12 Nuclear Gauge Testing

CHAPTER TWELVE:
NUCLEAR GAUGE TESTING

Nuclear moisture/density gauges are testing devices that use low level radiation to measure the wet density, dry density, and moisture content of soil and granular construction materials. Currently, INDOT uses the nuclear gauge for the measurement of wet density only. Extensive experience with portable gauges indicates that the radiation exposure to workers is generally low and that sealed sources are not easily damaged. The nuclear gauges used by INDOT pose no danger of radiation exposure to the operator when the appropriate safety practices are followed.

Completing a Radiation Safety Course before operating a gauge is a requirement of the Nuclear Regulatory Commission (NRC). The NRC licenses the possession and use of portable gauges and any other processes or devices that use radioactive materials. The NRC monitors the activities of the licensees. If violations of a licensee's safety program are discovered, the NRC has the authority to issue fines, suspend the license, or revoke the license. In cases of intentional misconduct, individuals may face fines or criminal prosecution. The NRC conducts periodic field inspections of licensee activities. This includes making visits to job-sites to observe the handling, transportation, and storage of gauges. Every gauge is required to be used according to the procedures outlined in the Radiation Safety Program.

To ensure your safety and compliance with licensing requirements, every gauge operator is required to wear a monitoring badge. The badge measures the radiation exposure the operator receives and is required to be worn anytime the operator is within 15 ft of the gauge.

Every INDOT employee is required to attend a certification class on radiation safety prior to using a nuclear gauge and attend an annual refresher course. Each gauge user is responsible for maintaining their certification status. Gauge operators are required to also demonstrate and maintain testing proficiency through the Qualified Technician Program and Independent Assurance Program.

NUCLEAR GAUGE

Troxler Electronic Laboratories, Inc manufactures the majority of the nuclear gauges used by INDOT. Even though operating procedures vary somewhat between gauges, certain steps are basic in the operation of any nuclear gauge. The Troxler model 3440 is used for illustrative purposes.

Basic Gauge Components

Figure 12-1 indicates the general location of parts that are common to all nuclear gauges.

