

Application Brief
TROXLER MODEL 3430 Plus / 3440 Plus
RoadReader™ Plus
Nuclear Moisture Density Gauge
September 2007

Introduction

The Troxler Model 3430+ / 3440+ nuclear moisture/density gauges are the updated version of the gauges which Troxler Electronic Laboratories, Inc. has offered their customers for many years. These gauges have been updated to offer more advanced electronics, updated software and improved features that users desire. These new devices were designed to be very similar to the current nuclear gauges that Troxler customers have become accustomed to, while offering many user-friendly features and some options which are brand new to the industry. Some of these new features include a larger display screen, data storage in both gauges, a backlit LCD screen and automatic measurement data storage. These two models appear very similar to each other, utilizing the same software, LCD screen and keypad, however the 3440 offers many customer requested features never before seen on a nuclear gauge. These brand new features include: a remote start keypad, USB data transfer to USB printer or removable (“thumb”) drive, backlit keypad, extra loud beeper and GPS capabilities (optional).

The RoadReader™ Plus gauges offer 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 3430+ / 3440+ provide many special functions and features in order to achieve the highest level of operator convenience. The gauges prompt the user through the steps of accessing and enabling all functions. This application brief will describe the operation, application and features of these gauges.

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 12 in. (30 cm) 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 4 in. (10 cm) 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 inverse 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 Models 3430+ and 3440+ gauges 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. These gauges offer 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 soil, sand, aggregate 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 Models 3430+ and 3440+ gauges provide 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 4 in. (10 cm) 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 Models 3430+ and 3440+ provide the Wet Density, Percent Marshall (Gmb), Percent Voidless (Gmm) and % Voids 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 Models 3430+ and 3440+ give 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 (moisture offset) 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 higher moisture content than is actually present. In soil and asphalt mode a density correction factor (density offset) 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 measuring in a trench or near a large vertical object. The Nomograph mode is also available to correct for the influence of underlying materials when measuring thin-layer asphalt layers (less than 3.5 in. / 8.9 cm). These functions are simple to access from the gauge's Offset and Mode menus, which walk the operator through the processes step by step.

Keypad

The Models 3430+ and 3440+ gauge keypad is designed so the operator can easily access any of the gauge's many options. The control panel consists of 30 keys with user friendly menus allowing almost all functions to be accessed with one or two keystrokes. 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 enlarged Liquid Crystal Diode screen allowing for descriptive menus and easy viewing from a standing position.

Data Storage

The Model 3430+ and 3440+ gauges can store up to 999 test readings for later recall or downloading to a printer or computer. The 3440+ offers the option of outputting stored data to a printer via the USB drive or to a removable ("thumb") drive for transfer of data to your computer. Measurements are stored under specific project numbers by pressing the STORE key after a measurement or by enabling the Auto Store option. The *Auto-Store* function, when enabled, automatically stores sample data upon completion of a measurement. The data is stored under the active project, using a sequential sample ID number.

In addition to the measurement information, project number and station number, the gauge is capable of storing additional notes. For each measurement, the gauge can store a location description of up to 12 characters, as well as a note of up to 15 characters. For an *Asphalt* mode measurement, the gauge can also store the location with respect to the centerline (left, right, or neither), and the distance from the centerline.

Batteries and Power Consumption

These gauges run on a rechargeable nickel metal hydride (NiMH) battery or AA Alkaline batteries. Under normal conditions a fully charged battery will remain operational for approximately 3 weeks for the 3430+ and 1 to 2 weeks for the 3440+ (of standard use). When the "BATTERY LOW" warning appears, there are approx. 2-3 hours remaining before the battery must be recharged. A full charge (approx. 2.5 hrs.) 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 are onboard permanently and can be used in the event that recharging is not an option. It is recommended that these alkaline batteries (5 AA batteries) are replaced annually.

Additional Features and Options

A number of other features are offered by the Model 3430+ / 3440+ gauges to provide ease of operation and to ensure that the gauge is performing properly. The Model 3430+ now offers data storage for later download, a full 30 key keypad and an enlarged 4 line by 20 character LCD (Liquid Crystal Diode) screen. An illuminated display screen is standard on both the Model 3430+ and 3440+ gauges. The 3440+ provides a convenient new illuminated keypad as a standard feature to facilitate operation for night paving from dusk to dawn.

The Model 3440+ offers the automatic depth mode using updated technology which proves to be very durable. The automatic depth mode automatically reads the depth that the source rod is lowered to when a measurement is performed. The gauge determines the source depth; therefore the operator is not required to program in the depth of each test. The Model 3440+ has a brand new feature that allows the operator to start a measurement from a small keypad on the top of the source rod near the handle. On this “remote” keypad there is a Start button and an ESC (Escape) button. This gauge also offers an extra loud beeper to indicate the completion of a measurement or standard count.

The optional Global Positioning System (GPS) can be included on the 3440+ gauge. Precise GPS coordinates are stored with each measurement record. The GPS receiver used in the Model 3440+ has Wide Area Augmentation System (WAAS) capabilities, which improves the location accuracy. To determine latitude and longitude, a GPS receiver must receive signals from at least three satellites. The receiver in this gauge is accurate to within 15 m (approx. 50 ft.) when receiving GPS data alone. The WAAS capabilities increase the accuracy to within 3 m (10 ft.). The measurement display and stored record denotes the quality of the location fix according the number of digits displayed, information is displayed to the nearest 1/100 of a second if WAAS is available and the nearest 1/10 of a second if it is not available.

The Model 3430+ and 3440+ gauges 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. An 18-month limited warranty is offered with the Model 3430+ and 3440+ nuclear moisture/density gauges. In addition to those options listed here, even more are included on the Model 3440+ to assist the operator in the everyday testing of soils and asphalt. The gauges will also have foreign language software options which are currently not available. Available language options are expected to be English, French and Spanish.

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 are also done by the Models 3430+ and 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 feature is offered in order to achieve a desired degree of precision under certain conditions. Several types of offset can be enabled to temporarily “recalibrate” the gauge for use in measuring particular materials that do not fall within the range of a normal calibration.

Summary

The new Troxler 3430+ and 3440+ nuclear moisture / density gauges are as reliable and even more user-friendly than the current models which are 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 (replaced ASTM D-2922 and ASTM D-3017 as of November 2006), D 2950, and C 1040 are met or exceeded by these gauges. With the Model 3430+ and 3440+ gauges, Troxler has added a number of new features to the proven technology of the company’s earlier products to provide unparalleled performance, flexibility, ease of use, and operator safety. In addition to the typical moisture and density measuring capabilities of the Troxler nuclear density gauges, these new models offer many new features and options that will make construction material testing enjoyable! These new gauges are truly representative of peak products in Troxler’s line of nuclear moisture / density gauges.

Measurement Precision

Model 3430+ / 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 | -1.06 -17 | -1.06 -17 | -1.06 pcf -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 | | | |