Nuclear Gauge Testing Manual

Edition 4, Amendment 2

September 2024

Copyright

© The State of Queensland (Department of Transport and Main Roads) 2024.

Licence

This work is licensed by the State of Queensland (Department of Transport and Main Roads) under a Creative Commons Attribution (CC BY) 4.0 International licence.

CC BY licence summary statement

In essence, you are free to copy, communicate and adapt this work, as long as you attribute the work to the State of Queensland (Department of Transport and Main Roads). To view a copy of this licence, visit: https://creativecommons.org/licenses/by/4.0/

Translating and interpreting assistance

The Queensland Government is committed to providing accessible services to Queenslanders from all cultural and linguistic backgrounds. If you have difficulty understanding this publication and need a translator, please call the Translating and Interpreting Service (TIS National) on 13 14 50 and ask them to telephone the Queensland Department of Transport and Main Roads on 13 74 68.

Disclaimer

While every care has been taken in preparing this publication, the State of Queensland accepts no responsibility for decisions or actions taken as a result of any data, information, statement or advice, expressed or implied, contained within. To the best of our knowledge, the content was correct at the time of publishing.

Feedback

Please send your feedback regarding this document to: tmr.techdocs@tmr.qld.gov.au

List of contents: Edition 4, Amendment 2

Introduction

1 Scope

The *Nuclear Gauge Testing Manual* (NGTM) is published to assist the Department of Transport and Main Roads in the construction and maintenance of the state road network.

The 4th Edition of the NGTM was published in 2023 and is available in electronic form only.

The NGTM is applicable to the use of both the nuclear surface moisture-density gauge and the nuclear thin-layer density gauge.

- Nuclear surface moisture-density gauges have been designed specifically to measure the density and/or moisture content of earthen materials (for example, soil or crushed rock) and asphalt. These earthen materials may be unbound or treated with stabilising agents such as cement, foamed bitumen or lime.
- Nuclear thin-layer density gauges have been designed specifically for the density measurement of thin layers of asphalt.

Within the NGTM, both gauge types, or combinations of these gauge types, are referred to as nuclear gauges.

The methods published in the NGTM are also referenced in the following departmental publication:

- *Materials Testing Manual*.

2 Content

The NGTM contains four parts as follows:

a) Part 1: *Introduction*

b) Part 2: *Calibration*

c) Part 3: *Test methods*, and

d) Part 4: *Operating instructions*.

3 Definitions

3.1 Standard definitions

The standard definitions listed in Table 3.1 shall apply to the *Nuclear Gauge Testing Manual*.

Table 3.1 – Standard definitions

Term	Definition
Plant-mixed stabilisation	Involves the stationary pug mill mixing of a stabilisation agent with an unbound granular material sourced from a quarry or reclaimed construction and demolition waste (usually concrete). The quality of unbound granular pavement material used in plant mixing must conform to an unbound pavement specification.
Sample	The material to be forwarded for examination and/or testing which is representative of a lot. A sample is either a single entity (a spot sample) or, more usually, a representative sample, and derived by combining sample increments of approximately equal quantities from a lot, and thoroughly mixing to provide a single uniform sample and then dividing the sample into a suitable quantity for examination and/or testing.

Term	Definition
Test location	The location, described in terms of longitudinal, lateral and, if required, vertical distance from where a single insitu test is performed.
Unbound materials	Quarry materials, natural gravels or recycled materials produced for base and sub-base pavement construction.

3.2 Definitions in other publications

Further relevant definitions are contained in the following Austroads publication and Transport and Main Roads Technical Specifications:

a) *Austroads Glossary of Terms*

b) MRTS01 *Introduction to Technical Specifications*

c) MRTS04 *General Earthworks*

d) MRTS05 *Unbound Pavements*

e) MRTS06 *Reinforced Soil Walls*

f) MRTS07A *Insitu Stabilised Subgrades using Quicklime or Hydrated Lime*

g) MRTS07B *Insitu Stabilised Pavements using Cement or Cementitious Blends*

h) MRTS07C *Insitu Stabilised Pavements using Foamed Bitumen*

i) MRTS08 *Plant-Mixed Heavily Bound (Cemented) Pavements*

j) MRTS09 *Plant-Mixed Foamed Bitumen Stabilised Pavements*

k) MRTS10 *Plant-Mixed Lightly Bound Pavements*

l) MRTS30 *Asphalt Pavements*, and

m) MRTS115 *Insitu Stabilised Subbases using Triple Blend.*

3.3 Standard abbreviations

The standard abbreviations listed in Table 3.3 shall apply to the NGTM.

Table 3.3 – Standard abbreviations

Abbreviation	Definition
BS	Backscatter
CPN	Campbell Pacific Nuclear

3.4 Abbreviations in other publications

Further relevant abbreviations are contained in the *Austroads Glossary of Terms*.

4 Referenced documents

4.1 Australian Standards

Table 4.1 lists the Australian Standards including Austroads Test Methods referenced in the NGTM.

Table 4.1 – Referenced Australian Standards

Reference	Title
AS 1289.1.4.2	*Methods of testing soils for engineering purposes, Method 1.4.2: Sampling and preparation of soils – Selection of sampling or test sites – Stratified random number method*
AS 1289.2.1.1	*Methods of testing soils for engineering purposes, Method 2.1.1: Soil moisture content tests – Determination of the moisture content of a soil – Oven-drying method (standard method)*
AS 1289.2.1.2	*Methods of testing soils for engineering purposes, Method 2.1.2: Soil moisture content tests – Determination of the moisture content of a soil – Sand bath method (subsidiary method)*
AS 1289.2.1.4	*Methods of testing soils for engineering purposes, Method 2.1.4: Soil moisture content tests – Determination of the moisture content of a soil – Microwave-oven-drying method (subsidiary method)*
AS 1289.2.1.5	*Methods of testing soils for engineering purposes, Method 2.1.5: Soil moisture content tests – Determination of the moisture content of a soil – Infrared lights method (subsidiary method)*
AS 1289.2.1.6	*Methods of testing soils for engineering purposes, Method 2.1.6: Soil moisture content tests – Determination of the moisture content of a soil – Hotplate drying method*
AS 1289.2.3.1	*Methods of testing soils for engineering purposes, Method 2.3.1: Soil moisture content tests – Establishment of correlation – Subsidiary method and the standard method*
AS 1289.5.8.4	*Methods of testing soils for engineering purposes, Method 5.8.4: Soil compaction and density tests – Nuclear surface moisture-density gauges – Calibration using standard blocks*
AS 2891.1.2	*Methods of sampling and testing asphalt, Method 1.2: Sampling – Coring method*
AS/NZS 2891.9.2	*Methods of sampling and testing asphalt, Method 9.2: Determination of bulk density of compacted asphalt – Presaturation method*
AS/NZS 2891.14.3	*Methods of sampling and testing asphalt, Method 14.3: Field density tests – Calibration of nuclear thin-layer density gauge using standard blocks*
AS/NZS 2891.14.4	*Methods of sampling and testing asphalt, Method 14.4: Field density tests – Calibration of nuclear surface moisture-density gauge – Backscatter mode*
VicRoads RC 900.07	*Calibration of nuclear thin-layer density gauge using standard blocks*

5 Principles of measurement

5.1 Nuclear gauge components

The essential components of a nuclear gauge comprise a source of gamma radiation for density measurement, a source of neutron radiation for moisture content measurement, detectors of gamma radiation and slow neutron radiation as appropriate, and electronics to convert the detected radiation into measures of density / moisture content.

5.2 Density measurement

Nuclear gauges use the emission and detection of gamma radiation for the measurement of the density of a material. Gamma radiation is a form of high-energy radiation which readily penetrates most materials. In the transmission of gamma rays between a source and detector, a proportion of these rays will be absorbed and scattered in accordance with the density of the material between the source and detector. As the density of this material increases, the number of gamma rays absorbed and scattered increases and the number reaching the detector decreases.

A relationship then exists between the detected gamma radiation and the density of the material. This relationship is commonly expressed in the following form:

$$DCR = Ae^{B\rho}$$

where DCR = density count ratio

ρ = density of the material

A, B, C = calibration constants for the nuclear gauge

The electronics of the gauges referenced in this manual use this exponential relationship to display density directly for a given value of count ratio.

An isotope of caesium (Cs - 137) is used as the source of gamma radiation in nuclear gauges for the measurement of density. The quantity of radioactive material used in the gamma source is usually either 0.296 or 0.37 GBq.

5.3 Moisture content measurement

Nuclear surface moisture-density gauges use the emission and detection of neutron radiation for the measurement of the moisture content of a material. Neutrons are emitted into a material and collisions occur between these neutrons and the nuclei of atoms within the material. These collisions will successively reduce the energy of these neutrons until they are slowed sufficiently to allow them to be detected by a 'slow neutron' detector.

The most effective collision by far in producing slow neutrons is that between a neutron and a nuclei of about the same mass (that is, hydrogen). The number of slow neutrons produced in a material is then proportional to the number of hydrogen atoms in the material. For most soil-type materials where hydrogen is present only in the form of water, the number of slow neutrons detected is directly proportional to the moisture content of the material.

A relationship can then be established between the detected slow neutron radiation and the moisture content of the material. This relationship is commonly expressed in the following form:

$$MCR = F(w) + E$$

where MCR = moisture count ratio

w = moisture content of the material

E, F = calibration constants for the nuclear gauge

The electronics of the gauges referenced in this manual use this equation to display moisture content directly for a given value of count ratio.

An isotope of americium (Am-241) in combination with beryllium (Be) is used as the source of neutrons for nuclear surface moisture-density gauges for the measurement of moisture content. The quantity of radioactive material used in the neutron source is usually either 1.48 or 1.85 GBq.

5.4 Density measurement modes

Nuclear surface moisture-density gauges are designed to use the emission and detection of gamma radiation for determining density in two measurement modes – direct transmission and backscatter.

The direct transmission method involves placing the source and detector on opposite sides of the material to be measured (that is, detector on the surface and source within the material). The gamma radiation emitted from the source then passes through the material to be measured before it is detected. This method is partially destructive in that it requires a hole to be formed in the material to locate the source; however, it does provide a measure of the average density of the material between the source and detector. Measurement positions are normally provided to 300 mm in increments of 25 mm.

The backscatter method commonly uses one measurement position (for example, BS in Troxler, Humboldt and Instrotek gauges) or two measurement positions (for example, BS and AC in CPN gauges). It involves placing the source and detector on the same side of the material to be measured (that is, on the surface). The gamma radiation emitted from the source is then scattered back towards the detector if it is to be detected. This method is performed rapidly and is truly non-destructive; however, it has restricted measurement depth and its measurements are biased toward the surface of the material with about 80 to 90 percent of its measurement coming from the top 50 mm of material for the BS measurement position. It does not provide a true measure of the average density of the material. The backscatter method is also very sensitive to surface roughness and is less precise than the direct transmission method.

Due to its sensitivity to surface roughness and inferior accuracy and precision, the backscatter method has been excluded from this manual as an option for the density measurement of soil-type materials; however, it has been retained as the preferred option for the density measurement of asphalt where problems associated with surface roughness and measurement depth are reduced, and where its rapid and non-destructive nature compensates for its inferior accuracy and precision.

The nuclear thin-layer density gauge uses two backscatter geometries to provide independent measures of material density. Mathematical computation of responses from the two geometries then allows a reduction in the influence from the underlying layer on density measurement. Use of this gauge is restricted to asphalt having a nominal maximum size not greater than 40 mm and a nominal layer thickness between 25 and 100 mm. This is the only nuclear gauge method allowed for the density measurement of compacted asphalt having a layer thickness between 25 and 50 mm.

For nuclear thin-layer density gauges, a relationship has been developed to combine numerically the independent measures of material density to calculate the overlay density. This relationship is commonly expressed in the following form:

$$\rho_T = \frac{K_2\rho_1 - K_1\rho_2}{K_2 - K_1}$$

where ρ_T = density of the overlay material

ρ_1 = system 1 density of the material

ρ_2 = system 2 density of the material

K_1, K_2 = values that quantify the influences of the density of the overlay material and of the underlying material on the density measured by the gauge.

The values of K_1, K_2 are calculated using the overlay thickness and depth factor calibration constants determined for each density system in the gauge.

5.5 Moisture measurement mode

The emission of neutron radiation and detection of 'slow neutron' radiation for the determination of moisture content is not designed for direct transmission measurement. It is conducted only in a backscatter mode with the source and detector positioned close together to provide a linear relationship between detected radiation and moisture content.

The effective measurement depth for moisture content varies according to the moisture content of the material and decreases with increasing moisture content. For a moisture content range of 0.1 to 0.3 t/m³, the measurement depth is about 250 to 200 mm respectively; however, detection of 'slow neutrons' relies on diffusion to the detector and, as such, moisture content measurements are biased towards the surface of the material. This bias will not affect the accuracy of moisture content measurement, provided that the water within the material is evenly distributed.

6 Calibration

6.1 Standard blocks calibration

Standard blocks calibration is a prerequisite for nuclear gauge measurement of both density and moisture content. It allows the conversion of nuclear gauge count data to measures of density and moisture content. Standard blocks calibration is described in Part 2 of this manual and is performed in accordance with the relevant Australian Standard and VicRoads Test Method as follows:

- Nuclear surface moisture-density gauge (direct transmission) AS 1289.5.8.4
- Nuclear thin-layer density gauge AS/NZS 2891.14.3 or RC 900.07
- Nuclear surface moisture-density gauge (backscatter) AS/NZS 2891.14.4.

The standard blocks calibration determined for a nuclear gauge will vary according to the particular type of standard blocks set chosen and the number, uniformity and composition of the standard blocks within the set. While standard blocks calibration methods allow the use of any one of two types of block sets, it places few conditions on the blocks selected for each set and makes no attempt to align the calibrations obtained from different block sets.

It is accepted that standard blocks calibration of nuclear gauges will not be undertaken by each user and will be restricted to those organisations and laboratories having the appropriate facilities; however, the user is required to arrange for standard blocks calibration and undertake calibration checks in accordance with the procedures and time frames specified in this manual.

6.2 Calibration adjustment – material bias

It is recognised that the density and moisture content results obtained from traditional tests (for example, sand replacement, core density) will differ from those results obtained from a nuclear gauge calibrated against standard blocks. The cause of this difference is due to a combination of factors relating to calibration (accuracy, precision), testing (test precision, commonality of tested material), material condition (surface roughness, density / moisture gradients, homogeneity) and material type (chemical composition). The contribution of each of these factors is not easily determined and will vary from job to job.

This difference (traditional test result – nuclear gauge test result) can be either positive or negative but tends to be positive for most materials (that is, nuclear gauge test tends to provide lower density results than those obtained using traditional tests). For many materials, this difference is small and can be ignored; however, for some materials, it is substantial, and adjustment of the standard blocks calibration may be necessary.

The approach adopted within this manual in relation to adjustment of the standard blocks calibration is as follows:

- For moisture content measurement of earthen materials, calibration adjustment is always made via a material bias for soil moisture content as determined from comparative nuclear gauge and oven-drying moisture content results.
- For wet density measurement of earthen materials, calibration adjustment is made via a material bias for soil wet density as determined from comparative nuclear gauge and sand replacement wet density result. For materials used in pavement layers and stabilised materials, calibration adjustment is always made.
- For density measurement of asphalt, calibration adjustment is always made via a material bias for asphalt density as determined from comparative nuclear gauge and core sample compacted density results.

The procedure adopted for calibration adjustment involves determining that value which, when applied to the nuclear gauge result, most closely approximates the traditional test result in the average case. The basic assumption behind this procedure is that the real difference between the nuclear gauge and traditional test results is constant over the property range and that a single adjustment only needs to be applied.

The calibration adjustment procedure also includes certain checks to ensure that the limited data used in adjustment of the standard blocks calibration is not erroneous as follows.