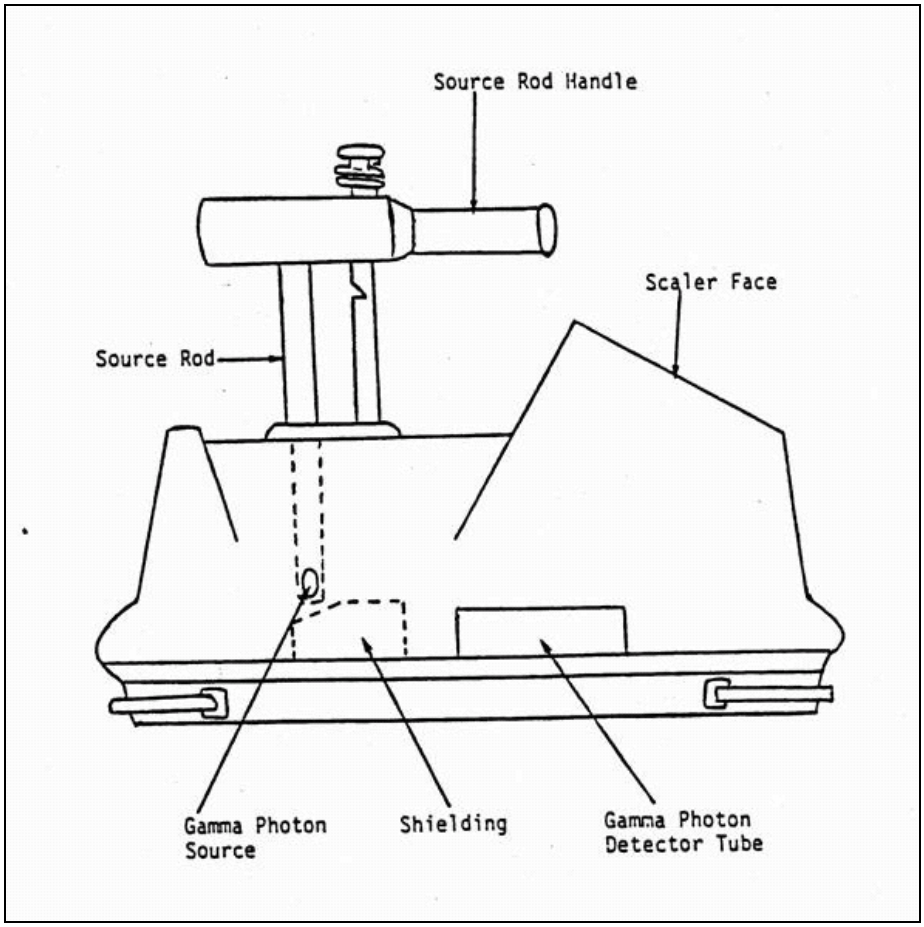


Figure 12-1. Basic Gauge Components

All of the operating controls of the nuclear gauge are located on the scalar faceplate. Figure 12-2 is the scalar faceplate for the Model 3440.

