Non-Destructive Density Gauge Use on Asphalt Pavement

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The Nuclear Gauge

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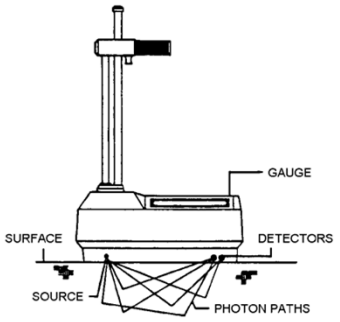

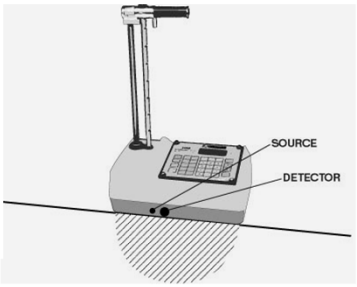

Nuclear Gauges contain small sealed sources which allow measurement of density and moisture of construction materials.
They are very safe when used correctly are handled in accordance with regulations.

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Regulations / Safety

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Licensing

- **Licensing** Possession and use of radioactive material requires the user to have and maintain a license issued by the USNRC or Agreement State.
- **Storage** Proper storage of radioactive material is required. In general, it must be stored at least 15 ft. from nearest full-time work station. In addition, a double lock system is required and a radiation caution sign posted.
- **Disposal** The gauges must be disposed of by transferring to another properly licensed gauge user or to a licensed disposal facility.

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Safety / Radiation Protection

The typical Troxler gauge contains a Cs-137 source and an Am-241:Be source. By following a few simple rules you can be assured that working with or around nuclear gauges will pose no threat to your health or safety.**

Methods to Reduce Exposure:

- **Time** Keep time spent around radioactive sources to a minimum
- **Distance** Radiation intensity decreases as distance increases
- **Shielding** Shielding is built into the gauges to reduce exposure when it is not in the measurement positions. Additional shielding *can* be used for storage areas.

**From the US NRC document “Working Safely with Nuclear Gauges”

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Gauge Operation

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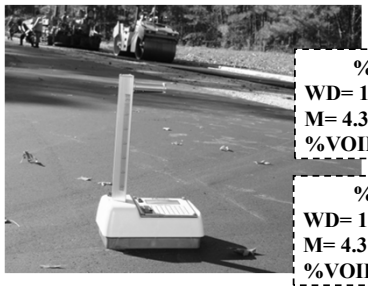
Measurement Results- What does the gauge tell me?



$\%G_{mb}$= 96%
WD= 146
M= 4.3 %M= 3.0
%VOIDS= 7%

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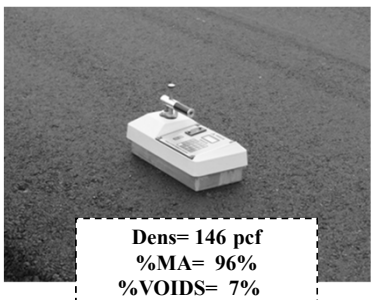

Dens= 146 pcf
%MA= 96%
%VOIDS= 7%

Percent Compaction ($\%G_{mb}$ or %MA); the compaction of the material as compared to the optimum compaction of that material **%MA** = (WD / Target) x 100 **%Gmb** = (WD / Target) x 100

Wet Density (WD); the total density of the material

Moisture content (M);in pcf or kg/m3 **Percent Moisture** (%M); (%M = (M / DD) x 100

% Voids= 100 – (WD / Gmm Target)

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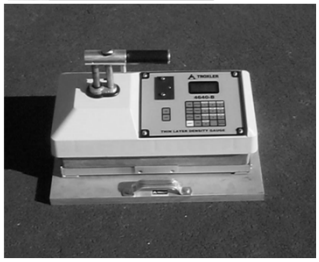
Preparing the gauge for use:



The **Standard Count** is an important function and must be performed when the gauge is received and every day that the gauge is used. This count:

- Diagnoses possible problems within the gauge
- Adjusts the gauge for source decay and
- Adjusts for environmental influences

These guidelines should be followed:

- *Warm up the gauge* for at least 10 minutes before performing the standard count.
- No other nuclear sources should be within 30 feet (10m).
- Standard count should be taken at least 6 feet (2 m) from any large vertical object.
- Standard block should be clean and dry.
- Block should be sitting on a smooth, dry, compacted surface with a density of at least 100 pcf (1600kg/m^3).