- The nuclear gauge test results are validated by plotting the count ratio and test data from the nuclear gauge to ensure all data points lie on the plot. For thin-layer gauges, the test results are validated by plotting the count ratio and test data for both density systems of the nuclear gauge to ensure all data points lie on the plot.
- The traditional test results used in determining the calibration adjustment are checked by determining their scatter around the adjusted standard blocks calibration in terms of an estimate of the standard error. Analysis of such data reveals that the standard error should not be greater than 0.055 t/m³ for soil wet density, 0.025 t/m³ for asphalt density and 0.020 t/m³ for soil moisture content.
- The calibration adjustment for a material type or condition is checked regularly by obtaining additional calibration data and using these data to upgrade and confirm the adjustment. Minimum requirements are included for the frequency of such checks.

7 Test Methods and operating instructions

Part 3 of this manual contains Test Methods for determining the insitu dry density of soil materials, the insitu density of asphalt and the associated material biases for soil moisture content, soil wet density and asphalt density. Part 4 of this manual contains operating instructions for taking a standard count, performing a statistical count, setting the test parameters and taking a measurement. The operating instructions relate to the makes and models of nuclear gauge listed in Table 2.

The Test Methods and operating instructions are based on specific information contained within the manufacturer's instruction manual for a gauge, together with best practice guidelines developed over four decades of nuclear gauge use within the Department of Transport and Main Roads. In general, standardised procedures have been developed for all nuclear gauge makes / models, particularly in the areas of gauge verification and stability analysis, count periods, gauge orientation and site preparation. Consequently, while there may be some procedural differences from the manufacturer's recommendation for some gauges, such differences will only enhance the accuracy and precision of the nuclear gauge results obtained.

For the testing of soils and crushed rock materials, results are obtained from two orientations of the nuclear gauge at each test site to determine site density and/or moisture content. The use of two orientations at 90º provides a larger testing area with little increase in overall testing time. It also allows a check to be performed on the results obtained from the nuclear gauge. Based on an analysis of data from these two orientations, the difference in dry density results between the two orientations at 90º should be no more than 0.075 t/m³. The use of two orientations then provides an improved estimate of the average density / moisture content of the site.

For the testing of asphalts, results are obtained from two orientations of the nuclear gauge at each test site to determine site density. The use of two orientations at 180º provides a larger testing area with little increase in overall testing time. It also allows a check to be performed on the results obtained from the nuclear gauge. Based on an analysis of data from these two orientations, the difference in density results between the two orientations at 180º should be no more than 0.075 t/m³. The use of two orientations then provides an improved estimate of the average density of the site.

Various procedures are suggested by nuclear gauge manufacturers to check the performance of nuclear gauges. Standard count checks, gauge function checks and density system consistency checks have been adopted for all gauge makes / models identified within this manual to assess gauge performance. Any variation in the acceptance limits used by the manufacturer and this manual are due to differences in the methods used for data analysis rather than differences in the required levels of performance.

8 Safety

This manual does not attempt to address all safety concerns, if any, associated with its use. It is the responsibility of the user of this manual to establish appropriate occupational health and safety practices that meet statutory regulations.

Nuclear gauges contain radioactive substances which continuously emit gamma and neutron radiation. Although the quantity of radioactive material is small, it is important that the use of nuclear gauges is in accordance with the user's approved Radiation Safety and Protection Plan.

9 Notes

Information contained in sections with the heading 'Notes on method' is for guidance in understanding or clarifying the associated requirement.

10 Approved gauges

The nuclear gauges approved for use on Queensland Department of Transport and Main Roads projects are shown in Table 10.

Table 10 – Approved gauges

Troxler	Campbell Pacific Nuclear	Humboldt	InstroTek
3440P	MC3 Elite	5001EZ-2	Xplorer2 3500
3430P	MC1 Elite	5001SD	Xplorer 3500
3440		5001EZ	
3430			
4640B			

Calibration

1 Nuclear gauge calibration

1.1 General

Prior to the use of a nuclear gauge for density and/or moisture content testing, calibration of the density and/or moisture systems of the nuclear gauge shall be performed in accordance with the relevant Australian Standard and VicRoads Test method as follows:

- Nuclear surface moisture-density gauge (direct transmission) — AS 1289.5.8.4
- Nuclear thin-layer density gauge — AS/NZS 2891.14.3 or RC 900.07
- Nuclear surface moisture-density gauge (backscatter) — AS/NZS 2891.14.4

Additional calibrations of the nuclear gauge shall be undertaken at least once every two years and following any major repair or component replacement.

1.2 Density system consistency check

Density system consistency checks shall be performed at least monthly to confirm the density calibration for each calibrated source rod position. Such checks are performed on a density standard block as described in the relevant Australian Standard or a secondary block of naturally-occurring stone.

A secondary block shall conform with the following:

- minimum dimensions of length 500 mm, width 290 mm and depth not less than 200 mm and at least 50 mm deeper than the greatest depth at which the check will be conducted
- placed in a fixed location, which is at least 1 m from any vertical projection and sufficiently clear of other nuclear gauges or radiation sources to have no effect on nuclear gauge density measurement of the block
- for backscatter measurement, the nuclear gauge base is fully confined within the top surface of the block and clear of any direct transmission access hole, and
- for direct transmission measurement, the block contains an access hole of diameter 30 mm maximum drilled normal to the top surface of the block. The access hole is located to ensure the nuclear gauge base is confined fully within the top surface of the block during both direct transmission and backscatter measurement.

Measurement positions are marked on the block for direct transmission and backscatter measurement (where required) to ensure that all measurements for a nuclear gauge will be made on the same position on the block.

1.2.1 Initial measurement

An initial density measurement of the standard density / secondary block for a nuclear gauge is made prior to its use in the field and within one month of its calibration being determined. The procedure shall be as follows:

a) Determine a standard count and perform a Standard Count Check in accordance with Clause 5.1 of Test Method N01, N04 or N06 as appropriate (refer to Part 3 of this manual).

b) Perform a Gauge Function Check – Statistical Performance in accordance with Clause 5.2 of Test Method N01, N04 or N06 as appropriate (refer to Part 3 of this manual).

c) Position the nuclear gauge within the appropriate marked position on the block.

d) Move the source rod to the calibrated position to be checked and take eight 1-minute density readings or equivalent combination, in accordance with the appropriate Operating Instruction detailed in Part 4 of the manual.

e) Record the mean density as the initial gauge density of the block for the calibrated position (ρ_i).

f) Repeat Steps (d) and (e) for each of the remaining calibrated source rod positions (note: for a nuclear thin-layer density gauge, the check is performed for test thicknesses of 25 (25.4) mm, 50 mm, 75 mm and 100 mm).

1.2.2 Subsequent measurement

For each calibrated source rod position, further density measurements of the block using the nuclear gauge are made prior to use in the field, at intervals not exceeding one month or if it is suspected that the gauge is malfunctioning. The procedure shall be as follows:

a) Determine a standard count and perform a Standard Count Check in accordance with Clause 5.1 of Test Method N01, N04 or N06 as appropriate (refer to Part 3 of this manual).

b) Perform a Gauge Function Check – Statistical Performance in accordance with Clause 5.2 of Test Method N01, N04 or N06 as appropriate (refer to Part 3 of this manual).

c) Position the nuclear gauge within the appropriate marked position on the block.

d) Move the source rod to the calibrated position to be checked and take at least four one-minute density readings, or equivalent combination, in accordance with the appropriate Operating Instruction detailed in Part 4 of this manual.

e) Record the mean density as the current gauge density of the block for the calibrated position (ρ_c).

f) Repeat Steps (d) and (e) for each of the remaining calibrated source rod positions (note: for a nuclear thin-layer density gauge, the check is performed for test thicknesses of 25 (25.4) mm, 50 mm, 75 mm and 100 mm).

1.2.3 Gauge acceptance

Accept the density calibration for a particular source rod position, provided that the difference between ρ_i and ρ_c is no greater than 0.020 t/m³ for direct transmission measurements and 0.050 t/m³ for backscatter measurements. Otherwise, withdraw the gauge from service for the calibrated position until the reason for the fault is determined and the fault rectified. Depending on the type of repair undertaken, the gauge may require recalibration.

1.2.4 Gauge relocation

If a gauge is relocated to an area remote from the standard density / secondary block, and a different block will be used for this check, the value(s) of ρ_i for this block this block shall be determined as follows:

a) During the 24-hour period prior to transporting the gauge, determine the final gauge density of the block (ρ_f) for each of the calibrated source rod positions in accordance with Steps (a) to (f) of Clause 1.2.1 (note: for a nuclear thin-layer density gauge, the check is performed for test thicknesses of 25 (25.4) mm, 50 mm, 75 mm and 100 mm).

b) Assess the gauge for acceptance in accordance with Step 1.2.3 using ρ_i and ρ_f.

c) Provided that this check allows acceptance of the density calibration for the gauge, perform an initial density measurement (ρ_{i2}) on the new block in accordance with Steps (a) to (f) of Clause 1.2.1, prior to its use in the field and within one month of its arrival at the new location (note: for a nuclear thin-layer density gauge, the check is performed for test thicknesses of 25 (25.4) mm, 50 mm, 75 mm and 100 mm). Adjust the initial density measurement on the new block for movement in the measurements on the initial standard density / secondary block. Calculate the adjusted initial density measurement $\rho_{i2a} = \rho_{i2} - \left|\rho_f - \rho_i\right|$for each of the calibrated source rod positions on the new block.

d) Perform subsequent density system consistency checks (ρ_{c2}) on the new block for each of the calibrated source rod positions in accordance with Steps (a) to (f) of Clause 1.2.2, prior to its use in the field and at intervals not exceeding one month or if it is suspected that the gauge is malfunctioning.

1.2.5 Relocated gauge acceptance

Accept the density calibration for a particular source rod position, provided that the difference between ρ_{i2a} and ρ_{c2} is no greater than 0.020 t/m³ for direct transmission measurements and 0.050 t/m³ for backscatter measurements. Otherwise, withdraw the gauge from service for the calibrated position until the reason for the fault is determined and the fault rectified. Depending on the type of repair undertaken, the gauge may require recalibration.

Test Method N01: Compacted density of soil – nuclear gauge

1 Source

This Test Method was developed in-house using techniques evolved through internal departmental research investigations and incorporates information provided by nuclear gauge manufacturers.

2 Scope

This Test Method sets out the procedure for the determination of the compacted density of soils and crushed rock materials using a nuclear surface moisture-density gauge in the direct transmission mode. Insitu dry density is determined from measured values of wet density and moisture content.

For wet density measurement, an adjustment is made to the wet density for all materials used in pavements (for example, unbound materials such as quarry materials or natural gravels, insitu stabilised materials or plant-mixed stabilised materials) and for all other stabilised materials. For nuclear gauge moisture content measurement, an adjustment is made to the moisture content as determined from comparative nuclear gauge and oven-drying moisture content results.

Where it is not practical to use a nuclear gauge to measure insitu moisture content, the standard oven-drying method, or a subsidiary method can be used. The use of a subsidiary method is conditional on a correlation established with the oven-drying method in accordance with Test Method AS 1289.2.3.1.

3 Apparatus

The following apparatus is required:

3.1 Nuclear gauge of an approved make and model as listed in Part 1, Section 6 of the *Nuclear Gauge Testing Manual*, logbook, manufacturer's handbook for the gauge and capable of the following:

a) direct transmission measurement in 25 mm increments from 50 mm to 300 mm

b) uncertainty of the predicted density at the depth used for the test not exceeding 0.06 t/m³, and

c) uncertainty of the predicted water content not exceeding 0.07 t/m³.

3.2 Reference block, as supplied by the manufacturer with the nuclear gauge, traceable to the nuclear gauge and used for the calibration of the gauge.

3.3 Drill, a rotary hammer drill or a drill rod and hammer capable of forming a hole at least 16 mm in diameter.

3.4 Guide plate, a flat metal template at least the same size as the base of the nuclear gauge, with a hole in one end for the drill rod.

3.5 Fines, dry fine sand or dry native fines passing a 0.600 mm test sieve.

3.6 Brush.

4 Calibration and biasing

Calibration and biasing shall be performed as follows:

4.1 Standard blocks calibration

Calibrate the nuclear gauge on standard blocks at least once every two years for both wet density measurement and moisture content measurement in accordance with Test Method AS 1289.5.8.4. For wet density measurement, obtain a separate calibration for each test depth. Recalibrate the nuclear gauge following any major repair or component replacement.

4.2 Material moisture bias

4.2.1 Where the insitu moisture content of a material is to be measured using a nuclear gauge, determine a moisture bias for the nuclear gauge and material source (and, if applicable, material type and subtype) in accordance with Test Method N02.

4.2.2 Re-determine this bias whenever any of the following apply:

a) when a standard blocks calibration of the nuclear gauge is performed

b) the nominal depth of the layer being tested changes by more than 50 mm

c) the mean insitu moisture content has changed by more than 2 per cent from the mean value at the time the moisture bias was determined, or

d) there is a change in the source rock or the source of any fine component.

4.2.3 In addition to the requirements of Step 4.2.2, check the moisture bias in accordance with Test Method N02 as follows:

a) following the compaction of not more than 10,000 tonnes of material or 14 days whichever produces the lesser number of checks, or

b) if the time between the determination or checking of the moisture bias and use is greater than 3 months.

4.3 Material wet density bias

4.3.1 Determine a wet density bias for the nuclear gauge, material source (and, if applicable, material type and subtype) and test depth in accordance with Test Method N03.

4.3.2 Re-determine this bias whenever any of the following apply:

a) following the calibration of the nuclear gauge, or

b) there is a change in the source rock or the source of any fine component.

4.3.3 In addition to the requirements of Step 4.3.2, check the wet density bias in accordance with Test Method N03 as follows:

a) following the compaction of not more than 10,000 tonnes of material or 14 days whichever produces the lesser number of checks, or

b) if the time between the determination or checking of the wet density bias and use is greater than 3 months.

5 Operational checks

To ensure that the nuclear gauge is operating normally, checks shall be undertaken routinely or following repair as follows:

5.1 Standard count check (frequency: each day of use)

5.1.1 Remove the nuclear gauge and reference block from the store and place the reference block on the designated test location. A location is to be selected which is at least 1 m from any large object and 10 m from any other nuclear gauge. Mark this location and use for all counts associated with operational checks.

5.1.2 Take a standard count in accordance with the appropriate standard count operating instruction in Part 4: *Operating Instructions: Operational Checks* of the *Nuclear Gauge Testing Manual* and ensure the following:

a) the nuclear gauge is correctly located on the reference block

b) the source rod handle is correctly located in the shielded position, and

c) density standard count and moisture standard count values are recorded.

Keep a record of each gauge to record operational check data (standard count and gauge function check) and the date of measurement (Note 11.1).

5.1.3 Calculate the mean of the previous four recorded and accepted density standard counts and the mean of the previous four recorded and accepted moisture standard counts.

5.1.4 Calculate the limits for density and moisture as follows and record:

$$L = \overline{SC} - 2\sqrt{\frac{\overline{SC}}{PS}}$$

$$U = \overline{SC} + 2\sqrt{\frac{\overline{SC}}{PS}}$$

where $\overline{\mathrm{SC}}$ = mean density standard count (DS) or mean moisture standard count (MS)

L = lower limit for density (L_ρ) or moisture (L_w)

U = upper limit for density (U_ρ) or moisture (U_w)

PS = nuclear gauge prescale factor (refer to Table 1)

5.1.5 If the recorded standard count values lie within the range L_ρ to U_ρ for density and L_w to U_w for moisture, the density or moisture standard count is accepted and the nuclear gauge may be used for testing.

5.1.6 If the recorded standard count value lies outside the range L_ρ to U_ρ for density or L_w to U_w for moisture, repeat Steps 5.1.2 to 5.1.5. If either standard count is again outside the appropriate range, remove the nuclear gauge from service and have it repaired by a licensed service agent (Note 11.2).

5.2 Gauge function check – statistical performance (frequency: monthly)

5.2.1 Remove the nuclear gauge and reference block from the store and place the reference block on the designated test location. A location is to be selected which is at least 1 m from any large object and 10 m from any nuclear gauge. Mark this location and use for all counts associated with operational checks.