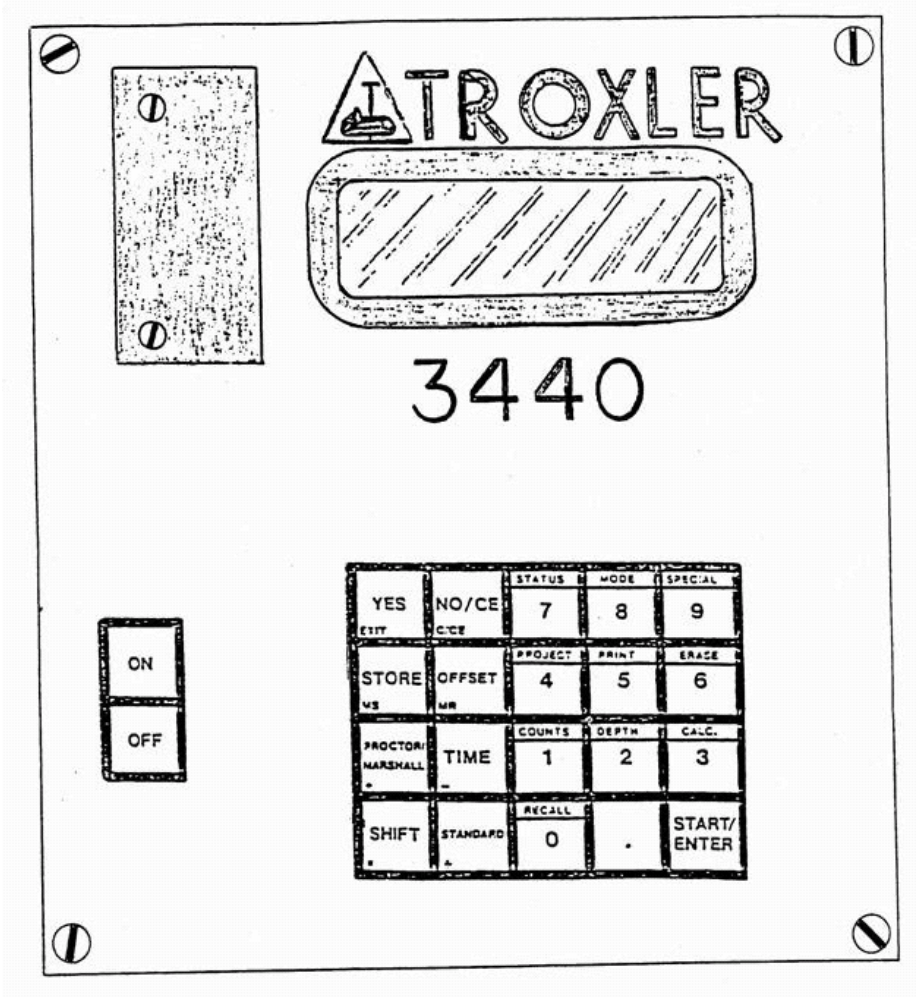


Figure 12-2. Model 3440 Scaler Faceplate

SOURCE ROD

The handle of the source rod controls the position of the radioactive source. Pressing the trigger releases the handle allowing the source rod to be repositioned in the notches (Figure 12-3). If the source rod is lowered to the first notch down from the safe position, the tip is just about even with the bottom of the gauge. In this configuration, the gauge is said to be in "Backscatter". Lowering the rod further puts the gauge in "Direct Transmission". The handle is required to be solidly seated in the notch position selected, otherwise, density and moisture readings may be inconsistent and inaccurate. Also, care is required to be used in positioning the handle to prevent pinching the hand, especially when raising the handle to the safe position.

