reference No.	9405696	County	WILLIAMSON
Project No.	94011-3243-04	Contract No.	
Material	BULK SOIL SAMPLE	Project Supervisor	R. JOWERS
Report No.	1	Date Sampled	11-Sep-17
Serial No.	178305	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.	0-5
Location, ft.	65LT
2"	
1-1/2"	
1"	
3/4"	
3/8"	
No. 4	
No. 10	99
No. 16	
No. 40	99
No. 100	93
No. 200	64
Silt and Clay	
Clay	33

SOIL CONSTANTS

Liquid Limit	32
Plastic Limit	23
Plasticity Index	9
Calculated Cl	8
Type	
Group	

DETERMINED CORRECTED FOR +4 MATERIAL

Proctor Density	103.8
Optimum Moisture	18.6
95 % Density	
Moisture Range Above Subgrade	11.4
Moisture Range Below Subgrade	23.1

Proctor Density & Optimal Moisture

TN TDOT Department of Transportation

STATE OF TENNESSEE ASPHALT JOB MIX FORMULA

2016 V4.06 V4.06

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: Tri-State Sand LLC	
Anti-Strip Additive:		Arr Maz	Dosage: 0.5%
AC Contribution:	Virgin AC 2.99	RAP AC 1.01	Percent Virgin AC: 74.7
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/Ft³: 161.5
L.O.I.:		Ignition Oven Corr. Factor	
		Warm Mix?	

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Theoretical Maximum Density

Setting Up Depth

- **Press <DEPTH>**. This is only for Aggregate/Soil. Asphalt is always in Backscatter mode.
- Aggregate/Soils: **Enter depth.**
- **Press Enter**

Setting Up Units

- **Press <Special>.** Press the down arrow ↓ seven times to select Set Units (PCF), **Press <START/ENTER>**.

Setting Up Count time

- **Press <TIME>**. Enter ≥ 15 seconds when testing at four 90° locations for Asphalt. Use down/up ↓↑arrows to change time. **Press Enter.** Enter 1 minute when testing soil/agggregate

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.

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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)

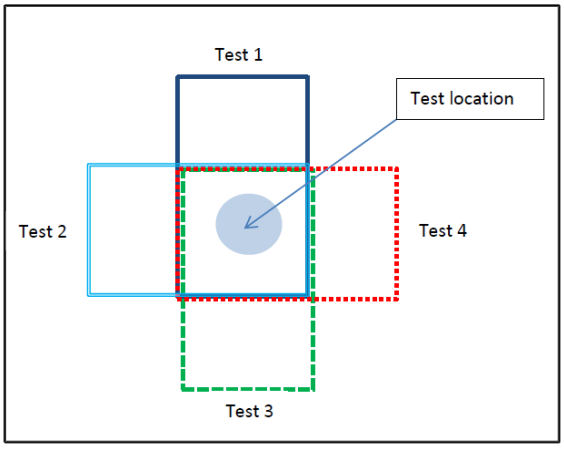

Figure 1. Testing at four 90° locations

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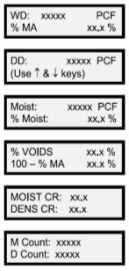
Testig (Asphalt)

- 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.



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.

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.

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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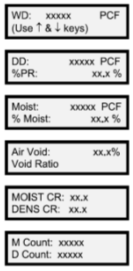
Taking a Measurement – Soil and Aggregate Material

- 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



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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.

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REV NOV 2, 2017

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.

PART ONE – ACCEPTANCE TESTING

Hot Mix Asphalt

Mixtures: 307-A, 307-B, 307-BM, 307-BM2, 307-C, 307-CW, 411-D, 411-Es

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.)

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:

- *"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.