5.2.2 Take at least 16 density and moisture counts in accordance with the appropriate statistical count operating instruction in Part 4: *Operating Instructions: Operational Checks* of the *Nuclear Gauge Testing Manual* and ensure the following:

a) the nuclear gauge is correctly located on the reference block

b) the source rod handle is correctly located in the shielded position, and

c) density and moisture count values are recorded.

Keep a record for each gauge to record operational check data (standard count and gauge function check) and the date of measurement.

5.2.3 Calculate the mean and standard deviation of the density counts and moisture counts.

5.2.4 Calculate the density ratio and moisture ratio using the following formula and record the values in the nuclear gauge logbook:

$$r = \frac{s}{\sqrt{\overline{C}}}$$

where r = density ratio (r_ρ) or moisture ratio (r_w)

s = standard deviation of the density or moisture counts

$\overline{C}$ = mean density count ($\overline{C}_\rho$) or mean moisture count ($\overline{C}_w$)

Where an accepted form of statistical analysis is performed by the microprocessor, it is not necessary to record individual count values. Only record the density and moisture ratio values and omit Steps 5.2.3 and 5.2.4.

5.2.5 If the density ratio and moisture ratio lie within the limits given in Table 2, the nuclear gauge is verified to be operating normally and may be used for testing.

5.2.6 If either the density ratio or the moisture ratio lies outside the relevant limits given in Table 2, repeat Steps 5.2.2 to 5.2.5. If either ratio is again outside the limits, remove the nuclear gauge from service and have it repaired by a licensed service agent.

5.3 Density system consistency check (frequency: monthly)

Perform a density system consistency check in accordance with Part 2 Clause 1.2 of the *Nuclear Gauge Testing Manual*.

6 Configuration

On each day of use, configure the nuclear gauge before testing any material by undertaking a standard count and setting or checking test parameters for the material (and, if applicable, material type and subtype) as follows:

6.1 Standard count

6.1.1 Remove the nuclear gauge and reference block from the transport case and place the reference block on the surface of the material (and, if applicable, material type and subtype) under test. When using the nuclear gauge within 1 m of a large object or in a trench, take a separate standard count at each test site.

6.1.2 Take a standard count in accordance with the appropriate standard count operating instruction in Part 4: *Operating Instructions: Operational Checks* of the *Nuclear Gauge Testing Manual* and ensure the following:

a) the nuclear gauge is correctly located on the reference block

b) the source rod handle is correctly located in the shielded position, and

c) density and moisture standard count values are recorded with the test data and, where the functionality exists, stored in the nuclear gauge microprocessor.

6.2 Test parameters

Check or set user definable test parameters in accordance with the appropriate test parameters operating instruction in Part 4: *Operating Instructions: Testing – Soils* of the *Nuclear Gauge Testing Manual* (Note 11.3).

7 Test site selection and preparation

Determination of test locations and preparation of each test site shall be as follows:

7.1 Use random stratified sampling to determine sampling and test locations in accordance with the requirements of the specification, sampling plan or testing methodology as appropriate.

7.2 At a designated test location, use the guide plate to define a test site that is flat and free from depressions. The test site is formed by two overlapping rectangles at right angles to each other, with each rectangle being at least the size of the guide plate and the hole being common within the overlapping area as shown in Figure 1. The guide plate may be used to trim the surface of some materials, provided the surface is not de-densified by such action.

7.3 Sweep all loose material from the test site and sprinkle fine sand or native fines on the surface. Move the guide plate over the surface until the voids are just filled, ensuring that the sand or fines does not form an added layer.

7.4 Place the guide plate on the test site and drill a hole at least 50 mm beyond the specified measurement depth (Note 11.4). Where the measurement depth is not stipulated in the appropriate specification, select a depth in keeping with the following criteria:

a) the measurement depth for unbound pavement layers is 15 mm to 39 mm less than the nominal layer thickness where alternative vertical tolerance A is specified, up to the maximum direct transmission measurement depth of 300 mm (Note 11.5)

b) the measurement depth for unbound pavement layers is 25 mm to 49 mm less than the nominal layer thickness, where alternative vertical tolerance B is specified, up to the maximum direct transmission measurement depth of 300 mm (Note 11.5)

c) the measurement depth for plant-mixed stabilised layers is 15 mm to 39 mm less than the nominal depth of the layer up to the maximum direct transmission measurement depth of 300 mm, or

d) the measurement depth for insitu stabilised layers (subgrade or pavement) is 5 mm to 29 mm less than the nominal depth of the layer up to the maximum direct transmission measurement depth of 300 mm.

7.5 Remove the guide plate and repair the prepared test site using some additional sand or fines if required.

7.6 Use the guide plate to mark the test site to allow the placement of the nuclear gauge over the test site and to align the source rod to the hole (Note 11.6).

8 Testing

Testing shall be performed as follows:

8.1 Place the nuclear gauge on the marked test site, lower the source rod into the formed hole and move the source rod to the required measurement depth.

8.2 Ease the source rod against the hole wall by moving the nuclear gauge in the direction of the source rod handle.

8.3 Confirm the firm seating of the nuclear gauge on the test site by rotating the nuclear gauge several degrees left or right if required. Maintain contact between the source rod and the formed hole. If unable to obtain firm seating of the nuclear gauge, prepare a new test site immediately adjacent to the original site.

8.4 Take a 1-minute count in accordance with the appropriate measurement operating instruction in Part 4: *Operating Instructions: Testing – Soils* of the *Nuclear Gauge Testing Manual*. Record relevant density and moisture test data while meeting the requirements of Table 3.

8.5 Rotate the nuclear gauge through 90º ensuring that the test site is not disturbed. Repeat Steps 8.2 to 8.4 and then move the source rod to the shielded position (Note 11.6).

8.6 Compare the dry density values from the two orientations. If the difference exceeds 0.075 t/m³, examine and further prepare the test site as necessary and repeat Steps 8.1 to 8.5.

8.7 If the dry density difference again exceeds 0.075 t/m³, abandon the test site and select a new site immediately adjacent.

8.8 Where the insitu moisture content is to be measured using the standard oven-drying method or a subsidiary method:

a) obtain a moisture content sample in accordance with Test Method Q061, and

b) determine the oven-dry moisture content of the sample obtained in accordance with Test Method AS 1289.2.1.1 or one of the subsidiary Test Methods AS 1289.2.1.2, AS 1289.2.1.4, AS 1289.2.1.5 or AS 1289.2.1.6 for which a relationship with Test Method AS 1289.2.1.1 has been established in accordance with Test Method AS 1289.2.3.1.

9 Calculations

Calculations shall be as follows:

9.1 Nuclear gauge density and moisture measurement

9.1.1 Determine the mean nuclear gauge dry density for the test site by averaging the dry density values obtained at the 0º and 90º orientations.

9.1.2 Where any relevant biases have not been applied via the nuclear gauge microprocessor, adjust the mean nuclear gauge dry density calculated in Step 9.1.1 by applying these biases to calculate the compacted dry density as follows:

$$\rho_d = \overline{\rho}_{Gd} + B_\rho - B_w$$

where ρ_d = compacted dry density (t/m³)

$\overline{\rho}_{Gd}$ = mean nuclear gauge dry density (t/m³)

B_ρ = wet density bias (t/m³)

B_w = moisture bias (t/m³)

9.1.3 Determine the mean nuclear gauge water content for the test site by averaging the measured water content values obtained at the 0º and 90º orientations.

9.1.4 Where a moisture bias has not been applied via the nuclear gauge microprocessor, adjust the mean water content calculated in Step 9.1.3 by applying this bias to calculate the insitu moisture content as follows:

$$w = \frac{(\overline{W}_G + B_w)100}{\rho_d}$$

where w = insitu moisture content (%)

$\overline{W}_G$ = mean nuclear gauge water content (t/m³)

B_w = moisture bias (t/m³)

ρ_d = compacted dry density (t/m³)

9.2 Nuclear gauge density and standard oven drying or subsidiary moisture measurement

9.2.1 Determine the mean nuclear gauge wet density for the test site by averaging the wet density values obtained at the 0º and 90º orientations.

9.2.2 Where any relevant biases have not been applied via the nuclear gauge microprocessor, adjust the mean nuclear gauge wet density calculated in Step 9.2.1 by applying these biases to calculate the compacted wet density as follows:

$$\rho = \rho_G + B_\rho$$

where ρ = compacted wet density (t/m³)

ρ_G = mean nuclear gauge wet density (t/m³)

B_ρ = wet density bias (t/m³)

9.2.3 Determine the insitu water content for the test site as follows:

$$W = \frac{\rho w}{100 + w}$$

where W = insitu water content (t/m³)

ρ = compacted wet density (t/m³)

w = insitu oven dry or subsidiary moisture content (%)

9.2.4 Determine the compacted dry density for the test site as follows:

$$\rho_d = \rho - W$$

where ρ_d = compacted dry density (t/m³)

ρ = compacted wet density (t/m³)

W = insitu water content (t/m³)

10 Reporting

The following shall be reported:

a) compacted dry density or compacted wet density to the nearest 0.01 t/m³

b) insitu moisture content to the nearest 0.1% and the test method used

c) date tested, depth tested, lot number, test site number, and chainage and offset

d) source and description of the material together with the layer type and nominal depth of layer

e) a statement including the wet density bias, to the nearest 0.01 t/m³, and identification of the bias report as follows: 'An adjustment of x.xx t/m³, obtained from Report Number <report no>, has been made.'

f) a statement including the moisture bias, to the nearest 0.01 t/m³, and identification of the bias report as follows: 'An adjustment of x.xx t/m³, obtained from Report Number <report no>, has been made.', and

g) the number of this Test Method, that is N01.

11 Notes on method

11.1 Where there are no previous four standard counts taken within the previous five weeks of the current date or when moving the nuclear gauge to a new operating location and there is a new designated test location, it may be necessary to take four new standard counts in accordance with Steps 5.1.1 to 5.1.2.

11.2 It is expected that a standard count value will lie outside the range Lρ to Uρ about once in every 20 standard count checks. To have consecutive values outside this range is expected only once in 400 standard count checks. However, as the return of the gauge for checking and possible repair can be expensive and disruptive, it is acceptable to perform a gauge function check in accordance with sub-section 5.2. If verified that the gauge is not operating normally, remove the nuclear gauge from service and have it repaired by a licensed service agent.

11.3 The scope of user definable test parameters is dependent on the make and model of nuclear gauge. Such parameters include:

a) counting time, units and measurement mode

b) maximum dry density

c) density bias, and

d) moisture bias.

11.4 Where the underlying layer consists of the same material type and subtype as that in the layer under test, select the measurement depth that is closest to the nominal layer thickness. Under these conditions, it is acceptable for the source rod to penetrate into the underlying layer.

11.5 The vertical tolerances are found in MRTS05 *Unbound Pavements* Clause 8.4.4.3 and Annexure MRTS05.1 *Unbound Pavements* Clause 3.2.1.

11.6 To improve operator safety, it is recommended that the source rod containing radioactive materials not be extended out of its shielded (SAFE) position prior to placing it into the formed hole. Where possible, align the gauge to allow the placing of the source rod directly into the formed hole from the shielded position. The source rod should be returned to its shielded (SAFE) position at the completion of measurements.

Table 1 – Nuclear gauge prescale factors

Nuclear gauge make / model	Prescale factor
CPN / Elite series	8
Troxler / except Model 3450	16
Humboldt / All	16
InstroTek / Xplorer series	16

Table 2 – Gauge function check – density and moisture ratio limits

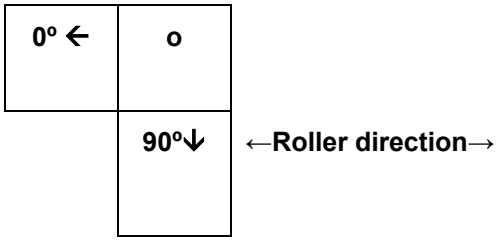
Nuclear gauge make/model	Lower limit	Upper limit
CPN / Elite series	0.25	0.45
Troxler / except Model 3450	0.17	0.33
Humboldt / All	0.60	1.40
InstroTek / Xplorer series	0.18	0.35

Table 3 – Minimum test data

Measurement	Routine test		Material bias or bias check	
	Nuclear gauge density and moisture	**Nuclear gauge density and oven dry/ subsidiary moisture**	**Density**	**Moisture**
density standard count	✓	✓	✓	
moisture standard count	✓			✓
wet density (t/m³)		✓	✓	✓
dry density (t/m³)	✓	✓*	✓*	✓*
water content (t/m³)	✓#			✓
moisture content (%)	✓			
density count	✓	✓	✓	
moisture count	✓			✓
relative compaction	✓^			

* These values are only recorded as a means of monitoring the validity of the test results (refer to Step 8.6).
# This value is only recorded when the moisture bias is not applied by the microprocessor.
^ This value is only valid when all relevant biases have been applied by the microprocessor.

Figure 1 – Test site



Test Method N02: Soil moisture bias

1 Source

This Test Method was developed in-house using techniques evolved through internal departmental research investigations and incorporates information provided by nuclear gauge manufacturers.

2 Scope

This Test Method sets out the procedure for the determination of the moisture bias associated with the measurement of insitu moisture content of soils and crushed rock materials using a nuclear gauge. The moisture bias represents the average moisture content difference between the nuclear gauge and oven-drying tests for a particular nuclear gauge and material. Differences in the moisture content values obtained by the nuclear gauge and oven-drying tests are due to differences in the material sampled by both tests, the effect of moisture gradients, the presence of any bound water on nuclear gauge results and any moisture losses from the sample prior to oven-drying.

Included in the method is a procedure for monitoring the applicability of an existing moisture bias and for providing ongoing adjustment of the bias to reflect subtle changes in material composition.

This method makes no provision for concurrent determination of wet density bias and, where both moisture content bias and wet density bias are required, reference Test Method N03.

3 Procedure

The procedure shall be as follows:

3.1 Select at least six test sites within the lot under consideration using random stratified sampling to determine sampling and test locations in accordance with the requirements of the specification, sampling plan or testing methodology as appropriate (Note 7.1). Number each test site and any bias check test site consecutively in chronological order.

3.2 At each test site, undertake the following:

3.2.1 Measure the nuclear gauge moisture content, water content, dry density and wet density in accordance with Test Method N01, except that no moisture bias and wet density bias are applied. Record the relevant density and moisture test data while meeting the requirements of Test Method N01 Table 3 for both the 0º and 90º orientations.

3.2.2 Obtain a moisture content sample in accordance with Test Method Q061 from the location shown in Figure 1.

3.2.3 Determine the oven-dry moisture content of the sample obtained in accordance with Test Method AS 1289.2.1.1. For stabilised materials, return moisture content samples to a laboratory and place in drying ovens within the same work shift as the moisture content sampling is undertaken.

4 Calculations

Calculations shall be as follows:

4.1 Field test data

4.1.1 Determine the mean moisture count, mean nuclear gauge moisture content, mean nuclear gauge water content and mean nuclear gauge wet density for each site by averaging the corresponding measurements for the 0º and 90º orientations.

4.1.2 Calculate the oven-dry water content for each site as follows:

$$W_{ov} = \frac{\rho_G w_{ov}}{100 + w_{ov}}$$

where W_{ov} = oven-dry water content (t/m³)

ρ_G = mean nuclear gauge wet density (t/m³)

w_{ov} = oven-dry moisture content (%)

4.2 Data validation

4.2.1 Calculate the moisture count ratio for each site to four significant figures as follows:

$$CR_w = \frac{C_w}{SC_w}$$

where CR_w = moisture count ratio

C_w = mean moisture count

SC_w = moisture standard count

4.2.2 Plot the mean nuclear gauge moisture content against the corresponding moisture count ratio using the data from all test sites (Note 7.2).

4.2.3 If any data pair does not lie on the linear plot, reject the nuclear gauge and oven-dry moisture data for this test site. Rejected data pairs cannot be used in the current bias determination or any future bias checks.