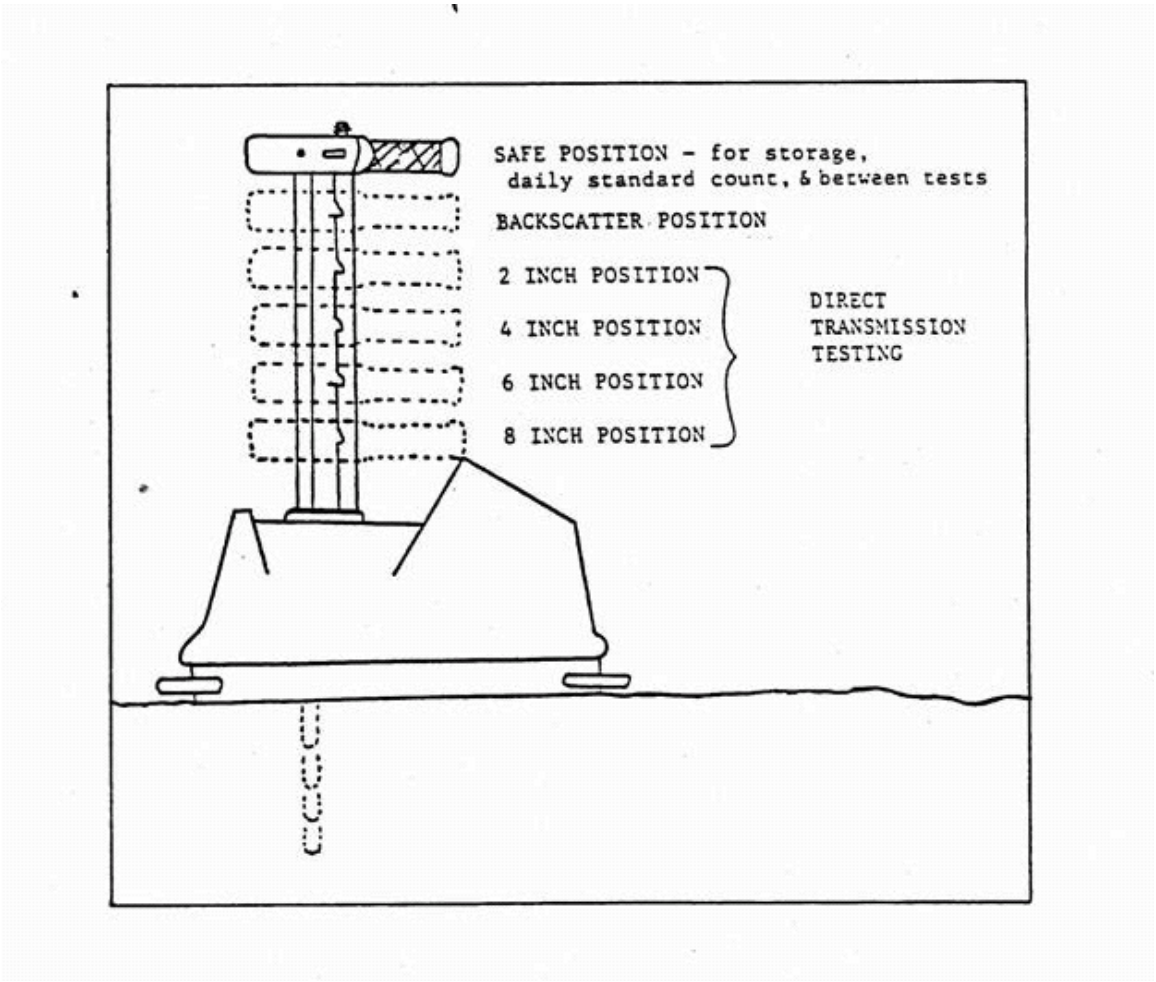


Figure 12-3. Source Rod

DAILY STANDARD COUNT

The purpose for obtaining a Daily Standard Count (DSC) is to verify that the gauge is working correctly and giving reliable readings. A DSC is best done by placing the gauge on a standard block of known density and composition, which has been placed on the material to be tested (aggregate, soil, etc). The standard block is included with each gauge and these blocks are not to be interchanged with blocks from other gauges. The standard count obtained from the test is recorded and saved for a reference.***PROCEDURE***

The procedure for obtaining the daily standard count is:

1) Place the gauge solidly on the standard block and remove the padlock. Make sure the scalar is at the butt plate end of the standard block.

2) The gauge handle is required to be in the safe position.

3) Push the on pad. The gauge goes to a self-diagnostic mode. If the screen displays "gauge ready" when turned on, wait a minimum of 15 minutes before operating.

4) Enter the proper information.
   a. Set units - pounds per cubic foot
   b. Set test time - 4 minutes is used by INDOT
   c. Set mode - soil, asphalt, concrete are the choices. INDOT tests are in the soil mode.
   d. Set depth - automatic or manual

5) Push the "standard" pad and answer the menu questions displayed on the screen. The DSC is an automatic 4-minute test and requires no programming.

6) Read and record the DSC.

FREQUENCY

Nuclear gauge operators are required to conduct the DSC:

1) At least once a day before testing begins

2) Whenever the gauge is turned off, then turned back on for additional testing

3) When the gauge is moved to another location
4) When the gauge is used on different materials

5) At least once a week, even if the gauge is not being used actively on a project

RECORDING THE COUNT

When picking up the gauge at the District Testing Lab, several blank DSC Summary Sheets or a monthly chart are obtained. These sheets are for the particular gauge issued and are used to record the DSC.

Although the Daily Standard Count drifts somewhat, the count does not vary from day-to-day more than +/- 1 % for density. For example, the DSC recorded on the first day was 469. The DSC on the following days should not be more than 474 or less than 464 for density (Figure 12-4).