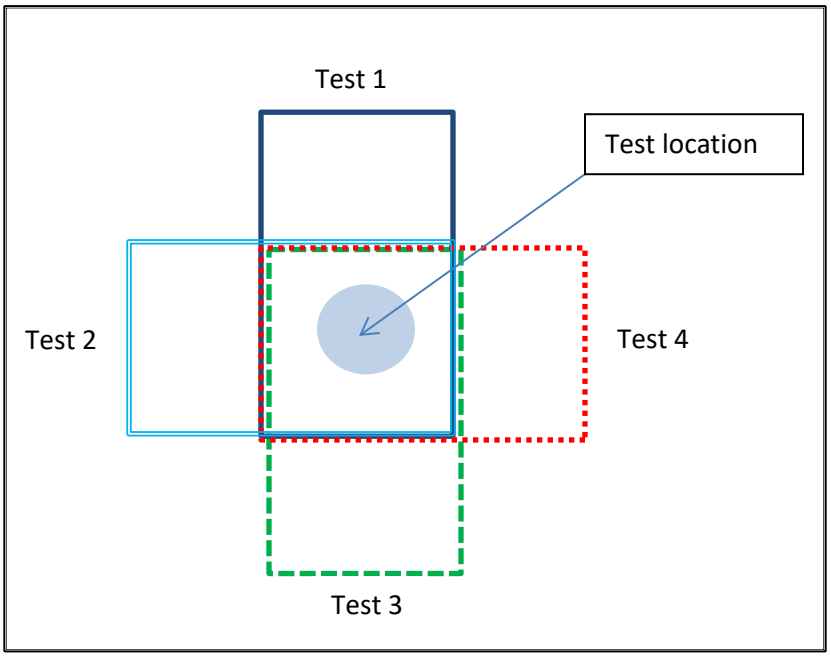

Figure 1. Testing at four 90° locations

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

- DT-0315, Daily Asphalt Density Report

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

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.

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 greater than or equal to 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)

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 the following mixtures:
  307-A, 307-B, 307-BM, 307-BM2, 307-C, 307-CW, 411-D, 411-Es
- The minimum size of a single test strip is 400 yd^2, but a larger area is recommended. The following roadway lengths provide an area of 400 yd^2 :
  - 9’ wide= 400’ long
  - 10’ wide= 360’ long
  - 11’ wide= 330’ long
  - 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

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.

May 1, 2017
Feb 14, 2018

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 daily 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-K16 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 Regional Materials and Tests Office has a regional Radiation Safety Officer (RSO) in the Materials and Tests Office as well as the Statewide RSO in Headquarters Materials and Tests. Each gauge operator is responsible for knowing the current contact information of their regional RSO.

1 Storage Site

1.1 The handle shall be locked and the gauge stored in its transport case.

1.2 The transport case shall be locked.

1.3 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).

1.4 The storage area shall be marked with a radiation sign that reads "CAUTION RADIOACTIVE MATERIALS" (can be obtained from HQ RSO).

1.5 Do not store a nuclear gauge in a motor vehicle except:

1.5.1 The nuclear gauge may be stored inside the gauge operator's truck when not in use on a construction site or at a location in transit between the permanent storage site and the project site. With permission of the gauge operator's supervisor, the gauge operator may store the gauge overnight in their truck, provided it is secured per section 4, at a location between the permanent storage site and the project site. In all other cases the gauge operator shall return the gauge to the permanent storage location.

1.5.2 Any time the gauge is stored in the truck it shall be secured for transport per section 4.

1.6 A log of all gauges stored at the site will be maintained at the storage site. All gauges must be checked in when not stored and checked out by the operator when in use.

1.7 Storage site must be enclosed (four walls and a roof) and it must protect gauges from the elements.

1.8 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.

2 Inspections:

2.1 Inspect the gauge before use 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, the clean the sliding block before using, transporting, or storing the gauge.

2.1.2 Do not store or transport the gauge unless the sliding block is completely closed. Increased radiation levels may violate transportation regulations and cause excessive personal radiation exposure.

2.1.3 If a radiation survey instrument is available, verify that the radioactive gamma source is in place by measuring the exposure rate at the surface of the gauge. If the exposure rate is not in the approximately range of 10 - 20 mrem per hour contact the regional RSO and discontinue use of the gauge until further notice.

2.2 Biannual Inspection

2.2.1 Gauges shall be leak tested every April and October. The Regional RSO shall conduct a 'swipe' test and submit the sample to the HQ RSO who will submit all samples to the lab for testing. In conjunction with the 'swipe' test, an inventory check must be completed. This means that the gauge must be physically located and accounted for.

3 Operator Certification and Monitoring:

3.1 Anyone operating a nuclear gauge shall be a certified TDOT Radiation Safety Technician.

3.2 The technician must wear their assigned dosimeter while operating or transporting the nuclear gauge. Dosimeter may not be shared between individuals and may only be used by the person who is named on the dosimeter.

3.3 Badges shall be turned in every March, June, September, and December to the regional RSO to be checked for individual exposure.

4 Transporting Nuclear Gauge to Project

4.1 The handle for the gauge shall be locked into the safe position during transport.

4.2 The nuclear gauge shall be locked inside the transport case during transport.

4.3 Transport the nuclear gauge in the rearmost part of the bed of a truck inside either:

4.3.1 a locked bed cover with the device secured in place with heavy chain to prevent the case from moving or

4.3.2 a mounted transportation box, specifically designed for the nuclear gauge case.