4.3 Data acceptance

Perform data acceptance with the remaining data as follows:

4.3.1 Calculate the mean nuclear gauge water content and mean oven-dry water content for all remaining test sites.

4.3.2 Calculate the moisture standard error as follows:

$$SE_W = \sqrt{\frac{\sum\left(W_{ov} - W_G - \overline{W}_{ov} + \overline{W}_G\right)^2}{n-2}}$$

where SE_W = moisture standard error (t/m³)

W_{ov} = oven-dry water content at each test site (t/m³)

W_G = nuclear gauge water content at each test site (t/m³)

$\overline{W}_{ov}$ = mean oven-dry water content for all test sites (t/m³)

$\overline{W}_G$ = mean nuclear gauge water content for all test sites (t/m³)

n = number of test sites

4.3.3 If the moisture standard error does not exceed 0.020 t/m³, accept the data and calculate the moisture bias in accordance with Subsection 4.4.

4.3.4 If the moisture standard error exceeds 0.020 t/m³, perform the following:

a) For each moisture data pair (oven-dry and nuclear gauge), calculate the moisture error as follows:

$$E_W = \left|(W_{ov} - W_G) - \left(\overline{W}_{ov} - \overline{W}_G\right)\right|$$

where E_W = moisture error (t/m³)

W_{ov} = oven-dry water content at each test site (t/m³)

W_G = nuclear gauge water content at each test site (t/m³)

$\overline{W}_{ov}$ = mean oven-dry water content for all test sites (t/m³)

$\overline{W}_G$ = mean nuclear gauge water content for all test sites (t/m³)

b) Remove the moisture content data pair (oven-dry and nuclear gauge), with the largest moisture error from the analysis.

c) Re-analyse the data by repeating Steps 4.3.1 to 4.3.4, except that:

i. if data from three or more test sites are eliminated, reject all test data and repeat the complete procedure

ii. if there are acceptable data from fewer than six test sites, reject all test data and repeat the complete procedure

iii. if all test data are again rejected, it is not appropriate to calculate a single wet density bias for the material, and

iv. Any data pairs removed from the analysis cannot be used in the current bias determination or any future bias checks.

4.4 Determination of moisture bias

Moisture bias may be calculated directly in t/m³ or expressed as a K value. There are options for determining the K value, depending on the functionality of the nuclear gauge. The K value can be either calculated external to the nuclear gauge and stored in the microprocessor or calculated internally by the microprocessor using input values of mean oven-dry moisture content and mean nuclear gauge moisture content (Notes 7.3, 7.4 and 7.5).

4.4.1 Moisture bias (t/m³)

Calculate the moisture bias using accepted data as follows:

$$B_w = \overline{W}_{ov} - \overline{W}_G$$

where B_w = moisture bias (t/m³)

$\overline{W}_{ov}$ = mean oven-dry water content for all accepted test sites (t/m³)

$\overline{W}_G$ = mean nuclear gauge water content for all accepted test sites (t/m³)

4.4.2 Moisture bias (K value)

a) External calculation

Calculate the moisture bias using accepted data as a K value and record to the nearest 0.01 as follows:

$$K = \frac{\overline{W}_{ov} - \overline{W}_{G}}{\overline{\rho}_{G} - \overline{W}_{ov}}$$

where K = K value

$\overline{W}_{ov}$ = mean oven-dry water content for all accepted test sites (t/m³)

$\overline{W}_{G}$ = mean nuclear gauge water content for all accepted test sites (t/m³)

$\overline{\rho}_{G}$ = mean nuclear gauge wet density for all accepted test sites (t/m³)

b) Internal calculation

i) Calculate the mean oven-dry moisture content as follows:

$$\overline{w}_{ov} = \frac{100\,\overline{W}_{ov}}{\overline{\rho}_{G} - \overline{W}_{G}}$$

where $\overline{w}_{ov}$ = mean oven-dry moisture content for all accepted test sites (%)

$\overline{W}_{ov}$ = mean oven-dry water content for all accepted test sites (t/m³)

$\overline{W}_{G}$ = mean nuclear gauge water content for all accepted test sites (t/m³)

$\overline{\rho}_{G}$ = mean nuclear gauge wet density for all accepted test sites (t/m³)

ii) Calculate the mean nuclear gauge moisture content as follows:

$$\overline{W}_{G} = \frac{100\,\overline{W}_{G}}{\overline{\rho}_{G} - \overline{W}_{G}}$$

where $\overline{w}_{G}$ = mean nuclear gauge moisture content for all accepted test sites (%)

$\overline{W}_{G}$ = mean nuclear gauge moisture content for all accepted test sites (t/m³)

$\overline{\rho}_{G}$ = mean nuclear gauge wet density for all accepted test sites (t/m³)

4.4.3 Calculate the minimum oven-dry moisture content (%) and maximum oven-dry moisture content (%) for all accepted test sites.

5 Bias check

Bias checks shall be performed as follows:

5.1 Monitor the moisture bias by performing three additional nuclear gauge moisture and oven-dry moisture content tests following the compaction of not more than 10,000 tonnes of material and perform testing in accordance with Section 3.

5.2 Determine and validate the nuclear gauge moisture count and nuclear gauge moisture content data in accordance with Steps 4.1 to 4.2.3.

5.3 Add the new moisture data pairs (nuclear gauge and oven-dry) to the previously accepted data while removing three existing and consecutive moisture data pairs commencing at the lowest test site number. When there are only six existing data points, remove only two so that seven data points are available for analysis.

5.4 Analyse the revised moisture data for acceptance in accordance with Subsection 4.3, except that no more than one of the new moisture data points may be eliminated.

5.5 Calculate an amended moisture bias for the accepted data in accordance with Subsection 4.4.

6 Reporting

The following shall be reported:

a) moisture bias as follows:

   i. to the nearest 0.01 t/m³

   ii. a K value to the nearest 0.01 units, and

   iii. K value inputs: that is, mean oven-dry moisture content to the nearest 0.1% and mean nuclear gauge moisture content to the nearest 0.1%.

b) the minimum oven-dry moisture content, mean oven-dry moisture content and maximum oven-dry moisture content to the nearest 0.1%

c) source and description of the material, together with the layer type and layer depth

d) nuclear gauge make, model and serial number

e) a tabulation containing the nuclear gauge and oven-dry moisture data used to determine the bias (including any eliminated data), together with the date tested, depth tested, lot number, test site number, chainage and offset

f) the date the bias was reported and, in the case of an amended moisture bias, the report number and date for the previous report, and

g) the number of this Test Method, that is N02.

7 Notes on method

7.1 To determine a moisture bias that is representative of the lot, distribute sampling locations throughout the lot.

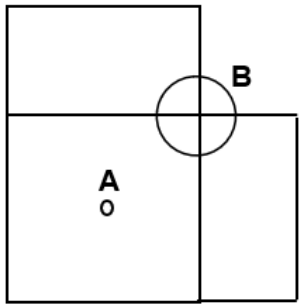
7.2 The relationship between nuclear gauge moisture content and moisture count ratio is linear over the expected moisture content range within a lot.

7.3 The method calculates and reports moisture bias in different formats. The user will choose the form that is suitable for the nuclear gauge make / model and the method operation; for example, the make and model will determine if the K value is entered directly into the nuclear gauge for biased use. Alternatively, the method of operation will determine if the gauge is used biased onsite, or unbiased with bias applied through the calculation and reporting process.

7.4 External calculation of K for direct entry into a nuclear gauge is required for CPN Elite MC-1, CPN Elite MC-3, Humbolt 5001EZ, Humbolt 5001EZ-2, Humbolt 5001SD, InstroTek Xplorer 3500, InstroTek Xplorer 2 3500, Troxler 3430 and Troxler 3430P gauges.

7.5 Internal calculation of K requiring entry of values for mean oven-dry moisture content and mean nuclear gauge moisture content is required for Troxler 3440 and Troxler 3440P gauges.

Figure 1 – Test site and moisture content sampling location



A: probe access hole location (small circle)

B: oven dry moisture content sampling location (large circle)

Test Method N03: Soil wet density bias

1 Source

This Test Method was developed in-house using techniques evolved through internal departmental research investigations and incorporates information provided by nuclear gauge manufacturers.

2 Scope

This Test Method sets out the procedure for the determination of the wet density bias associated with the measurement of compacted density of soils and crushed rock materials using a nuclear gauge. The wet density bias represents the average wet density difference between the nuclear gauge and sand replacement tests for a particular nuclear gauge, material and test depth. Differences in the wet density values obtained by the nuclear gauge and sand replacement tests are due to differences in the material sampled by both tests, the effect of chemical composition and test site characteristics (for example, density and moisture gradients, surface condition, particle size, homogeneity) on nuclear gauge results and inadequacies in the sand replacement test for some materials.

Included in the method is a procedure for monitoring the applicability of an existing wet density bias and for providing ongoing adjustment of the bias to reflect subtle changes in material composition.

This method also caters for concurrent determination of a moisture bias in accordance with Test Method N02.

3 Procedure

The procedure shall be as follows:

3.1 Select at least six test sites within the lot under consideration random stratified sampling to determine sampling and test locations in accordance with the requirements of the specification, sampling plan or testing methodology as appropriate (Note 7.1). For stabilised materials, complete work to determine the wet density to a stage where the wet density has been determined within 24 hours after the end of the work shift where stabilisation works were completed for the corresponding lot. Number each test site and any bias check test site consecutively in chronological order.

3.2 At each test site, undertake the following:

3.2.1 Measure the nuclear gauge wet density in accordance with Test Method N01, ensuring that no wet density bias is applied. Record the relevant density and moisture test data while meeting the requirements of Test Method N01 Table 3 for both the 0º and 90º orientations.

3.2.2 Where a moisture content bias is required in conjunction with a wet density bias, obtain and record moisture counts and nuclear gauge moisture content values in accordance with Test Method N02.

3.2.3 Select a position for a sand replacement test at either position D for a 150 mm diameter hole or position E for a 200 mm diameter hole as shown in Figure 1.

3.2.4 Remove any fine sand or fines from the nuclear gauge test position as selected in Step 3.2.2. Undertake a sand replacement test in accordance with Test Method Q141B and determine the wet density and oven-dry moisture content. Excavate, while avoiding the probe access hole and any associated surface cracking, to the full depth of the layer.

3.2.5 For stabilised materials, return moisture content samples to a laboratory and place in drying ovens within the same work shift as the moisture content sampling is undertaken.

4 Calculations

Calculations shall be as follows:

4.1 Field test data

Determine the mean density count and mean nuclear gauge wet density for each site by averaging the corresponding measurements for the 0º and 90º orientations.

4.2 Data validation

4.2.1 Calculate the density count ratio for each site to four significant figures as follows:

$$CR_\rho = \frac{C_\rho}{SC_\rho}$$

where CR_ρ = density count ratio

C_ρ = mean density count

SC_ρ = density standard count

4.2.2 Plot the nuclear gauge wet density against the corresponding density count ratio using the data from all test sites (Note 7.2).

4.2.3 If any data point does not lie on the linear plot, reject the nuclear gauge and sand replacement wet density data for this test site. Rejected data pairs cannot be used in the current bias determination or any future bias checks.

4.3 Data acceptance

Perform data acceptance with the remaining data as follows:

4.3.1 Calculate the mean nuclear gauge wet density and mean sand replacement wet density for all remaining test sites.

4.3.2 Calculate the wet density standard error as follows:

$$SE_\rho = \sqrt{\frac{\sum\left(\rho_S - \rho_G - \overline{\rho}_S + \overline{\rho}_G\right)^2}{n-2}}$$

where SE_ρ = wet density standard error (t/m³)

ρ_S = sand replacement wet density at each test site (t/m³)

ρ_G = nuclear gauge wet density at each test site (t/m³)

$\overline{\rho}_S$ = mean sand replacement wet density for all test sites (t/m³)

$\overline{\rho}_G$ = mean nuclear gauge wet density for all test sites (t/m³)

n = number of test sites

4.3.3 If the wet density standard error does not exceed 0.055 t/m³, accept the data and calculate the wet density bias in accordance with Subsection 4.4.

4.3.4 If the wet density standard error exceeds 0.055 t/m³, perform the following:

a) For each density data pair (sand replacement and nuclear gauge), calculate the wet density error as follows:

$$E_\rho = \left|\left(\rho_S - \rho_G\right) - \left(\overline{\rho}_S - \overline{\rho}_G\right)\right|$$

where E_ρ = wet density error (t/m³)

ρ_S = sand replacement wet density at each test site (t/m³)

ρ_G = nuclear gauge wet density at each test site (t/m³)

$\overline{\rho}_S$ = mean sand replacement wet density for all test sites (t/m³)

$\overline{\rho}_G$ = mean nuclear gauge wet density for all test sites (t/m³)

b) Remove the wet density data pair (sand replacement and nuclear gauge), with the largest wet density error from the analysis.

c) Re-analyse the data by repeating Steps 4.3.1 to 4.3.4, except that:

i. if data from three or more test sites are eliminated, reject all test data, and repeat the complete procedure

ii. if there are acceptable data from fewer than six test sites, reject all test data and repeat the complete procedure

iii. if all test data are again rejected, it is not appropriate to calculate a single wet density bias for the material, and

iv. any data pairs removed from the analysis cannot be used in the current bias determination or any future bias checks.

4.4 Wet density basis

4.4.1 Calculate the wet density bias using the accepted data as follows:

$$B_\rho = \overline{\rho}_S - \overline{\rho}_G$$

where B_ρ = wet density bias (t/m³)

$\overline{\rho}_S$ = mean sand replacement wet density for all accepted test sites (t/m³)

$\overline{\rho}_G$ = nuclear gauge wet density for all accepted test sites (t/m³)

4.4.2 Calculate the minimum sand replacement wet density and maximum sand replacement wet density for all accepted test sites.

5 Bias check

Bias checks shall be performed as follows:

5.1 Monitor the wet density bias by performing three additional nuclear gauge wet density and sand replacement wet density tests following the compaction of not more than 10,000 tonnes of material and perform the testing in accordance with Section 3.

5.2 Determine and validate the nuclear gauge density count and nuclear gauge wet density data in accordance with Steps 4.1 to 4.2.3.

5.3 Add the new wet density data pairs (sand replacement and nuclear gauge) to the previously accepted data while removing three existing and consecutive density data pairs commencing at the lowest test site number. Where there are only six existing data points, remove only two so that seven data points are available for analysis.

5.4 Analyse the revised wet density data for acceptance in accordance with Subsection 4.3, except that no more than one of the new density data pairs may be eliminated.

5.5 Calculate an amended wet density bias for the accepted data in accordance with Subsection 4.4.

6 Reporting

The following shall be reported:

a) wet density bias to the nearest 0.01 t/m³

b) minimum sand replacement wet density, mean sand replacement wet density and maximum sand replacement wet density for all accepted test sites to the nearest 0.01 t/m³

c) source and description of the material together with the layer type and layer depth

d) nuclear gauge make, model and serial number

e) a tabulation containing the nuclear gauge and sand replacement wet density data used to determine the bias (including any eliminated data), together with the date tested, depth tested, lot number, test site number, chainage and offset

f) the date the bias was reported, and

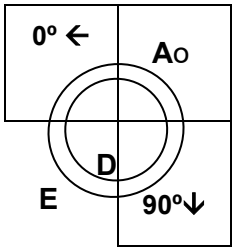
g) the number of this Test Method, that is N03.

7 Notes on method

7.1 To determine a wet density bias that is representative of the lot, distribute the sampling locations throughout the lot.

7.2 The relationship between nuclear gauge wet density and density count ratio is essentially linear over the expected density range within a lot.

Figure 1 – Test site and sand replacement location



A: probe access hole location (small circle)

D: 150 mm dia. sand replacement test location (medium circle)

E: 200 mm dia. sand replacement test location (large circle)

Test Method N04: Compacted density of asphalt – nuclear gauge

1 Source

This Test Method was developed in-house using techniques evolved through internal departmental research investigations and incorporates information provided by nuclear gauge manufacturers.

