

Application Brief
TROXLER MODEL 3440

Roadreader™
Nuclear Moisture Density Gauge

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Introduction

The Troxler Model 3440 Roadreader™ nuclear moisture/density gauge offers two test modes for measuring the density of soil, aggregate, concrete and asphalt materials. The direct transmission mode allows the source to be lowered below the surface in order to test a larger area of material and improve gauge precision. In backscatter mode the source is positioned near the surface of the test material and the top four inches of material are penetrated by gamma rays. Moisture content of the material is also tested in a manner similar to the backscatter mode. The Model 3440 provides many special functions and features in order to achieve the highest level of operator convenience. This gauge prompts the user through the steps of accessing and enabling all functions. This application brief will describe the operation, application and features of the Model 3440 Roadreader™ Surface Moisture / Density Gauge.

Measurement Technology

Surface nuclear gauges use the interaction of gamma radiation with matter to measure density through direct transmission or backscatter. In the direct transmission position the source rod extends through the base of the gauge into a predrilled hole up to 30 cm (12 in.) deep in the material being tested. The gamma rays are transmitted from the density source, through the test material and are counted by detectors located within the gauge. The average density between the source and detectors is then determined. The backscatter mode is a rapid and nondestructive means of testing materials that are approximately 10 cm (4 in.) in depth. The gamma source and the detectors remain inside the gauge, which rests on the surface of the test material. Gamma rays from the density source enter the test material. Those that are scattered back toward the detectors are counted, determining the density count for the material. This means of testing is usually used on asphalt and concrete. The photons counted is in direct relation to the density of the material; the higher the counts the lower the density, and the lower the counts the higher the density. Calibration constants, acquired in the factory during calibration on blocks of known density or moisture content, are used by the gauge to convert the counts obtained in the field test to a density or moisture measurement.

Moisture content is also measured in a nondestructive test mode. Moisture is determined through the detection of thermalized neutrons ("fast" neutrons which have been slowed by the hydrogen present in the material, normally in the form of water). As the moisture level of the test material increases, neutrons are thermalized at a greater rate so the moisture count increases.

Gauge Operation

The Troxler Model 3440 gauge can measure the moisture content, density and percent compaction of soils, soil-stone aggregates, concrete, asphalt treated bases, asphalt surfacing and other materials that are similar in density and / or moisture content. This gauge offers two modes of operation: soil and asphalt. The direct transmission and backscatter testing positions can be used with each mode.

Soil Mode is designed for measurements of soils, stone or other materials where both density and moisture content are desired. Direct transmission testing typically offers better precision and control of depth of measurement and is the preferred method. The Model 3440 gauge provides the Dry Density, Wet Density, Moisture, Percent Moisture and Percent Proctor when testing in the soil mode.

Surface preparation for soil testing is critical to gauge performance and test results. The scraper plate accessory provided can be used to prepare rough surfaces by moving it back and forth across the test area. Small voids, cracks, or holes can be filled with sand or native fines. This is most critical when testing in the backscatter position.

Asphalt Mode is used on full depth, greater than 100 mm (*4inch*) asphalt. Typically, the source rod is in the backscatter position, slightly above the asphalt, but direct transmission can be used if a hole can be drilled in the asphalt. The Model 3440 gauge provides the Wet Density, Percent Marshall and Percent Voidless values when testing in the asphalt mode.

When performing density tests on coarse asphalt surfaces, or on open graded mixes, the surface voids may be filled with soft sand, cement powder or native fines. However, the asphalt surface should remain bare so that the gauge base makes contact with the surface. It is also important that the gauge sit flat on the asphalt surface and does not “rock”.

Offsets

The Roadreader™ Model 3440 gives the user the ability to input offsets to gauge readings to correct for non-standard conditions. In soil mode, the user may apply a correction factor to adjust for the presence of chemically bound hydrogen or neutron absorbers that may affect the moisture count. For example, mica is a mineral that usually contains considerable molecular hydrogen and will cause the readings to indicate a higher moisture content than is actually present. In soil and asphalt mode a density correction factor may be used to correct for material composition or for material density outside of the calibration range. A trench offset may be used in either soil or asphalt mode when testing in a trench or near a large vertical object. Special Calibration is a function that allows the operator to temporarily “re-calibrate” the gauge for measuring materials that do not fall within the range of a normal calibration. These functions are simple to access from the gauge’s offset and special function menus, which walk the operator through the processes step by step.

Keypad

The Model 3440 gauge keypad is designed so the operator can easily access any of the gauge’s many options. The control panel consists of 22 keys with the numeric keys also representing a second function, accessed by pressing the shift key. The result is a keypad with 32 direct options available. Full access to gauge functions is provided while limiting the menus to be viewed or keys to be pressed. A “beep” verifies that the keystroke was received by the

gauge. Above the keypad is a four line by sixteen character Liquid Crystal Display screen allowing for descriptive menus.