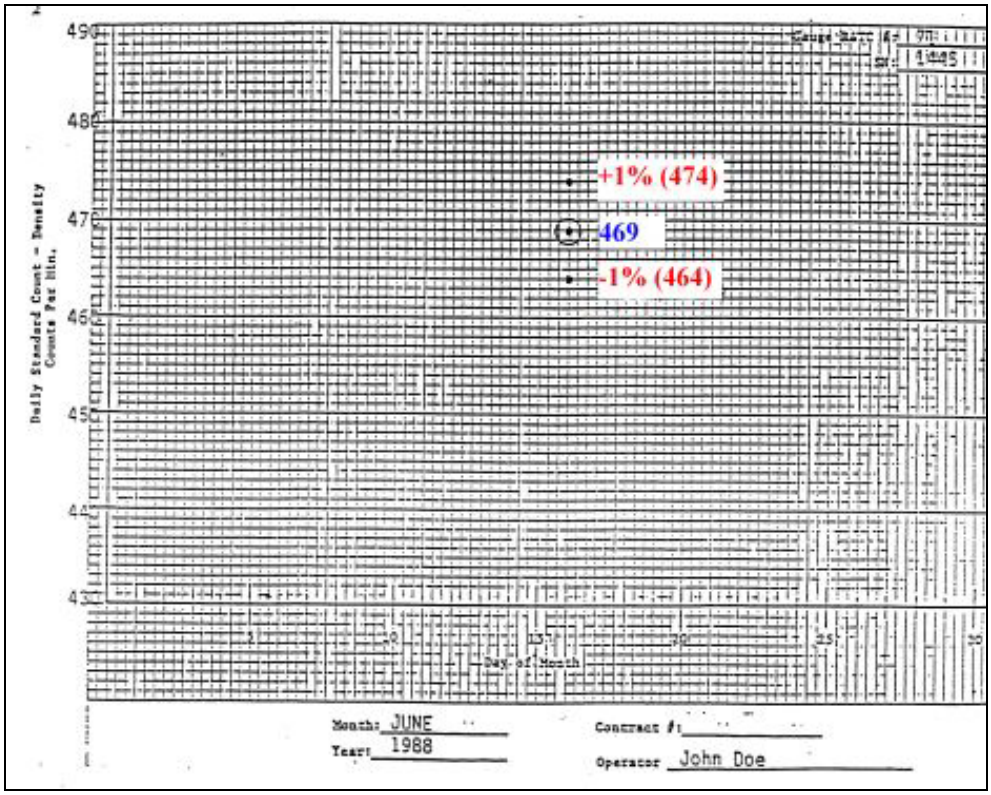


Figure 12-4. Daily Standard Count

Shifts in the DSC greater than 1 % may indicate that the gauge is not placed properly on the standard block, the gauge may be malfunctioning, or the construction material is emitting background radiation. If the reason(s) for excessive DSC variability cannot be determined, the District Testing office is contacted.

DAILY STANDARD COUNT GRAPHS

A DSC is required at least once a week, even if the gauge is not being used on a contract. When a gauge is first assigned to a new contract site, at least four DSC values are taken and saved to erase old counts that may be stored in the gauge.

A daily standard count graph or chart is required to be maintained with each gauge for a permanent record. The District includes a chart of daily standard count ranges with the gauge. The chart lists the maximum and minimum DSC to be expected on a monthly basis. DSC values outside these ranges are an indication of a problem and the District Radiation Safety Officer is required to be consulted.

BACKSCATTER DENSITY TESTING

In the Backscatter Method (Figure 12-5) for density testing, the nuclear gauge is required to be seated in contact with the surface of the material being tested. No air gaps may be under the gauge caused by surface debris or roughness. The long dimension of the gauge are required to be parallel to the direction of travel of the compaction equipment. When the source rod handle is depressed, the radiation source is lowered to just above the surface of the material and gamma photons are emitted.

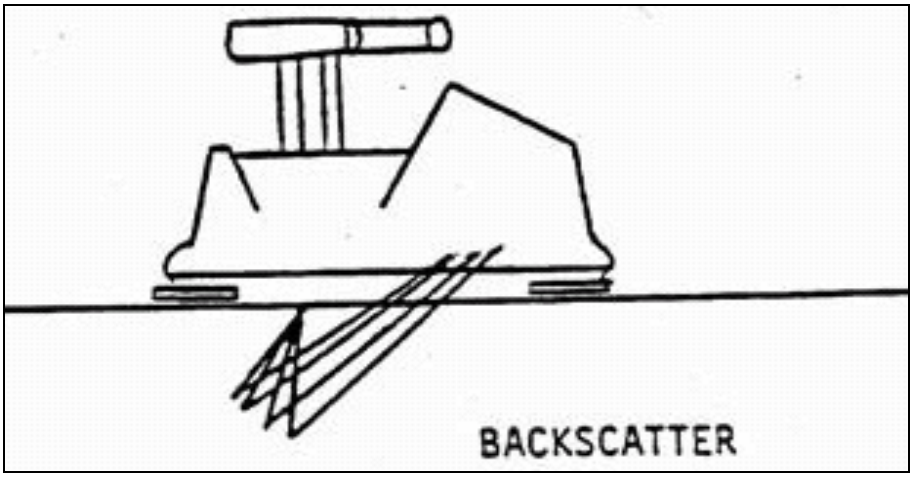


Figure 12-5. Backscatter Transmission Position

The gamma photons that measure density penetrate far into the material, but over 70 % of the photons are scattered back to the detector tubes in the first 2 in. of material being tested. 95 % of the photons are scattered back to the detector tubes from the top 3 in. There are not many gamma photons left to be scattered back below the 3rd in. Therefore, virtually no density information is obtained below 3 in. with the Backscatter Method. The Backscatter Method may be used with all INDOT gauges.