2 Scope

This Test Method sets out the procedure for the determination of the compacted density of asphalt using a nuclear gauge. The method is based on the backscatter mode of measurement and records the wet density output from the nuclear gauge as the compacted density of the asphalt.

An adjustment is made to the nuclear gauge wet density calibration as determined from comparative nuclear gauge wet density and core compacted density results.

3 Apparatus

The following apparatus is required:

3.1 Nuclear gauge of an approved make and model as listed in Part 1 of the *Nuclear Gauge Testing Manual*, logbook, manufacturer's handbook for the gauge and capable of the following:

a) backscatter measurement including thin-layer gauges such as the Troxler 4640B, and

b) calibration density uncertainty not exceeding 0.06 t/m³ for gauges used in backscatter mode and for thin-layer gauges such as the Troxler 4640B.

3.2 Reference block, as supplied by the manufacturer with the nuclear gauge, traceable to the nuclear gauge and used for the calibration of the gauge.

3.3 Guide plate or straightedge.

a) Guide plate, a flat metal template at least the same size as the base of the nuclear gauge, or

b) Straightedge, a steel straightedge about 300 mm long and 5 mm thick.

3.4 Dry fine sand passing a 0.600 mm test sieve.

3.5 Broom or brush.

4 Calibration and biasing

Calibration and biasing shall be performed as follows:

4.1 Standard blocks calibration

Calibrate the nuclear gauge on standard blocks at least once every two years for density measurement in accordance with the relevant Australian Standard and VicRoads Test Method as follows:

- Nuclear thin-layer density gauge — AS 2891.14.3 or RC 900.07
- Nuclear moisture-density gauge (backscatter) — AS 2891.14.4

Recalibrate the nuclear gauge following any major repair or component replacement.

4.2 Asphalt density bias

4.2.1 Determine a density bias for the nuclear gauge, asphalt mix and gauge layer thickness setting (thin-layer gauge only) in accordance with Test Method N05.

This bias is to be re-determined whenever any of the following apply:

a) when a standard blocks calibration of the nuclear gauge is performed

b) there is a change to the mix design, or

c) there is a change to the gauge layer thickness setting.

4.2.2 In addition to the requirements of Steps 4.2.1, check any applied density bias in accordance with Test Method N05 as follows:

a) whenever there is a change in site conditions (for example, surface roughness, nominal layer thickness, composition of underlying layer, density of underlying layer)

b) following the compaction of not more than 10,000 tonnes of material, or

c) if the density bias has not been used with the nuclear gauge for two months or more.

5 Operational checks

To ensure that the nuclear gauge is operating normally, checks shall be undertaken routinely or following repair as follows:

5.1 Standard count check (frequency: each day of use)

5.1.1 Remove the nuclear gauge and reference block from the store and place the reference block on the designated test location. A location is to be selected which is at least 1 m from any large object and 10 m from any other nuclear gauge. Mark this location and use for all counts associated with operational checks.

5.1.2 Take a standard count for each density detection system in accordance with the appropriate standard count operating instruction in Part 4: Operating Instructions: Operational Checks of the *Nuclear Gauge Testing Manual* and ensure the following:

a) the nuclear gauge is correctly located on the reference block

b) the source rod handle is correctly located in the shielded position, and

c) the density standard count values are recorded.

A record is to be kept for each gauge to record operational check data (standard count check and gauge function check) and the date of measurement. For nuclear gauges with two detection systems (for example, the nuclear thin-layer density gauge), record the check data for each system separately.

5.1.3 Calculate the mean of the previous four recorded and accepted density standard counts (Note 11.1).

5.1.4 Calculate the density limits for each density detection system as follows and record the limits (Note 11.3):

$$L_\rho = \overline{SC} - 2\sqrt{\frac{\overline{SC}}{PS}}$$

$$U_\rho = \overline{SC} + 2\sqrt{\frac{\overline{SC}}{PS}}$$

where $\overline{SC}$ = mean density standard count (DS)

L_ρ = lower limit for density

U_ρ = upper limit for density

PS = nuclear gauge prescale factor (refer to Table 1)

5.1.5 If the recorded standard count value for each system lies within the range L_ρ to U_ρ, the density standard count is accepted, and the nuclear gauge may be used for testing.

5.1.6 If either recorded standard count value lies outside the range L_ρ to U_ρ repeat Steps 5.1.2 to 5.1.5. If either standard count is again outside the range, remove the nuclear gauge from service and have it repaired by a licensed service agent (Notes 11.2 and 11.5).

5.2 Gauge function check – statistical performance (frequency: monthly)

5.2.1 Remove the nuclear gauge and reference block from the store and place the reference block on the designated test location. A location is to be selected which is at least 1 m from any large object and 10 m from any other nuclear gauge. Mark this location and use for all counts associated with operational checks.

5.2.2 Take at least 16 density counts for each density detection system in accordance with the appropriate statistical count operating instruction in Part 4: Operating Instructions: Operational Checks of the *Nuclear Gauge Testing Manual* and ensure the following:

a) the nuclear gauge is correctly located on the reference block

b) the source rod handle is correctly located in the shielded position, and

c) the density count values are recorded (Note 11.3).

5.2.3 Calculate the mean and standard deviation of the density counts.

5.2.4 Calculate the density ratio for each density detection system as follows and record the value:

$$r_\rho = \frac{s}{\sqrt{\overline{C}_\rho}}$$

where r_ρ = density ratio

s = standard deviation of the density counts

$\overline{C}_\rho$ = mean density count

Where an accepted form of statistical analysis is performed by the microprocessor, it is not necessary to record individual count values. Only record the density and moisture ratio values and omit Steps 5.2.3 and 5.2.4.

5.2.5 If the density ratio for each system lies within the limits given in Table 2, the nuclear gauge is verified to be operating normally and may be used for testing.

5.2.6 If any density ratio lies outside the relevant limits given in Table 2, repeat Steps 5.2.2 to 5.2.5. If any ratio is again outside the limits, remove the nuclear gauge from service and have it repaired by a licensed service agent.

5.3 Density system consistency check (frequency: monthly)

Perform a density system consistency check in accordance with Part 2, Subsection 1.2 of the *Nuclear Gauge Testing Manual*.

6 Configuration

On each day of use, configure the nuclear gauge before testing by undertaking a standard count and setting or checking test parameters appropriate to the asphalt mix design as follows:

6.1 Standard count

6.1.1 Remove the nuclear gauge and reference block from the transport case and place the reference block on the surface of the particular asphalt mix under test. Where the nuclear gauge is to be used within 1 m of a large object or in a trench, take a separate standard count at each test site.

6.1.2 Take a standard count in accordance with the appropriate standard count operating instruction in Part 4: Operating Instructions: Operational Checks of the *Nuclear Gauge Testing Manual* and ensure the following:

a) the nuclear gauge is correctly located on the reference block

b) the source rod handle is correctly located in the shielded position, and

c) the density standard count value is recorded with the test data and, where the functionality exists, stored in the nuclear gauge microprocessor.

6.2 Test parameters

Check or set user definable test parameters in accordance with the appropriate test parameters operating instruction in Part 4: Operating Instructions: Testing – Asphalt of the *Nuclear Gauge Testing Manual* (Note 11.3).

7 Test site selection and preparation

Determination of test locations and preparation of each test site shall be as follows:

7.1 Use random stratified sampling to determine sampling and test locations in accordance with the requirements of the specification, sampling plan or testing methodology as appropriate.

7.2 At a designated test location, use the guide plate or straightedge to define a test site which is flat and free from depressions. The test site is formed by a single rectangle being at least the size of the guide plate with the source rod being over the surface of the asphalt at each end of the test area as shown in Figure 1.

7.3 Sweep all loose material from the test site and sprinkle fine sand on the surface. Move the guide plate or straightedge over the surface until the voids are just filled, ensuring that the sand does not form an added layer. Remove the guide plate or straightedge.

8 Testing

Testing shall be performed as follows:

8.1 Place the nuclear gauge on the prepared test site such that the longitudinal axis of the nuclear gauge is parallel to the direction of rolling.

8.2 Confirm that the nuclear gauge is firmly seated without rocking. If the nuclear gauge cannot be firmly seated, prepare a new test site immediately adjacent to the original site. Move the source rod to the backscatter (BS) position.

8.3 Take a one-minute count in accordance with the appropriate measurement operating instruction detailed in Part 4: Operating Instructions: Testing – Asphalt of the *Nuclear Gauge Testing Manual*. Record the wet density and the density count data.

8.4 Rotate the nuclear gauge through 180º, ensuring that the test site is not disturbed. Repeat Steps 8.2 to 8.3 and then move the source rod to the shielded position.

8.5 Compare the wet density values from the two orientations. If the difference exceeds 0.075 t/m³, examine and further prepare the test site as necessary and repeat Steps 8.1 to 8.4.

8.6 If the wet density difference again exceeds 0.075 t/m³, abandon the test site and select a new site immediately adjacent.

9 Calculations

Calculations shall be as follows:

9.1 Determine the mean nuclear gauge wet density for the test site to the nearest 0.001 t/m³ by averaging the wet density values obtained at the 0º and 180º orientations.

9.2 Where the asphalt density bias has not been applied via the nuclear gauge microprocessor, adjust the compacted density calculated in Step 9.1 by applying this bias to calculate the compacted density as follows:

$$D_c = \rho_G + B_\rho$$

where D_c = compacted density (t/m³)

ρ_G = mean nuclear gauge wet density (t/m³)

B_ρ = asphalt density bias (t/m³)

10 Reporting

The following shall be reported:

a) compacted density to the nearest 0.001 t/m³

b) date tested, test mode, lot number, test site number, and chainage and offset

c) source and type of the asphalt together with the mix code number and nominal layer depth

d) for thin-layer gauges (such as Troxler 4640B), the gauge layer thickness setting to the nearest 1 mm

e) a statement including the density bias, to the nearest 0.001 t/m³, and identification of the bias report as follows: 'An adjustment of x.xxx t/m³, obtained from Report Number <report no>, has been made.', and

f) the number of this Test Method, that is N04.

11 Notes on method

11.1 Where the previous four standard counts have not been taken within the previous five weeks of the current date or the nuclear gauge has been moved to a new operating location and has a new designated test location, it may be necessary to take four new standard counts in accordance with Steps 5.1.1 to 5.1.2.

11.2 It is expected that a standard count value will lie outside the range L_ρ to U_ρ about one in every 20 standard count checks. To have consecutive values outside this range is expected only once in 400 standard count checks; however, as the return of the gauge for checking and possible repair can be expensive and disruptive, it is acceptable to perform a gauge function check in accordance with Subsection 5.2. If the gauge is not verified as operating normally, remove the nuclear gauge from service and have it repaired by a licensed service agent.

11.3 The scope of user definable test parameters is dependent on the make and model of nuclear gauge. Such parameters include:

a) counting time, units and measurement mode

b) maximum density

c) asphalt density bias, and

d) for thin-layer gauges (such as Troxler 4640B), the gauge layer thickness setting.

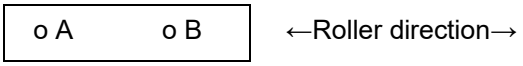
Table 1 – Nuclear gauge prescale factors

Nuclear gauge make / model	Prescale factor
CPN / Elite series	8
Troxler / except Models 3450 and 4640B	16
Troxler / Models 4640B	8
Humboldt / All	16
InstroTek / Xplorer series	16

Table 2 – Gauge function check – density ratio limits

Nuclear gauge make / model	Lower limit	Upper limit
CPN / Elite series	0.25	0.45
Troxler / except Models 3450 and 4640B	0.17	0.33
Troxler / Model 4640B	0.25	0.45
Humboldt / All	0.60	1.40
InstroTek / All	0.18	0.35

Figure 1 – Test site



Position A is the source rod location for 0° measurement and Position B is the source rod location for 180° measurement.

Test Method N05: Asphalt density bias

1 Source

This Test Method was developed in-house using techniques evolved through internal departmental research investigations and incorporates information provided by nuclear gauge manufacturers.

2 Scope

This Test Method sets out the procedure for the determination of the asphalt density bias associated with the measurement of compacted density of asphalt using a nuclear gauge. The asphalt density bias represents the average density difference between nuclear gauge wet density and core compacted density for a particular nuclear gauge, asphalt mix and layer thickness. Differences between nuclear gauge wet density and core compacted density are due to differences in the material sampled by both tests and the effect of chemical composition and test site characteristics (for example, density gradients, surface condition, homogeneity) on nuclear gauge results.

Included in the method is a procedure for monitoring the applicability of an existing asphalt density bias and providing ongoing adjustment of the bias to reflect subtle changes in asphalt mix composition / site conditions.

3 Procedure

The procedure shall be as follows:

3.1 Select at least 10 test sites within the lot under consideration using random stratified sampling to determine sampling and test locations in accordance with the requirements of the specification, sampling plan or testing methodology as appropriate (Note 7.1). Number each test site and any bias check test site consecutively in chronological order.

3.2 At each test site, undertake the following:

3.2.1 Measure the nuclear gauge wet density in accordance with Test Method N04, except that no asphalt density bias is applied. For thin-layer gauges, the gauge layer thickness should be set to the nominal thickness of the layer. Record the measured density counts and wet density values to the nearest 0.001 t/m³, for both the 0º and 180º orientations.

3.2.2 Obtain a 150 mm diameter core sample centrally within the site in accordance with Test Method AS 2891.1.2.

3.2.3 Measure the compacted density of the core sample in accordance with Test Method AS/NZS 2891.9.2 or Q306C as appropriate (Note 7.2). For stone mastic asphalt and open graded asphalt, determine the core sample compacted density in accordance with Test Method Q306C. For dense graded asphalt, the core sample may be tested in accordance with Test Method AS/NZS 2891.9.2 rather than Test Method Q306C, provided that its air void content is not less than the minimum specified level. Use the same compacted density method for both the bias determination and bias checks.

4 Calculations

Calculations shall be as follows:

4.1 Field test data

Determine the mean density count and mean nuclear gauge wet density for each site by averaging the corresponding measurements for the 0º and 180º orientations.

4.2 Data validation

Validate the density count, density standard count and nuclear gauge wet density data as follows (Note 7.3):

4.2.1 Calculate the density count ratio for each site to four significant figures as follows:

$$CR_\rho = \frac{C_\rho}{SC_\rho}$$

where CR_ρ = density count ratio

C_ρ = mean density count

SC_ρ = density standard count

4.2.2 Plot the nuclear gauge wet density against the corresponding density count ratio using the data from all test sites.

4.2.3 If any data pair does not lie on the linear plot, reject the nuclear gauge and core compacted density wet density data for this test site. Rejected data pairs cannot be used in the current bias determination or any future bias checks.

4.2.4 For thin-layer gauges with two detection systems, validate the density system 1 data (that is density count, density standard count and the standards blocks wet density) in accordance with Steps 4.2.1 to 4.2.3. Then validate the density system 2 data (that is density count, density standard count and the nuclear gauge wet density) in accordance with Steps 4 2.1 to 4.2.3.

4.3 Data acceptance

Perform data acceptance with the remaining data as follows:

4.3.1 Calculate the mean nuclear gauge wet density and mean core compacted density for all remaining test sites.

4.3.2 Calculate the density standard error as follows:

$$SE_\rho = \sqrt{\frac{\sum\left(D_C - \rho_G - \overline{D}_C + \overline{\rho}_G\right)^2}{n-2}}$$

where SE_ρ = density standard error (t/m³)

D_C = core compacted density at each test site (t/m³)

ρ_G = nuclear gauge wet density at each test site (t/m³)

$\overline{D}_C$ = mean core compacted density for all test sites (t/m³)

$\overline{\rho}_G$ = mean wet density for all test sites (t/m³)

n = number of test sites

4.3.3 If the density standard error does not exceed 0.025 t/m³, accept the data and calculate the asphalt density bias in accordance with Subsection 4.4.