Data Storage

The Model 3440 gauge can store up to 450 test readings for later recall or downloading to a printer or computer. Measurements are stored under specific project numbers and station numbers. In addition to the measurement information, project number and station number, the gauge is capable of storing additional numeric notes. The gauge can also prompt for the information commonly required on U. S. Federal Highway Administration (FHWA) projects when the *Special Rdwy* option is enabled on the *Special* function menu. These prompts are specific to Soil, Stone or Asphalt and include categories such as: FHWA number, lane direction, distance from centerline, lift number, test type, etc.

Batteries and Power Consumption

The Model 3440 gauge runs on a rechargeable NiCad battery. Under normal conditions a fully charged battery will remain operational for approximately 8 weeks. When the "BATTERY LOW" warning appears, there are a few hours remaining before the battery must be recharged. A full charge (16 hours) is recommended at that time, but a 30-minute recharge will provide several hours of use if necessary. Two adapters are included as standard accessories with this gauge: a 115 / 230 VAC (50 / 60 Hz) and a 12 VDC charger. Alkaline batteries (D size) can be used temporarily in the event that recharging is not an option. A separate battery case is supplied for this purpose.

Additional Features

A number of other features are offered by the Model 3440 gauge to provide ease of operation and to ensure that the gauge is performing properly. When in the automatic depth mode, the gauge automatically reads the depth strip on the index rod. The gauge determines the source depth; therefore the operator no longer is required to program in the depth of each test. This gauge also offers a calculator mode which, when enabled, allows the keypad to be used as a four function calculator. The "Auto Station" function will automatically increment the station number of each test by one after an initial station number is entered. The Model 3440 gauge can measure the density of thin layer asphalt or concrete provided the overlay thickness and the underlying material density is entered into the gauge. This feature, called the nomograph mode, is not as accurate as a true thin layer gauge but can produce satisfactory results under many conditions. The first 18 month limited warranty in the industry is offered with the Troxler Model 3440 Roadreader™ nuclear moisture/density gauge. In addition to those options listed here, many more are included on the Model 3440 to assist the operator in the everyday testing of soils and asphalt.

Correct gauge operation is promoted by a number of features. A STAT (statistical stability) test may be performed by the operator to validate the normal operation of the gauge. After a STAT test, a Drift test can check the long term drift of the gauge if a problem is suspected. Standard count comparison, validation and storage is also done by the Model 3440. The last 4 standard counts are stored in the gauge's memory and the average is compared to the new standard count to verify that it is within the specified limits. A precision option is offered in order to achieve a desired degree of precision under certain conditions. Special Calibration can be enabled to temporarily recalibrate the gauge constants for use in measuring particular materials that do not fall within the range of a normal calibration.

Summary

The Troxler Roadreader™ nuclear moisture / density gauge is used by many contractors, engineers, and highway departments for compaction control of soil, aggregate, concrete and full depth asphalt. The ASTM standard numbers D 6938, D 2950, and C 1040 are met or exceeded by this gauge. Two test modes are available for density determination: direct transmission and backscatter. The operator selects the mode depending on the material type and thickness of the layer being tested. The Model 3440 provides 30 special functions, storage of up to 450 test records, an 18 month warranty and many more options that make it simple to operate and a necessity for all technicians.

Measurement Precision

Model 3440 Nuclear Moisture/Density Gauge

<u>Direct Transmission</u> (6" / 150mm)	<u>15 sec.</u>	<u>1 min.</u>	<u>4 min.</u>
Precision at 125 pcf 2000kg/m ³	+/-0.42 +/-6.8	+/-0.21 +/-3.4	+/-0.11 pcf +/-1.7 kg/m ³
Composition error at 125pcf 2000kg/m ³	+/-1.25 +/-20	+/-1.25 +/-20	+/-1.25pcf +/-20kg/m ³
Surface error (0.05", 100% Void) pcf (1.25mm, 100%Void) kg/m ³	-1.1 -17	-1.1 -17	-1.1pcf -17kg/m ³
<u>Backscatter</u> (98%) (4" / 100mm)			
Precision at 125 pcf 2000kg/m ³	+/-1.00 +/-16	+/-0.50 +/-8	+/-0.25pcf +/-4kg/m ³
Composition error at 125 pcf 2000kg/m ³	+/-2.5 +/-40	+/-2.5 +/-40	+/-2.5pcf +/-40kg/m ³
Surface error (0.05", 100% Void) pcf (1.25mm, 100%Void) kg/m ³	-4.7 -75	-4.7 -75	-4.7pcf -75kg/m ³
<u>Moisture</u>			
Precision at 15 pcf 250kg/m ³	+/-0.64 +/-10.3	+/-0.32 +/-5.1	+/-0.16pcf +/-2.5kg/m ³
Surface error (0.05", 100% Void) pcf (1.25mm, 100%Void) kg/m ³	-1.12 -18	-1.12 -18	-1.12pcf -18kg/m ³
Depth of measurement at 15 pcf = 8.5 "			
250 kg/m ³ = 212.5 mm			