WHEN TO USE

In the Backscatter Method, in-place wet density is obtained by conducting tests on the surface of the material. This method is normally used when determining the density of granular materials. Generally, the Backscatter Method is not used on soils except when the soil is very loose and granular. Whenever backscatter is used, the bottom surface of the gauge is required to be clean. The backscatter test is required to be a 4-minute reading.

TEST SITE SELECTION

Test sites are required to be representative of the area being tested. Proper seating of the gauge, without air gaps, is necessary to ensure reliable readings. Most materials are compacted with vibratory, pneumatic, or steel wheel rollers that usually leave the surface smooth enough to test without special preparation. However, the material is required to be tested as soon after compaction as possible to avoid any unnecessary surface drying and shrinkage. If the surface has already dried, gently remove some of the dry surface material with a stiff brush until signs of moisture are visible. Extreme care is taken when scraping or brooming granular materials, as these materials may tend to loosen up when disturbed, and a reliable test is difficult to obtain.

PROCEDURE

The procedure using the backscatter method is as follows:

1) Refer to information issued with each gauge for supplemental information on conducting backscatter density testing.

2) The more tests taken, the more accurate the results are. More representative results are obtained if several tests are conducted on a lift of material and the test results averaged for final acceptance.

3) Follow the procedures in **AASHTO T 310**

DIRECT TRANSMISSION DENSITY TESTING

The Direct Transmission Method (Figure 12-6) helps reduce errors in nuclear gauge readings caused by poor surface conditions or from unforeseen conditions below the gauge. In this method, a hole is made so that the source rod may be lowered into the soil. Instead of just scattering gamma photons back to the gauge as is done with the backscatter method, a considerable number of photons travel from the source rod through the material being tested and directly to the detector tubes. Surface roughness errors are reduced and the measurement of density and/or moisture is more reliable.

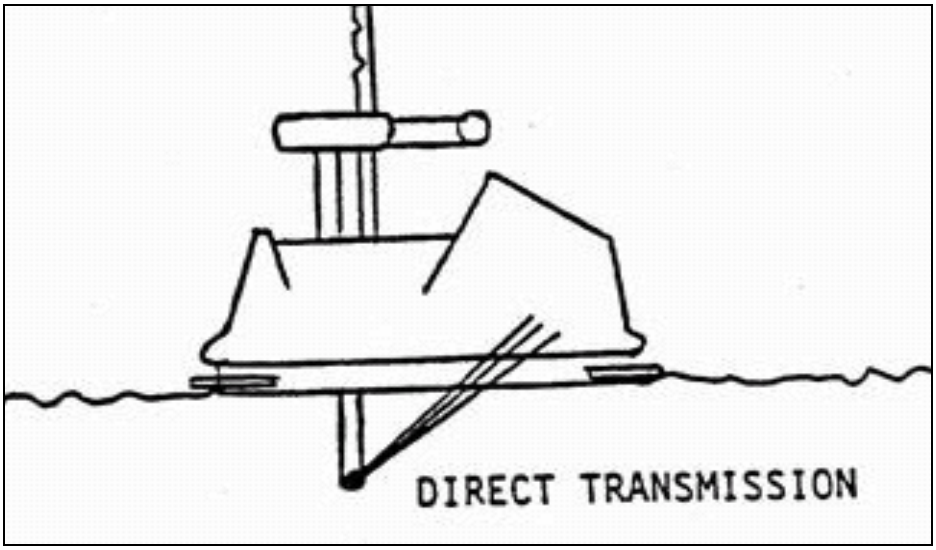


Figure 12-6. Direct Transmission Position

WHEN TO USE

The Direct Transmission Method is most commonly used on cohesive soils. Direct transmission would be used more extensively on all materials, but drilling a hole into granular material is difficult. Direct transmission tests are also conducted using a 4-minute reading.