4.3.4 If the density standard error exceeds 0.025 t/m³, perform the following:

a) For each density data pair (core compacted density and nuclear gauge wet density), calculate the density error as follows:

$$E_\rho = \left|(D_C - \rho_G) - (\overline{D}_C - \overline{\rho}_G)\right|$$

where E_ρ = density error (t/m³)

D_C = core compacted density at each test site (t/m³)

ρ_G = nuclear gauge wet density at each test site (t/m³)

$\overline{D}_C$ = mean core compacted density for all test sites (t/m³)

$\overline{\rho}_G$ = mean nuclear gauge wet density for all test sites (t/m³)

b) Remove the density data pair (core compacted density and nuclear gauge wet density) with the largest density error from the analysis.

c) Re-analyse the data by repeating Steps 4.3.1 to 4.3.4, except that:

i. if three or more test sites are eliminated, reject all test data, and repeat the complete procedure

ii. if there are acceptable data from fewer than eight test sites, reject all test data and repeat the complete procedure

iii. if all test data are again rejected, it is not appropriate to calculate a single asphalt density bias for the material, and

iv. any data pairs removed from the analysis cannot be used in the current bias determination or any future bias checks.

4.4 Asphalt density bias

4.4.1 Calculate the asphalt density bias using accepted data to the nearest 0.001 t/m³ as follows:

$$B_\rho = \overline{D}_C - \overline{\rho}_G$$

where B_ρ = asphalt density bias (t/m³)

$\overline{D}_C$ = mean core compacted density for all test sites (t/m³)

$\overline{\rho}_G$ = mean nuclear gauge wet density for all test sites (t/m³)

4.4.2 Calculate the minimum core compacted density and maximum core compacted density for all accepted test sites.

5 Bias check

Bias checks shall be performed as follows:

5.1 Monitor the asphalt density bias by performing three additional nuclear gauge wet density and core compacted density tests following the compaction of not more than 10,000 tonnes of material and perform testing in accordance with Section 3.

5.2 Determine and validate the density count and nuclear gauge wet density data in accordance with Steps 4.1 to 4.2.3.

5.3 Add the new density data pairs (core compacted density and nuclear gauge wet density) to the previously accepted data while removing three existing and consecutive density data pairs commencing at the lowest test site number. Where there are only eight existing data points, remove only two so that nine data points are available for analysis.

5.4 Analyse the revised density data for acceptance in accordance with Subsection 4.3, except that no more than one of the new density data pairs may be eliminated.

5.5 Calculate an amended asphalt density bias for the accepted data in accordance with Subsection 4.4.

6 Reporting

The following shall be reported:

a) asphalt density bias to the nearest 0.001 t/m³

b) minimum core compacted density, mean core compacted density and maximum core compacted density for all accepted test sites to the nearest 0.001 t/m³

c) source and type of the asphalt together with the mix code number and nominal layer depth

d) nuclear gauge make, model and serial number

e) a tabulation containing the nuclear gauge wet density and core compacted density data used to determine the bias (including any eliminated data), together with the date tested, lot number, test site number, and chainage and offset

f) the date the bias was calculated and, in the case of an amended asphalt density bias, the report number and date for the previous report

g) for thin-layer gauges (such as Troxler 4640B) the gauge layer thickness setting to the nearest 1 mm, and

h) the number of this test method, that is N05.

7 Notes on method

7.1 To determine an asphalt density bias which is representative of the lot, distribute sampling locations throughout the lot.

7.2 The relationship between nuclear gauge wet density and density count ratio is essentially linear over the expected density range within a lot.

Operating Instruction N101: Standard Count Troxler 3440

1 Set up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

▶ Press [ON] and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When **<READY>** is displayed:

▶ Press [STANDARD ÷] and the following is displayed:

> Standard Count-
> DS = XX
> MS = XX
> Take new count?

▶ Press [YES EXIT] and the following is displayed:

> Is gauge on Std.
> Block & Source
> rod in SAFE pos?

▶ Press [YES EXIT] and the following is displayed:

> Taking
> Standard Count-
> XX seconds
> remaining

▶ At the end of the counting period the following is displayed:

> MS = XX XX %P
> DS = XX XX %P
> Do you want to use
> the new STD

Record the following values:

- MS as the **moisture standard count**.
- DS as the **density standard count**.

▶ Press [YES EXIT] and the display will return to **<READY>**.

▶ Press [OFF] if the nuclear gauge is not required for further use.

Operating Instruction N102: Statistical Count Troxler 3440

1 Set up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

▶ Press ON and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When **<READY>** is displayed:

▶ Press SHIFT x

▶ Press SPECIAL 9 and the following is displayed:

SPECIAL FUNCTION
YES - Next menu
1 - STAT TEST
2 - DRIFT TEST

▶ Press COUNTS 1 and the following is displayed:

-STAT TEST-
Want to view last
Stat Data?

▶ Press NO/CE C/CE and the following is displayed:

Put gauge on Std
Block, rod in
SAFE position &
press START

▶ Press START/ ENTER = and the following is displayed:

-STAT TEST-
Reading #X
Time=XX secs

At the end of the counting period, the following will be displayed:

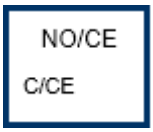
DENS STAT TEST
Avg cnts: XX
R: XX (XXXX)
ENTER for Moist

Record R as the **density ratio**.

▶ Press START/ ENTER = and the following is displayed:

MOIST STAT TEST
Avg cnts: XX
R: XX (XXXX)
View Stat. data?

Record R as the **moisture ratio**.

- Press 

and display will return to <**READY**>.

- Press 

if the nuclear gauge is not required for further use.

Operating Instruction N103: Standard Count Troxler 3430

1 Set up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

▶ Press [ON / YES] and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

▶ Press [STANDARD] and the following is displayed:

▶ Press [ON / YES] and the following is displayed:

▶ Press [START / ENTER] and the following is displayed:

At the end of the counting period the following will be displayed:

Record the following values:

- DS as the **density standard count**.
- MS as the **moisture standard count**.

▶ Press [ON / YES] and the display will return to <**READY**>.

▶ Press [OFF / NO] if the nuclear gauge is not required for further use.

Operating Instruction N104: Statistical Count Troxler 3430

1 Set up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

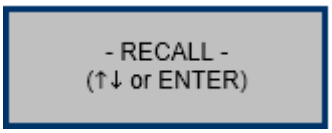
Check the source rod handle is correctly located in the shielded position.

▶ Press [ON / YES] and allow the nuclear gauge to complete the self-test routine.

2 Measurement

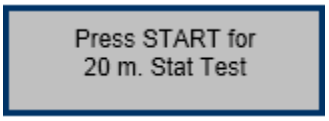
When <**READY**> is displayed:

▶ Press [SPECIAL] and the following is displayed:

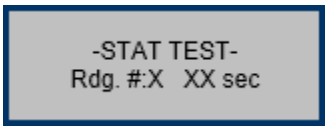


▶ Press [↓] repeatedly until the following is displayed:

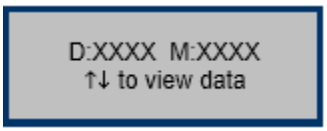
▶ Press [START / ENTER] and the following is displayed:



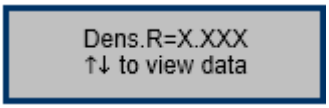
▶ Press [START / ENTER] and the following is displayed:



At the end of the counting period the following will be displayed:

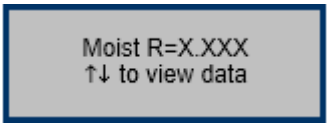


▶ Press [↓] and the following is displayed:



Record Dens. R as the **density ratio**.

▶ Press [↓] repeatedly until the following is displayed:



Record Moist R as the **moisture ratio**.

▶ Press [ON / YES] and the display will return to <**READY**>.

▶ Press [OFF / NO] if the nuclear gauge is not required for further use.

Operating Instruction N107: Standard Count Troxler 4640B

1 Set up

Position the air gap spacer on the reference block. Position the nuclear gauge on the spacer so the handle end rests over the two posts on the spacer.

Check the source rod handle is correctly located in the shielded position.

- Press ON and allow the nuclear gauge to complete the self-test routine.

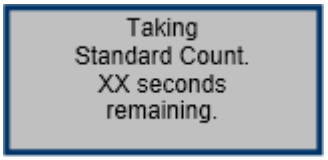
2 Measurement

When <**READY**> is displayed:

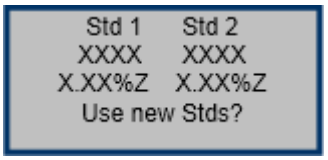
- Press STD + and the following will be displayed:

- Press YES EXIT and the following will be displayed:

- Press START/ ENTER = and the following will be displayed:



At the end of the counting period, the following will be displayed:



Record the following values:

- Std1 as the **System 1 standard count**.
- Std2 as the **System 2 standard count**.

- Press YES EXIT and the display will return to <**READY**>.
- Press OFF if the nuclear gauge is not required for further use.

Operating Instruction N108: Statistical Count Troxler 4640B

1 Set up

Position the air gap spacer on the reference block. Position the nuclear gauge on the spacer so the handle end rests over the two posts on the spacer.

Check the source rod handle is correctly located in the shielded position.

- Press [ON] and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

- Press [SHIFT x] [SPECIAL 9] and the following will be displayed:

```
Special Function
Yes - Next Menu
1 - Surface Voids
2 - Recover Erase
```

- Press [CALC 3] and the following will be displayed:

```
Place Gauge on
Spacer & both on
Block, Put Rod in
SAFE, Press ENTER
```

- Press [START/ENTER =] and the following will be displayed:

```
-STAT TEST-
    Reading # X

Time:  XX secs.
```

At the end of the counting period, the following will be displayed:

```
-STAT TEST-
Avg:  XXXX   X.XX Z
Avg:  XXXX   X.XX Z
View stat data?
```

Record the second value on the first line of displayed data as the **System 1 density ratio**.

Record the second value on the second line of displayed data as the **System 2 density ratio**.

- Press [NO/CE C/CE] and the display will return to <**READY**>.
- Press [OFF] if the nuclear gauge is not required for further use.

Operating Instruction N113: Standard Count Humboldt 5001EZ

1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge closest to the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

- Press PWR and allow the nuclear gauge to complete the initialising routine.

The following will be displayed:

```
*DATA    XX/XX/XX
*SET UP  XX:XX:XX
*ENGINEERING
                    DEPTH=SAF
```

2 Measurement

- Press F2 and the following will be displayed:

```
*SET UP 2
*SET MEASUREMENT MODES
*SET TRNCH COR.
*SET TARGETS
```

- Press F2 and the following will be displayed:

```
MEAS  =  FAST/NORM/SLOW
STD   =  4MIN/16MIN
TYPE  =  ASPH/SOIL/THIN
DEPTH =  AUTO/MANUAL
```

- Press F2 repeatedly until "**4MIN**" flashes.

- Press STD STAT and the following will be displayed:

```
DS = XXXX        MM/DD/YY
MS = XXX         MM:HH
* TAKE NEW STD
* USE CURRENT STD
```

- Press F3 and the following will be displayed:

```
TAKING STANDARD
TIME REMAINING       X:XX
DS =   X
MS =   X       DEPTH = SAF
```

- At the end of the counting period, the following will be displayed:

```
STD TEST RESULTS

DS =  XXXX.X
MS =  XXX.X
```

or

```
DS = XXXX     %ERR = X.X
MS = XXX      %ERR = X.X
*REJECT & TAKE NEW STD
*RETAIN THE NEW STD
```

Record the following displayed values if no error message is displayed:

- DS as the **density standard count**.
- MS as the **moisture standard count**.

▶ Press 

and the display will return to the main menu.

If an error message is displayed:

▶ Press 

and the display will return to the main menu.

▶ Press 

if the nuclear gauge is not required for further use.

Operating Instruction N114: Statistical Count Humboldt 5001EZ

1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge closest to the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

▶ Press PWR and allow the nuclear gauge to complete the initialising routine.

The following will be displayed:

```
*DATA    XX/XX/XX
*SET UP  XX:XX:XX
*ENGINEERING
                    DEPTH=SAF
```

2 Measurement

▶ Press F2 and the following will be displayed:

```
*SET UP 2
*SET MEASUREMENT MODES
*SET TRNCH COR.
*SET TARGETS
```

▶ Press F2 and the following will be displayed:

```
MEAS  =  FAST/NORM/SLOW
STD   =  4MIN/16MIN
TYPE  =  ASPH/SOIL/THIN
DEPT  =  AUTO/MANUAL
```

▶ Press F2 repeatedly until "**16MIN**" flashes.

▶ Press STD STAT and the following will be displayed:

```
DS = XXXX          MM/DD/YY
MS = XXX           MM:HH
* TAKE NEW STD
* USE CURRENT STD
```

▶ Press F3 and the following will be displayed:

```
TAKING STATISTICS
TIME REMAINING        X:XX
DS =X
MS =X          DEPTH = SAF
```

▶ At the end of the counting period, the following will be displayed:

```
STAT TEST RESULTS

DS =  XXXX.X      R = X.XXX
MS =  XXX.X       R = X.XXX
```

or

```
DS = XXXX          %ERR = X.X
MS = XXX           %ERR = X.X
*REJECT & TAKE NEW STD
*RETAIN THE NEW STD
```

Record the following displayed values:

- R in the DS row as the **density ratio**.
- R in the MS row as the **moisture ratio**.

If an error message is displayed:

▶ Press F4 F3 to take new counts.

▶ Press MAIN MENU and the display will return to the main menu.

▶ Press F2 and the following will be displayed:

```
*SET UP 2
*SET MEASURE MODES
*SET TRENCH COR.
*SET TARGETS
```

▶ Press F2 and the following will be displayed:

```
MEAS   =FAST/NORM/SLOW
STD    =4MIN/16MIN
TYPE   =ASPH/SOIL/THIN
DEPTH  =AUTO/MANUAL
```

▶ Press F2 repeatedly until "**4MIN**" flashes.

▶ Press MAIN MENU and the display will return to the main menu.

▶ Press PWR if the nuclear gauge is not required for further use.

Operating Instruction N119: Standard Count Instrotek Xplorer 3500

1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

▶ Press [ON / YES] and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

▶ Press [STD] and the following is displayed:

```
DS=XXXX  MS=XXX
New Std Count?
```

▶ Press [ON / YES] and the following is displayed:

```
Standard Count
Press START
```

▶ Press [START / ENTER] and the time will count down from 240 seconds and display:

```
Time = XXX sec
Standard Count
```

At the end of the counting period, the following will be displayed:

```
DS = XXXX  MS = XXX
Use New STD CNT?
```

Record the following values:

- DS as the **density standard count**.
- MS as the **moisture standard count**.

▶ Press [ON / YES] and display will return to <**READY**>.

▶ Press [OFF / NO] if the nuclear gauge is not required for further use.

Operating Instruction N120: Statistical Count Instrotek Xplorer 3500

1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

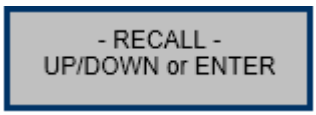
Check the source rod handle is correctly located in the shielded position.

- Press [ON / YES] and allow the nuclear gauge to complete the self-test routine.

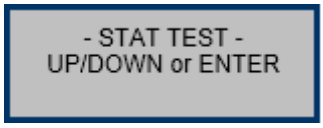
2 Measurement

When <**READY**> is displayed:

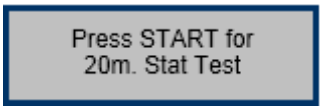
- Press [MENU] and the following is displayed:

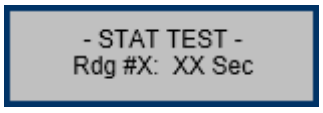
- Press [DOWN] repeatedly until the following is displayed:

- Press [START / ENTER] and the following is displayed:

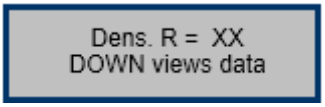
- Press [START / ENTER] and the following is displayed:

  At the end of the counting period, the following is displayed:

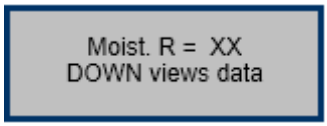
  

- Press [DOWN] and the following is displayed:

  Record Dens. R as the **density ratio**.