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Standard Count

- The standard count value is used in the calculation of the final measurement results (WD, M, DD, %M). Therefore it is important that it is a correct value.
- Most gauge models will do the Pass / Fail calculation for you. This involves comparing the *most recent* standard count to a value that is the *average of the last 4 standard counts* taken.
- It is a good idea to keep a standard count log with all gauges in order to track any shifts or changes over time.

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Standard Count

Refer to the recent calibration report if unsure what the standard counts should be.

Troxler Model 03411 Calibration Report (Page 1 of 3)

Gauge model - 03411 A Gauge serial number - 015756

Reference standard count: Density = 3371 Moisture - 0699

Calibration Date: 04-27-1988 Print Date: 02-13-2009 Bay = 004

*** Density calibration count data ***

Depth (in)	Magnes 1783	Mag/Al 2218	Alumin 2721
BS	01446	00957	00646

Troxler Model 03411 Calibration Report (Page 2 of 3)

***** Density Standard Decay Sheet *****

Gauge model - 03411 B
Serial - 015756

Calibration Date: 04-27-1988
Print Date: 02-13-2009

Ref. std. cnt. = 3371

Range of projected density standard counts at future dates

Date	Lower Limit of Projected density Standard Count	Upper Limit of Projected density Standard Count
05-01-1988	3336	3404
06-01-1988	3330	3397
07-01-1988	3324	3391
08-01-1988	3317	3384
09-01-1988	3311	3378
10-01-1988	3305	3371
11-01-1988	3298	3365
12-01-1988	3292	3358
01-01-1989	3285	3352
02-01-1989	3279	3345
03-01-1989	3273	3339
04-01-1989	3267	3333
05-01-1989	3261	3327

The true gravimetric densities of the metallic blocks used in this calibration are listed on Page 1 of this document. To account for

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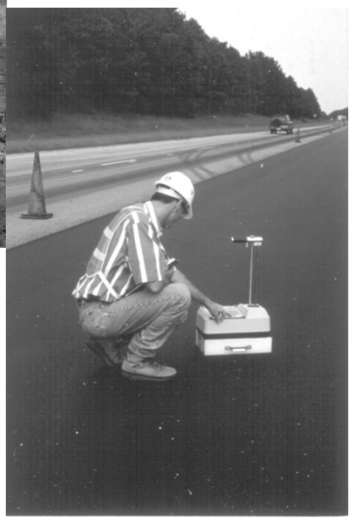

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Measurement Modes

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Backscatter Readings

Backscatter measurements are performed when the handle is lowered to the first notch below the “safe” position. The source is then positioned just above the test surface.

The photons from the cesium source travel through the test material and are scattered back to the detectors.

Those that reach the detectors in the gauge base are counted. This count (DC) is then equated to a density using the information from the gauge’s calibration and the daily standard count.

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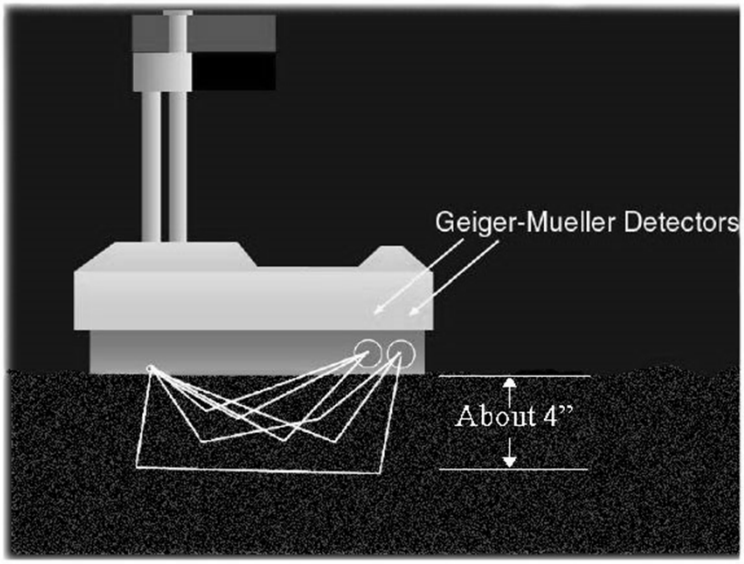
Backscatter Density