SITE SELECTION AND PREPARATION

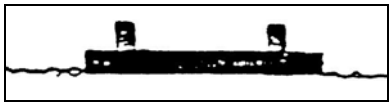
A location that is representative of the material being tested is selected. If the test is to follow a pass with a pneumatic, sheepsfoot, or segmented roller, a grader blade or shovel is used to plane the top surface so the gauge rests on a flat surface.

Care in scraping a site is required so that the material being placed and not the layer immediately below the material placed is tested. A fairly smooth surface is required; however, the surface may be sloped. The direction of the gauge is oriented to be parallel with the travel of the compaction equipment.

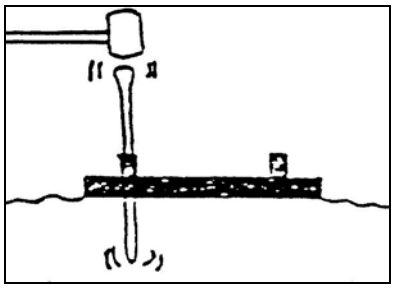
GAUGE HOLE

The following procedure is required for making a hole to conduct direct transmission tests:

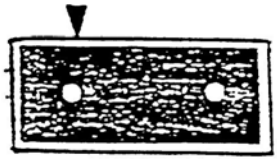
1) Place the scraper plate on the surface to be tested.



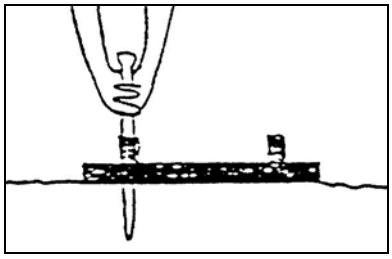
2) Push the drill rod through the rod guide into the material. If this is not possible, gently drive the drill rod into the material with a hammer, without compacting the soil more. Go 2 in. deeper than the depth to be tested.



3) Before removing the drill rod, mark the outline of the scraper plate. Also, mark the location of the hole, so the exact location of the gauge is known.



4) Remove the drill rod by pulling the rod straight up. If difficult to remove, lightly tap the side of the rod without compacting the side of the hole. Pull the rod upward as the rod is tapped.



5) Remove the scraper plate. If the hole has been enlarged due to excessive tapping, another test site is selected.

PROCEDURE

The procedure using the direct transmission method is as follows:

1) Refer to information issued with each gauge for supplemental instructions on conducting direct transmission testing.
2) The more tests that are taken, the more accurate the results are

3) Follow the procedures in **AASHTO T 310**

INCONSISTENT READINGS

When using the nuclear gauge, occasionally a number is obtained that is outside the normal range of values. This may be caused by:

1) Poor seating of the gauge

2) Bad surface condition

3) A rock or other material just beneath the surface
4) Random radiation

5) Large objects near the gauge during the test

6) Low battery

If inconsistent or obviously erroneous readings are obtained, the reading is disregarded and additional tests taken nearby. Rotating the orientation of the gauge by 180° and testing within the same prepared hole for direct transmission testing is done. The test site is required to be inspected after the nuclear gauge testing. The material that was under the gauge test site is removed to check for large rocks or other contamination.

Visual inspection of embankment layers is required to be conducted along with all density tests to ensure that the embankment is capable of standing up to equipment and traffic loads while being constructed.

REGULAR MAINTENANCE

The nuclear gauge was designed for field use, but the gauge is required to be treated with care. Simple precautions and maintenance extends the time between repairs and maintains the gauges use for testing. After each use, the exterior of the gauge is wiped to remove dirt and dust which collects during field operation.