- Press [DOWN] repeatedly until the following is displayed:

  Record Moist R as the **moisture ratio**.

- Press [START / ENTER] and the display will return to <**READY**>.

- Press [OFF / NO] if the nuclear gauge is not required for further use.

Operating Instruction N121: Standard Count Troxler 3440P

1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

- Turn the power switch on and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

- Press STD repeatedly until the following is displayed:

  -Standard Count-
  DS = XX
  MS = XX
  Take new count?

- Press YES repeatedly until the following is displayed:

  Is gauge on Std.
  Block & Source
  rod in SAFE pos?

- Press ENTER START repeatedly until the following is displayed:

  Taking
  Standard Count
  XX seconds
  remaining

At the end of the counting period, the following is displayed:

DS = XX XX %P
MS = XX XX %P
Do you want to use
the new STD?

Record the following values:

- MS as the **moisture standard count**.
- DS as the **density standard count**.

- Press YES and the display will return to <**READY**>.

- Turn the power switch off if the nuclear gauge is not required for further use.

Operating Instruction N122: Statistical Count Troxler 3440P

1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

- Turn the power switch on and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

- Press [SETUP]
- Press [↓] until stat test appears as an option
- Press [4] the following is displayed:

```
1. Take STAT Test
2. Review STAT Test
3. Print STAT Test
<ESC> to Exit
```

- Press [1] the following is displayed:

```
Place Gauge on
Std. Block & Source
Rod in SAFE Pos.
Press <START>
```

- Press [ENTER START]

At the end of the counting period, the following will be displayed:

```
DENS STAT TEST
Avg cnts: XXXX
R: XX (XXXX)
ENTER for Moist
```

Record R as the **density ratio**.

- Press [ENTER START] the following is displayed:

```
MOIST STAT TEST
Avg cnts: XX
R: XX (XXXX)
View Stat. data?
```

Record R as the **moisture ratio**.

- Press [NO] and display will return to the SETUP menu.
- Press [ESC] to exit.
- Turn the power switch off if the nuclear gauge is not required for further use.

Operating Instruction N123: Standard Count Troxler 3430P

1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

- Turn the power switch on and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

- Press STD repeatedly until the following is displayed:

  -Standard Count-
  DS = XX
  MS = XX
  Take new count?

- Press YES repeatedly until the following is displayed:

  Is gauge on Std.
  Block & Source
  rod in SAFE pos?

- Press ENTER START repeatedly until the following is displayed:

  Taking
  Standard Count
  XX seconds
  remaining

At the end of the counting period, the following is displayed:

DS = XX XX %P
MS = XX XX %P
Do you want to use
the new STD?

Record the following values:

- MS as the **moisture standard count**.
- DS as the **density standard count**.

- Press YES and the display will return to <**READY**>

- Turn the power switch off if the nuclear gauge is not required for further use.

Operating Instruction N124: Statistical Count Troxler 3430P

1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

- Turn the power switch on and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

- Press [SETUP]
- Press [↓] until stat test appears as an option
- Press [4] the following is displayed:

```
1. Take STAT Test
2. Review STAT Test
3. Print STAT Test
<ESC> to Exit
```

- Press [1] the following is displayed:

```
Place Gauge on
Std. Block & Source
Rod in SAFE Pos.
Press <START>
```

- Press [ENTER START]

At the end of the counting period, the following will be displayed:

```
DENS STAT TEST
Avg cnts: XXXX
R: XX (XXXX)
ENTER for Moist
```

Record R as the **density ratio**.

- Press [ENTER START] the following is displayed:

```
MOIST STAT TEST
Avg cnts: XX
R: XX (XXXX)
View Stat. data?
```

Record R as the **moisture ratio**.

- Press [NO] and display will return to the SETUP menu
- Press [ESC] to exit.
- Turn the power switch off if the nuclear gauge is not required for further use.

Operating Instruction N127: Standard Count CPN MC1 and MC3 Elite

1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

- Press [ON / YES] and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

- Press [STD] and the following is displayed:

  DS= ###
  MS= ###
  Take new Std Count?
  Press YES or NO

- Press [ON / YES] and the following is displayed:

  Place Gauge on Poly
  Std. Block in SAFE
  Position
  Press Start

- Press [START / ENTER] and the following is displayed:

  Standard Count
  Time: XXX sec.

  At the end of the counting period, the following will be displayed:

  DS= ###
  MS= ###
  Use new STD CNT?
  Press YES or NO

  Record the following values:

  - DS as the **density standard count**.
  - MS as the **moisture standard count**.

- Press [ON / YES] and the display will return to <**READY**>.

- Press [OFF / NO] if the nuclear gauge is not required for further us.

Operating Instruction N128: Statistical Count CPN MC1 and MC3 Elite

1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

- Press [ON / YES] and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

- Press [MENU]
- Press [1] when the display reads: [Stat Test]
- Press [START / ENTER]

After 20 minutes, the display will show the results of the test, you can scroll through to see each count.

Operating Instruction N129: Standard Count Humboldt 5001SD

1 Set-up

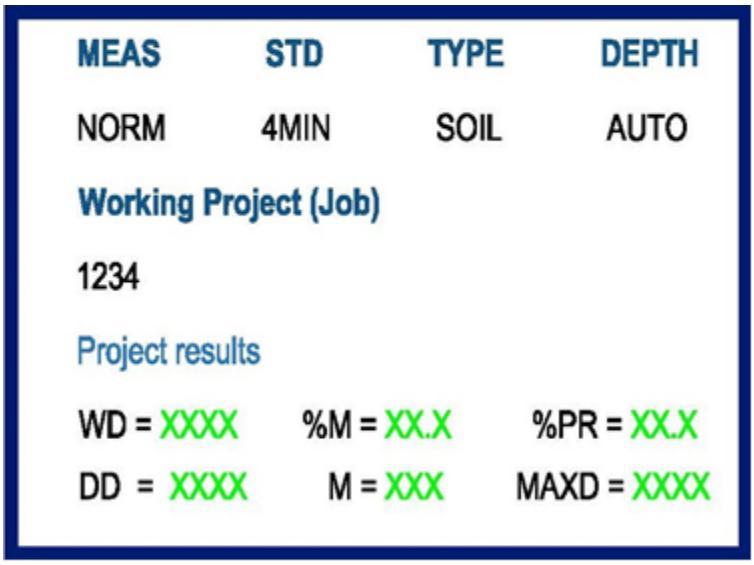
Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge closest to the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

▶ Press 

and allow the nuclear gauge to complete the initialising routine.

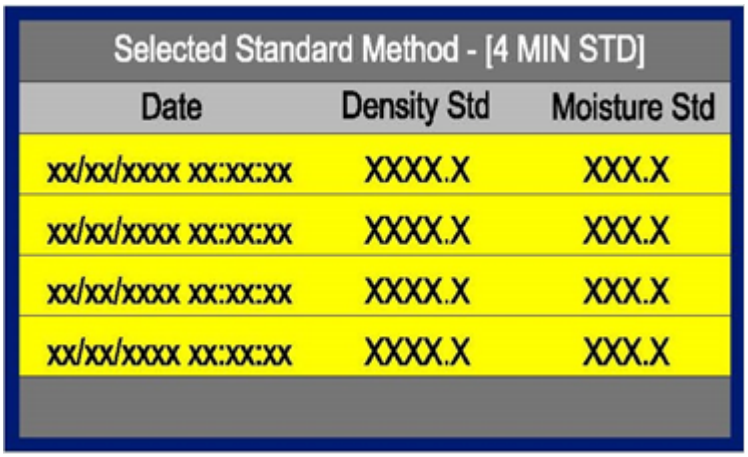
The following will be displayed:



2 Measurement

▶ Press 

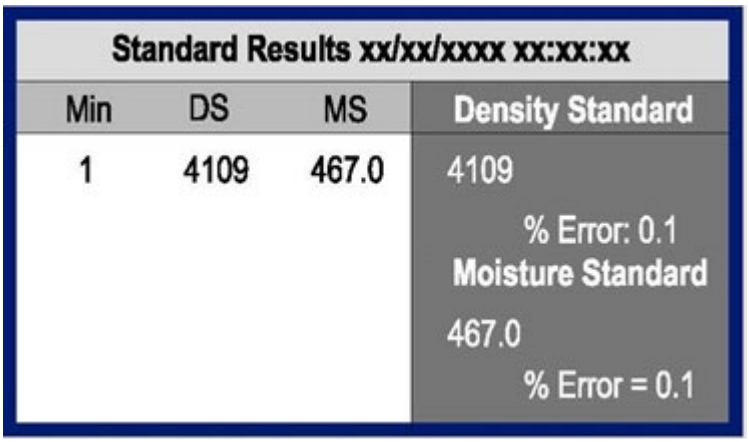
The following will be displayed:



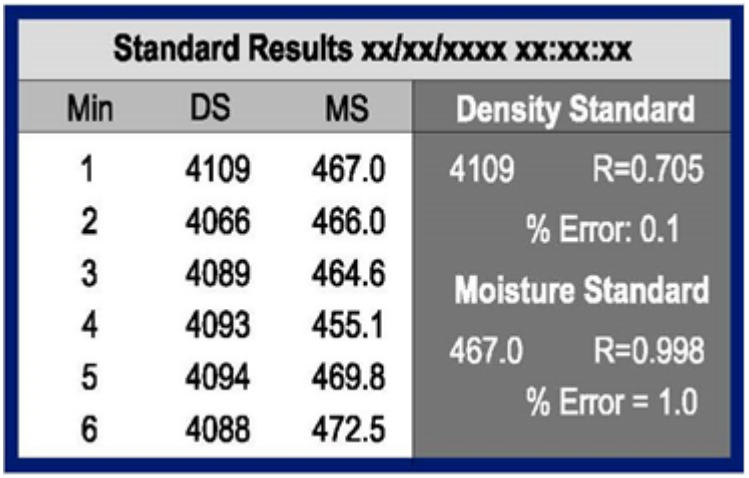
▶ Press 

The following will be displayed:

▶ At the end of the counting period, the following will be displayed



or



Record the following displayed values if no error message is displayed:

- DS as the **density standard count**.
- MS as the **moisture standard count**.

▶ Press 

to accept and store the standard count

▶ Press 

and the display will return to the main menu.

▶ Press 

if the nuclear gauge is not required for further use.

Operating Instruction N130: Statistical Count Humboldt 5001SD

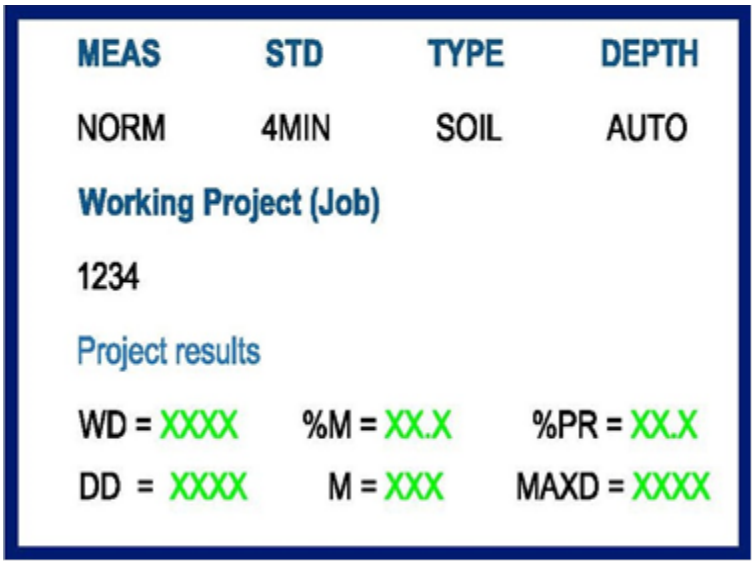
1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge closest to the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

▶ Press 

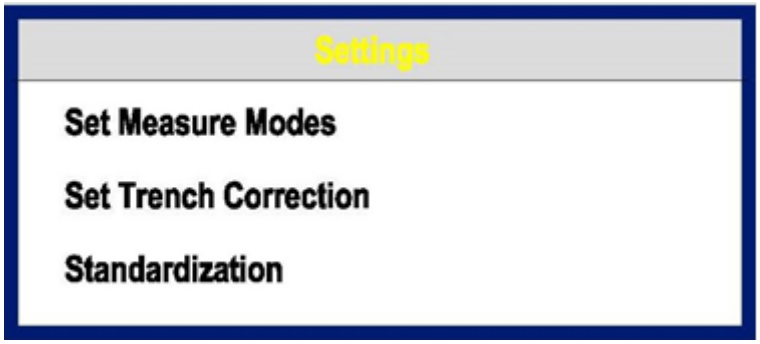
The following will be displayed:



2 Measurement

▶ Press 

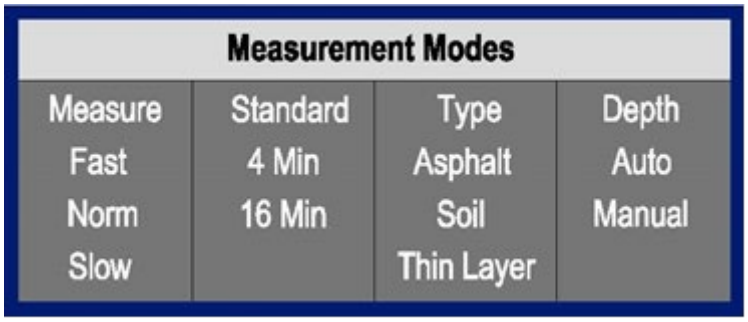
The following will be displayed:



Select **'Set Measure Modes'.**

▶ Press 

The following will be displayed:

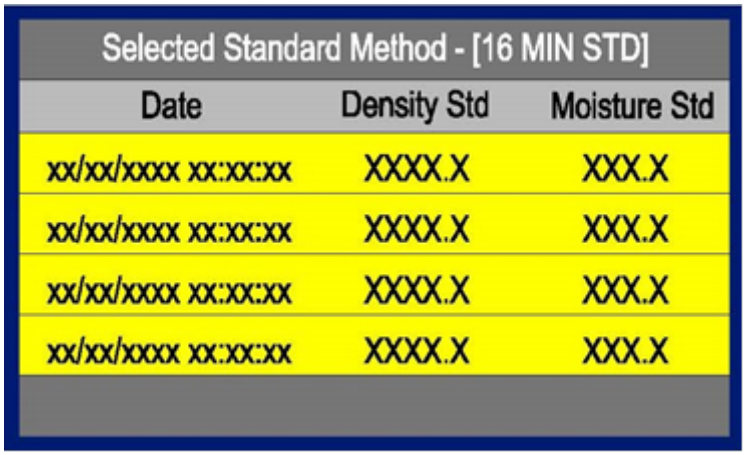


▶ Press **'16MIN'** Check all other settings are **'Norm'**, **'Soil'** and **'Auto'**.