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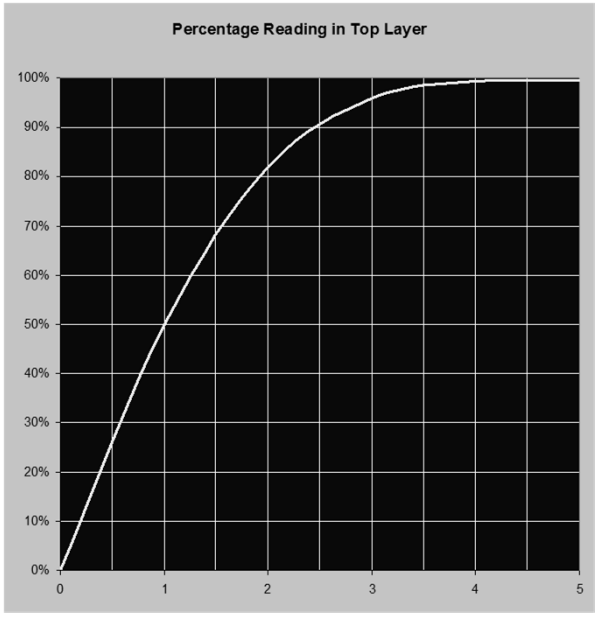
Top Layer Effect in Backscatter

Example: The top 2 inches is approx. 82% of the reading, the top 3 inches is approx. 96% of the reading.



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Model 4640

Measuring Density of Thin Layer Pavements (1”- 4”)

Model 3450

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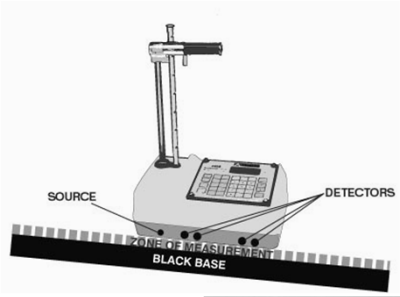
Thin Layer Mode



- **Thin layer gauges:**
  - Contain more detector tubes than the typical soil / asphalt density gauge. This allows the gauge to measure density at different levels below the gauge.
  - The **system 1** tubes mainly measure the density of the shallow material and the **system 2** tubes mainly measure the density of the deeper material. The gauge then uses these densities to calculate the density of the layer thickness which is specified by the operator.

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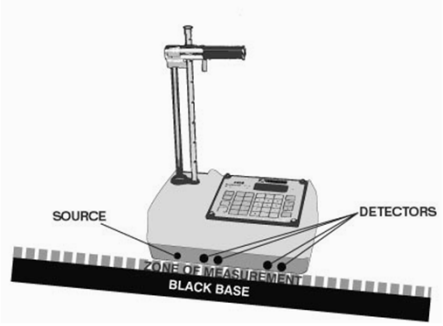
Thin Layer Gauges

Thin Layers gauges are highly recommended for Thin-Layer overlay applications.

When placing an overlay the underlying asphalt density is unpredictable. The Thin-Layer gauge measures the density of the overlay and the deeper layer so the changes in the underlying material are "seen" by the gauge.



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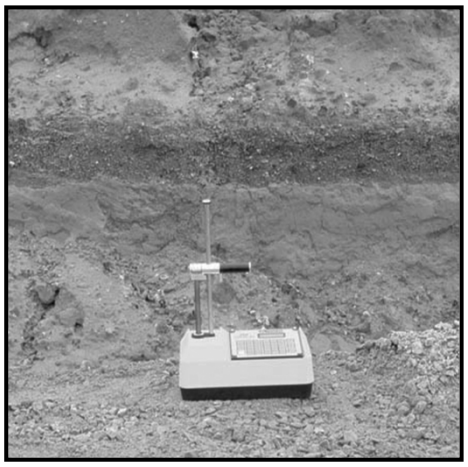
Direct Transmission Readings

In *direct transmission* mode, the source is lowered below the surface of the test material into a predrilled hole. The area that is being measured is between the cesium source and the detectors in the gauge base. This mode is generally used on soil materials, but can be used on asphalt.



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Gauge Calibration

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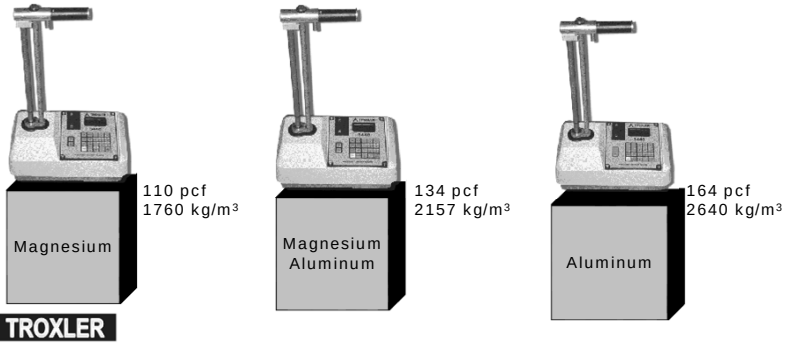
Calibration

To calibrate the gauge, a density curve is calculated from measurements on metallic blocks of a known density. The counts from each block at each depth position are entered into computer software and the calibration constants are derived.