In the Direct Transmission Method, the source rod is depressed into the prepared hole in the compacted soil. To keep particles of dirt from being drawn into the gauge and jamming the source rod, the gauge contains a small wiper near the source rod opening. Unfortunately, the wiper is not as effective when the soil is wet, and the particles tend to adhere to the source rod. Under the current INDOT license, the source rod cannot be wiped. Therefore, the scraper ring is cleaned ONLY with the source rod in the SAFE position with a clean, dry rag or paper towel.

Gasoline, kerosene, or any other flammable material is not used. Lastly, the nuclear gauge or associated equipment is never repaired, lubricated, or modified in any way. If the source rod jams, the rod is not forced loose. Instead, the gauge is placed in a safe and secure location away from people and the District Radiation Safety Officer contacted.

PREVENTING GAUGE DAMAGE

The nuclear gauge is a fairly durable piece of testing equipment; however, there are some field situations that have the potential to damage the gauge. The following tips help keep the gauge in good working condition.

NUCLEAR GAUGES DO'S AND DON'TS

1) DO NOT - Charge the batteries until you get a low battery indication or until you get a series of inconsistentreadings.
2) DO NOT- Let your gauge get wet

3) DO NOT - LEAVE YOUR GAUGE UNATTENDED UNLESS THE GAUGE IS SECURED IN THE FIELD OFFICE, VEHICLE, ETC.

4) DO NOT - Interchange DSC charts from one gauge to another

5) DO NOT - Transport a nuclear gauge unless you have the gauge in the case, and you have the accompanying travel papers within arm's reach and properly secured in the vehicle.

6) DO NOT - Get paint on the gauge. This causes false readings. If you accidentally get paint on the gauge, you are required to clean all of the paint off before returning the gauge.

7) DO NOT - Transport the gauge without a TLD
8) Do - Charge batteries for a full 16 hours per charging procedure for the type of gauge you are using

9) Do - Clean the bottom of the gauge as needed (Only with the source rod in the safe position).

10) Do - Call District Testing and give them new field officelocation and phone number each time you move to another project

11) Do - Return the gauge within 5 working days after the gauge is no longer needed on your project.

12) Do - Return your old TLD upon receipt of your new TLD and within 5 days after the end of the quarter. Also, return your TLD when returning your gauge.

13) Do - Notify District Testing for any of the following:

a. Change of home address and/or phone number
b. Change of project and/or location
c. Termination of employment

14) Do - Call District Testing if you have a problem or an emergency. If you are not sure of something: CALL

15) Do - Try to pick up a gauge 2 to 3 weeks prior to the start of a project. This affords you ample time to familiarize yourself with the gauge. In any event, you are required to give 5 working days notice before you want to pick up a gauge

16) Do – Call District Testing IMMEDIATELY if the gauge is LOST, DAMAGED, OR STOLEN. For after-hours emergencies, contact your District Radiation Safety Officer IMMEDIATELY.

17) Do - Store the gauge with the padlock in place in the gauge handle (in the safe position)

18) Do - Keep the gauge key secure and separated from the gauge

19) Do - Store the locked gauge in a locked, secure field office and in a locked room within the field office.

FIELD USE OF THE NUCLEAR GAUGE

The nuclear gauges used in accordance with **AASHTO T 310** are used for the determination of in-place wet density of soil and aggregate. The Specification requirements for 95 % compaction of embankments or 100 % compaction of subgrades are the same whether the Technician uses a sand cone density test or a nuclear gauge density test. Proper selection of proctors are conducted the same as with other in-place density tests. Moisture tests are required to also be conducted using **ITM 506** for soil or **AASHTO T 255** for aggregates to calculate dry density from the wet density value recorded from the nuclear gauge.

The moisture content read by the nuclear gauge and the resultant dry density are recorded by the gauge. These two values are for information only and reviewing these values throughout the life of the contract gives the Technician an opportunity to compare gauge values with acceptance test values. Acceptance tests are required to always be conducted with wet density readings from the nuclear gauge and percent moisture by the appropriate test method for the type of material being tested.