4.4 No one other than DOSIMETER BADGE WEARER with HAZMAT TRAINING is allowed in the vehicle while the nuclear gauge is in the vehicle.

4.5 While in transit the following paperwork must be in the vehicle and readily accessible by the driver:

- nuclear gauge bill of lading (BOL),
- operator's nuclear safety certificate,
- nuclear gauge shipping paper,
- TDOT Radiation Safety Plan (SOP 7-2),

4.6 At any time the vehicle is parked while the gauge is stowed for transit, the shipping paper must be place face up in the driver's seat.

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 truck when testing is eminent.

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 shall never be left unattended on site.

5.4 If it becomes necessary to move between locations inside the project, lock the handle into the SAFE position and replace the nuclear gauge into the transport case and place in the rear of truck bed. At no time shall the nuclear gauge be placed into the cab of the tuck.

5.4.1 It is not necessary to lock the case and bed cover for short trips inside the project limits

5.5 When the nuclear gauge is in operation all personnel must be a minimum of 30' away from the gauge except if they are wearing a dosimeter badge.

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

6 Emergency Response Plan: In the case of accident, damage, loss, or theft of nuclear gauge adhere to the following procedure:

6.1 Priority Response Actions To Be Taken By Gauge Operator

6.1.1 FIRST PRIORITY: 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.)

6.1.2 ADDITIONAL ACTIONS BY GAUGE OPERATOR:

6.1.2.1 Visually inspect gauge for damage, including visual inspection of source rod. Determine if sources are, or can be placed in their shielded positions.

6.1.2.2 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.

6.1.2.3 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, THEN evacuate and secure an area large enough to include any possible locations where the source might be located. Prevent entry by all unauthorized persons into the evacuated area.

6.1.2.4 If a vehicle or construction equipment is involved in the incident, detain the equipment until it is determined that there is no contamination.

6.1.2.5 As soon as possible after these actions have been accomplished, notify the RSO of the incident.

6.1.2.6 Describe in detail the incident, condition of the gauge, and actions taken. Follow any additional instructions given by the RSO as soon as possible.

6.2 **Response Actions to Be Taken By the Regional RSO**

6.2.1 Give additional advice to gauge operator (if needed).

6.2.2 Notify the police, fire, or other emergency agencies as needed or required.

6.2.3 Notify the HQ RSO

6.2.4 The HQ RSO will notify the Tennessee Department of Environmental Conservation Division of Radiological Health at (615) 532-0364.

6.2.5 The HQ 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
U.S. DOT
1 (800) 424-8802

6.2.6 Travel to the accident site and perform the following:
- 6.2.6.1 Confirm the actions taken by the operator to be correct.
- 6.2.6.2 Conduct a visual inspection of the gauge, shielding, and source rod to determine if radioactive sources are still in the gauge.
- 6.2.6.3 If radioactive sources are found to be missing, or damage to the shielding is suspected:
  - 6.2.6.3.1 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 any reading is greater than the listed values you can suspect that the source shielding has been violated.
  - 6.2.6.3.2 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.
  - 6.2.6.3.3 Perform a leak test on the gauge and source rod.
  - 6.2.6.3.4 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.
  - 6.2.6.3.5 If no contamination is found, notify the Regional 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.
  - 6.2.6.3.6 Document all actions taken, or not taken, and provide sketches and/or photos.

6.3 **Follow Up Actions Taken By Regional Radiation Safety Officer**
- 6.3.1 Take photos of the damaged gauge prior to shipping for repairs or disposal.
- 6.3.2 Place gauge in secure storage location until approved for shipment to manufacturer if needed.
- 6.3.3 Notify the gauge manufacturer of gauge damage and accident.
- 6.3.4 Send photos of the gauge along with leak test info to the manufacturer for clearance and shipping instructions.
- 6.3.5 Document any actions and instructions given for records.
- 6.3.6 Notify by telephone or mail/email ALL regulatory agencies as required of post-accident corrective actions and safety precautions taken.
- 6.3.7 Ship the damaged gauge to manufacturer per instructions given. (Note: NEVER ship a damaged nuclear gauge until it has been leak tested and the wipe cleared.

6.3.8 Review accident causes and measures taken. Establish new or revised guidelines to prevent similar future occurrences.

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. _____ Grading _____

Report No. _____ ASPHALT DENSITY REPORT Date _____

Contract No. _____

Project Reference No. _____ County _____ Region _____

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:

lb/yd^2 (kg/yd^2) _____	
Lot No.	Avg. % Density

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

Signature _____

Title _____