When a measurement is performed in the field, the measurement count can be used to calculate a density.

A block with a known moisture content is also used to perform a moisture calibration.



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Calibration

It is recommended that the nuclear gauges are calibrated and basic maintenance performed every 12 months (ASTM requires calibration or verification every **12 months**). The gauges should be calibrated at a Troxler authorized facility to be sure that it is an appropriate calibration. A calibration performed by Troxler is NIST traceable.

110 pcf
1760 kg/m^3

134 pcf
2157 kg/m^3

164 pcf
2640 kg/m^3

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Maintenance

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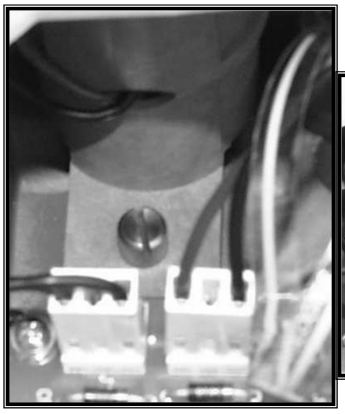
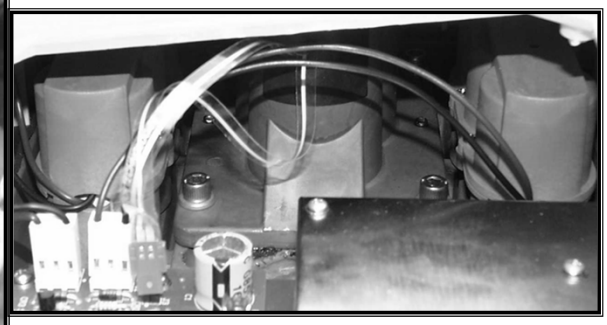
Batteries





Rechargeable batteries are easily replaceable.

Alkaline batteries can also be used in Troxler gauges.

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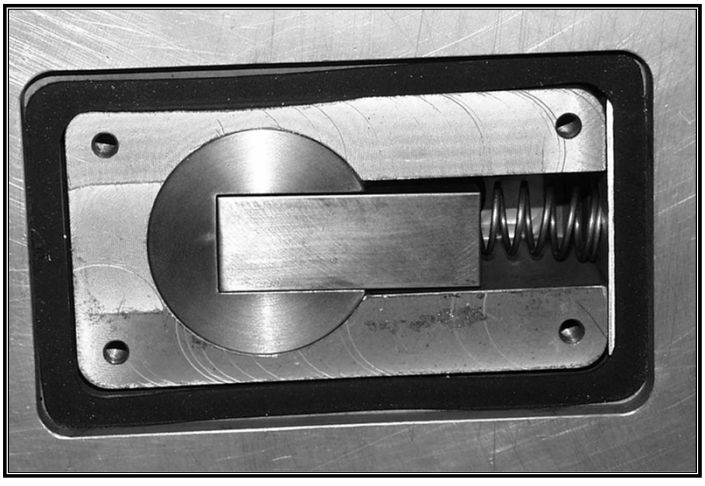
Clean & Lubricate Sliding Block Area



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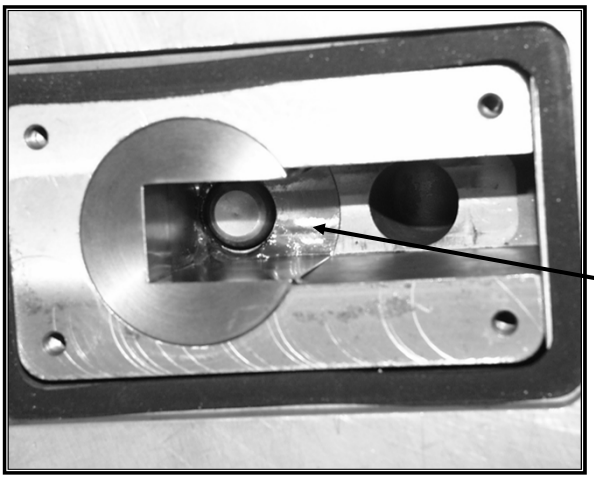
Clean & Lubricate Sliding Block Area



Lubricate the top angled surface of the sliding block before replacing. (Magnalube / Teflon based lubricant)

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Keep the Gauge Base Clean

If asphalt / soil is stuck to the gauge base it will not make contact with the test material surface.

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Keep the Gauge Dry

Do not use the gauge in the rain. If it gets wet dry it immediately. If needed, open the keypad and allow air to flow through.

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Electromagnetic Gauge

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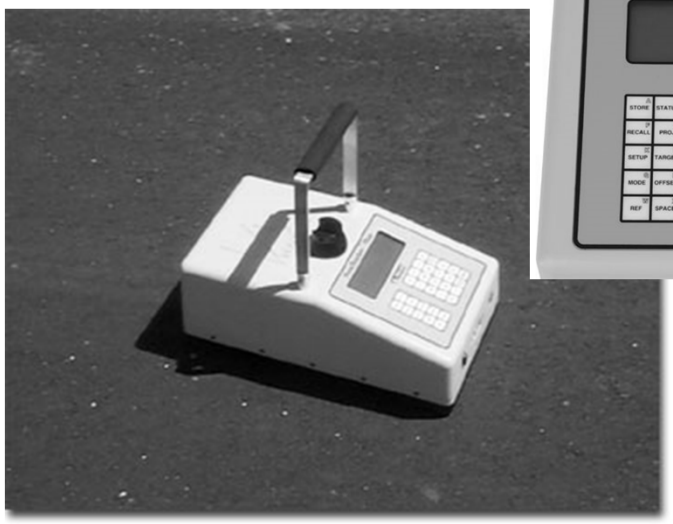
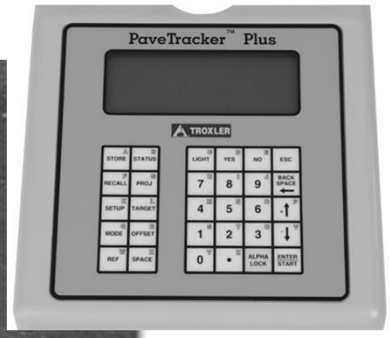
Non-Nuclear Density Device





Troxler PaveTracker™ Plus

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Non-Nuclear (Electromagnetic) Density Device

What does it tell me?

96.3% Gmb (MA)
94.3% Gmm (Voidless)
D: 143.5
5.7% Voids

How does it work?

Measures Density by detecting changes in the pavement **Dielectric Constant**

As the asphalt is compacted, the air voids decrease. Therefore the dielectric constant changes (increases).

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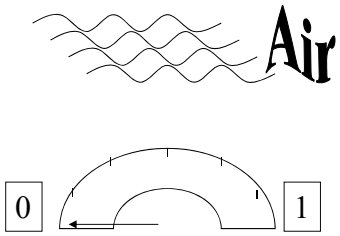
Non-Nuclear (Electromagnetic) Density Device



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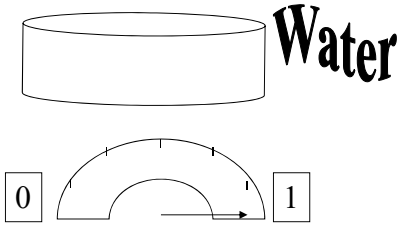

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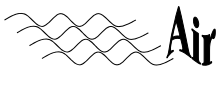
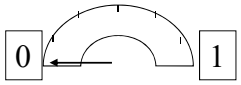
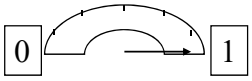
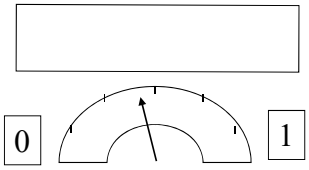






Asphalt has a Dielectric Constant of ~ .45



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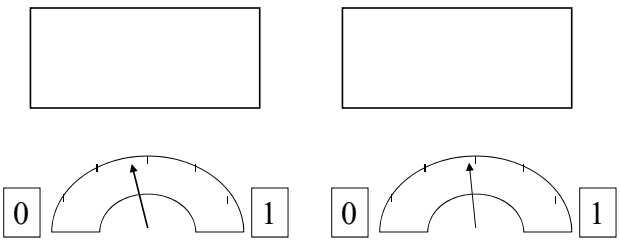

As Asphalt Compacts –
Dielectric Constant goes up

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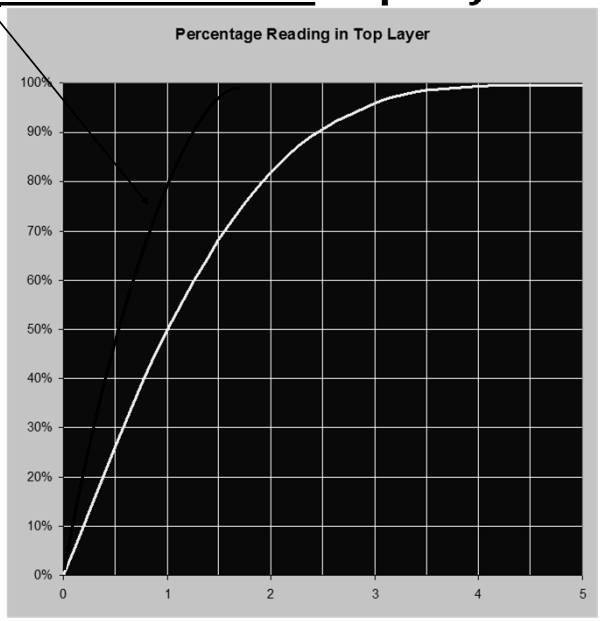
Non-Nuclear Device Top Layer Effect

The non-nuclear, electromagnetic technology allows measurement to a depth of about 1.75 inches on average. This is true of any gauge using this technology.



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Advantages / Disadvantages to the Non-nuclear Density Device

- Advantages
  - **No License Required**
  - **No Operator Certification Required**
  - **Immediate Feedback**
  - **Lightweight (11 lbs)**
  - **Indicates Changes Such As Segregation**
- Disadvantages
  - **Comparative, Rather than Direct Measurements**
  - **Works only on asphalt material (not soils)**

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Offsets-

often needed for nuclear gauges and very important for non-nuclear gauges.

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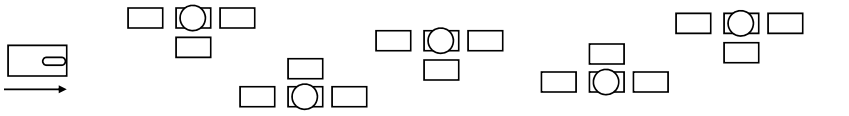
Density Offset

Gauge readings can be compared to core densities by taking measurements on or around core sites.
The average of these gauge measurements can be compared to the average core densities to find the difference.
The average difference can then be programmed in the gauge as a *density offset*. State DOTs have unique procedures that should be followed.

Typically 3 – 4 readings are performed at 3 to 5 core sites for comparison.



If using a backscatter gauge (non- thin layer) on asphalt lifts less than 3 inches, an offset should be performed. This is especially critical on a thin overlay. Thin layer gauges are best for overlay situations due to the unpredictable underlying material.

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Common Mistakes

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Common Mistakes Made by Nuclear Gauge Operators

- Always use a 1 minute count time (or more). This gives better precision.
- Place the source rod in the proper position. Do not pass the notch. Do not allow the source to contact fresh asphalt.
- Place the gauge on a smooth site, check to be sure there are no air gaps under the gauge.
- Be sure that the gauge bottom is clean of debris.
- Use a thin layer gauge when measuring thin overlays (less than 3 inches). Typical backscatter reading will be influenced by the underlying layer.
- Position the gauge in line with the roller path. Do not cross “roller ruts”.

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Common Mistakes Made by Nuclear Gauge Operators

- Perform standard count daily following the rules listed in the operator's manual.
- Service and calibrate gauges as necessary (12 months).
- Know and use the proper target density (or densities).
- Store measurement data for viewing / printing- this avoids questions about data.
- Call Troxler if you have a question or problem.

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Introducing the new Model 3430 and 3440

Both models offer:

•Powered by rechargeable NiMH batteries or optional back-up alkaline batteries
•Larger 4 line x 20 character display screen
•Measurement data storage available in all gauges
•A backlit LCD screen

3440 extra features:

•Remote start keypad on top of the handle
•USB data transfer option via USB printer
•USB port for data transfer via removable ("thumb") drive
•Loud external beeper to indicate the end of a count (optional)
•Automatic indexing- gauge senses the depth of the source rod
•Optional GPS (global positioning satellite) function- reports latitude and longitude of measurement location at completion of reading
•Backlit keypad for viewing in dimly lit jobsites (optional)

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Slideshow