▶ Press 

▶ Press 

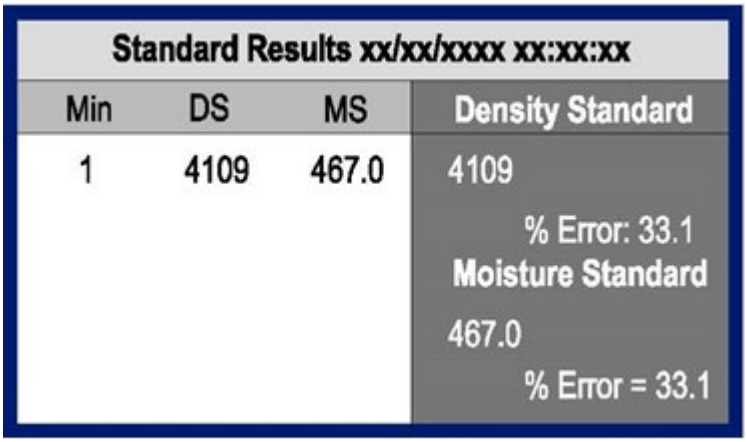
The following will be displayed:



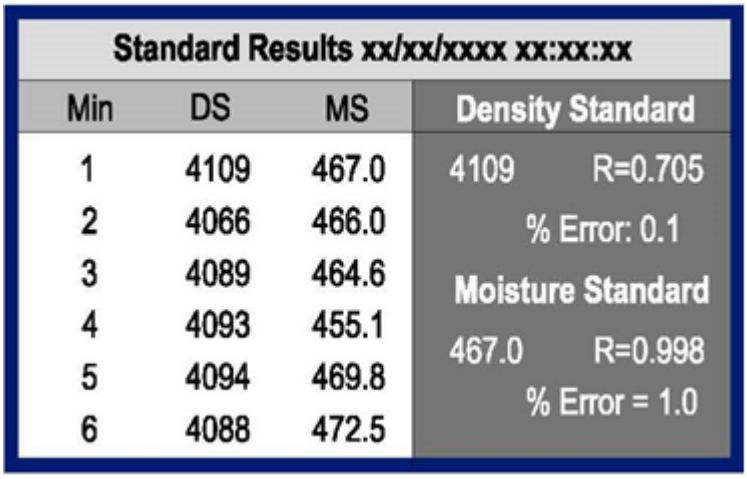
▶ Press 

The following will be displayed:

- During the counting period, the following display will be updated with counts every one minute:



- At the end of the counting period, the following will be displayed:



Record the following displayed values:

- R in the DS row as the **density ratio**.
- R in the MS row as the **moisture ratio**.

If an error message is displayed:

▶ Press OK

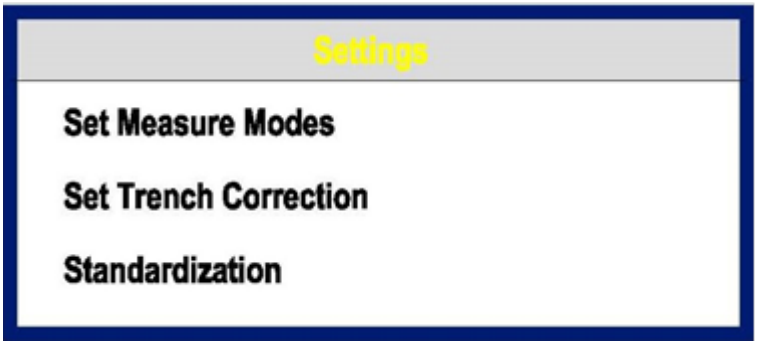
or

STD / STAT to take new counts.

▶ Press MENU and the display will return to the main menu.

▶ Press SETUP

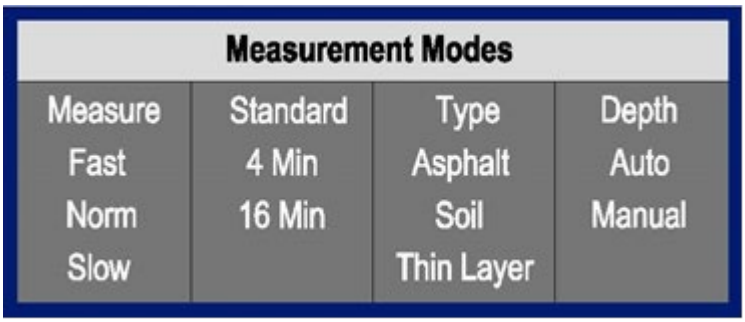
The following will be displayed:



Select **'Set Measure Modes'.**

▶ Press OK

The following will be displayed:



- Press **'4MIN'** Check all other settings are **'Norm'**, **'Soil'** and **'Auto'**.
- Press 

- Press 

and the display will return to the main menu.
- Press 

if the nuclear gauge is not required for further use.

Operating Instruction N131: Standard Count Instrotek Xplorer 2 3500

1 Set up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

- Press 

and allow the nuclear gauge to complete the self-test routine.

2 Measurement

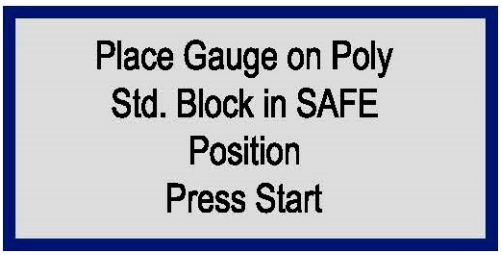
When **<GAUGE READY>** is displayed:

- Press 

and the following is displayed:

- Press 

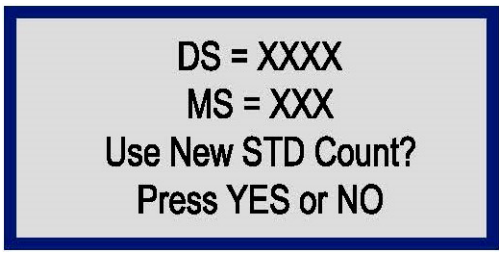
and the following is displayed:



- Press 

and the time will count down from 240 seconds and display:

- At the end of the counting period the following will be displayed:



Record the following values:

- DS as the **density standard count**.
- MS as the **moisture standard count**.

- Press 

and the display will return to <**GAUGE READY**>.

- Press 

if the nuclear gauge is not required for further use.

Operating Instruction N132: Statistical Count Instrotek Xplorer 2 3500

1 Set up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge furthest from the source rod is in contact with the metal plate on the side of the block.

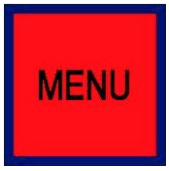
Check the source rod handle is correctly located in the shielded position.

▶ Press 

and allow the nuclear gauge to complete the self-test routine.

2 Measurement

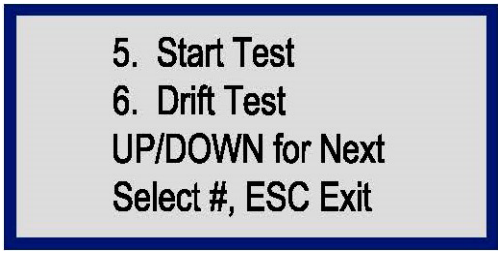
When **<GAUGE READY>** is displayed:

▶ Press 

and the following is displayed:

▶ Press 

repeatedly until the following is displayed:

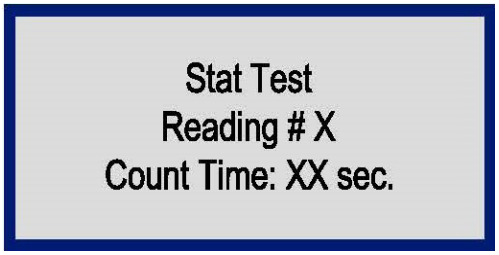


▶ Press 

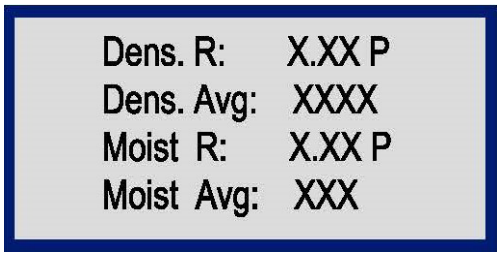
and the following is displayed:

▶ Press 

and the following is displayed

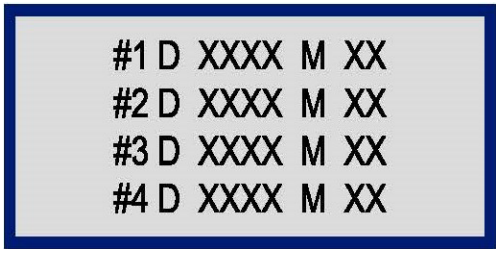


- At the end of the counting period the following is displayed:

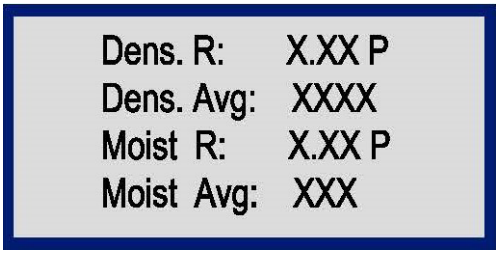


Record Dens. R as the **density ratio**.
Record Moist R MS as the **moisture ratio**.

- Press DOWN and the following is displayed:



- Press DOWN repeatedly to view individual counts and return to the following screen:



- Press START / ENTER and the display will return to <**GAUGE READY**>.
- Press NO / OFF if the nuclear gauge is not required for further use.

Operating Instruction N133: Standard Count Humboldt 5001EZ-2

1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge closest to the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

- Press **POWER** and allow the nuclear gauge to complete the initialising routine.

The following will be displayed:

```
F1 DATA          XX/XX/XXXX
F2 SETUP
F3 ENGINEERING
                 DEPTH = SAFE
```

2 Measurement

- Press **F2**

The following will be displayed:

```
F1 SETUP 2
F2 SET MEASURE MODES
F3 SET TRENCH COR.
F4 SET TARGETS
```

- Press **F2**

The following will be displayed:

```
F1 MEAS   FAST / NORM / SLOW
F2 STD    4MIN / 16MIN
F3 TYPE   ASPH / SOIL / THIN
F4 DEPTH  AUTO / MANUAL
```

- Press **F2** repeatedly until **'4MIN'** flashes.
- Press **STD/STAT**

The following will be displayed:

▶ Press F3

The following will be displayed:

▶ At the end of the counting period, the following will be displayed:

or

Record the following displayed values if no error message is displayed:

- DS as the **density standard count**.
- MS as the **moisture standard count**.

▶ Press MAIN MENU and the display will return to the main menu.

If an error message is displayed:

▶ Press F4 MAIN MENU and the display will return to the main menu.

▶ Press POWER if the nuclear gauge is not required for further use.

Operating Instruction N134: Statistical Count Humboldt 5001EZ-2

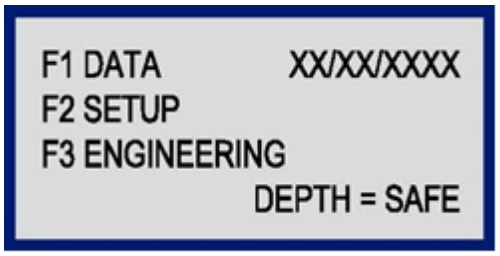
1 Set-up

Position the nuclear gauge on the reference block between its raised edges, such that the side of the nuclear gauge closest to the source rod is in contact with the metal plate on the side of the block.

Check the source rod handle is correctly located in the shielded position.

- Press **POWER** and allow the nuclear gauge to complete the initialising routine.

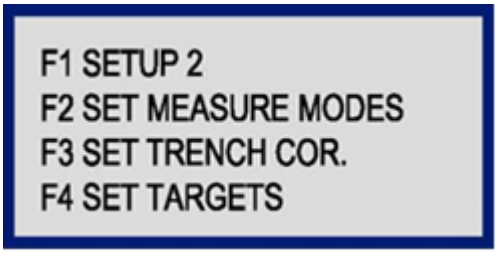
The following will be displayed:



2 Measurement

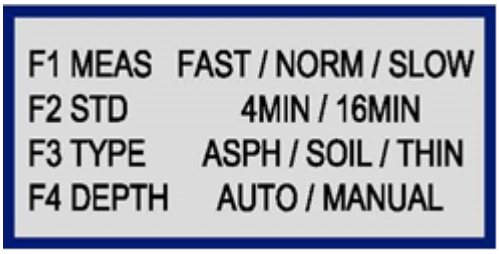
- Press **F2**

The following will be displayed:



- Press **F2**

The following will be displayed:

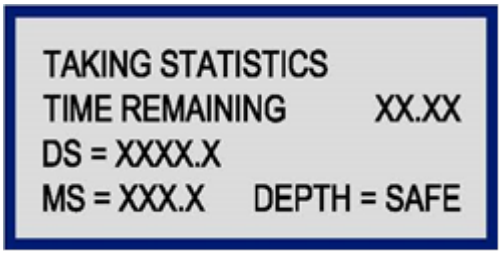


- Press **F2** repeatedly until **'16MIN'** flashes.
- Press **STD/STAT**

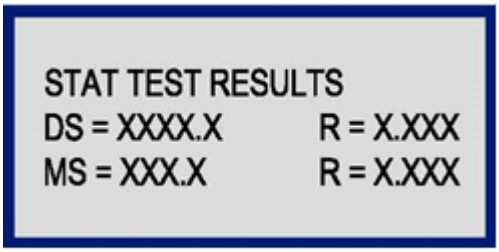
The following will be displayed:

▶ Press 

The following will be displayed:



▶ At the end of the counting period, the following will be displayed:



Record the following displayed values:

- R in the DS row as the **density ratio**.
- R in the MS row as the **moisture ratio**.

If an error message is displayed:

▶ Press 

or

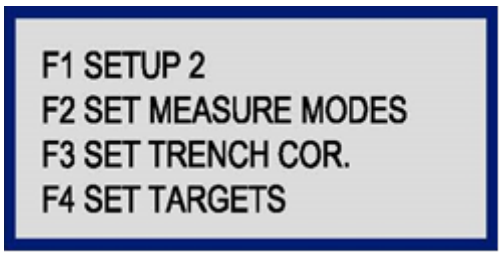
to take new counts.

▶ Press 

and the display will return to the main menu.

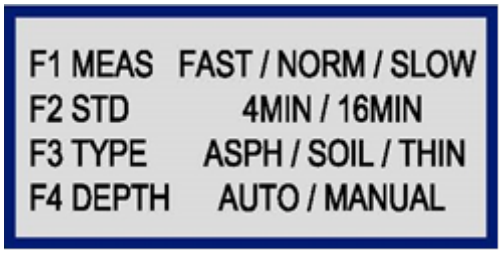
▶ Press 

The following will be displayed:



- Press F2

The following will be displayed:



- Press F2 repeatedly until **'4MIN'** flashes.
- Press MAIN MENU and the display will return to the main menu.
- Press POWER if the nuclear gauge is not required for further use.

Operating Instruction N201: Test Parameters (Soils) Troxler 3440

1 Set-up

▶ Press [ON] and allow the nuclear gauge to complete the self-test routine.

2 Units

When <**READY**> is displayed:

▶ Press [SHIFT / x]

▶ Press [SPECIAL / 9] and the following is displayed:

```
SPECIAL FUNCTION
YES – Next menu
1 - STAT TEST
2 - DRIFT TEST
```

▶ Press [YES / EXIT] repeatedly until the following is displayed:

```
YES – Next menu
9 - SET UNITS
10 - BAND RATE
11 - COMM PROTOCOL
```

▶ Press [SPECIAL / 9] and the following is displayed:

```
UNITS in XXX
Press 1 – PCF
      2 – METRIC
ENTER – No change
```

▶ Press [DEPTH / 2] and the following is displayed:

```
UNITS IN METRIC
```

The display will return to <**READY**>.

3 Count time

▶ Press [TIME / -] and the following is displayed:

```
TIME: XX
1 – 15 sec
2 – 1 min
3 – 4 min
```

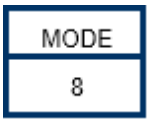
▶ Press [DEPTH / 2] and the following is displayed:

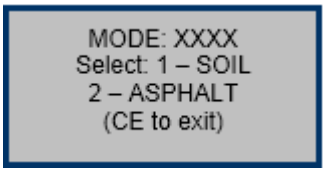
```
-COUNT TIME-
1 min
```

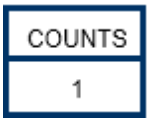
The display will return to <**READY**>.

4 Soil mode

▶ Press 

▶ Press 

and the following is displayed: 

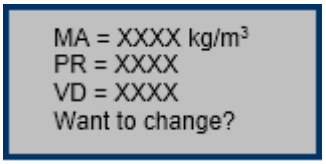
▶ Press 

And the following will be displayed briefly: 

The display will return to <**READY**>.

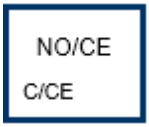
5 Maximum dry density

▶ Press 

and the following is displayed: 

To retain the value, go to 5.1.
To change the value, go to 5.2.

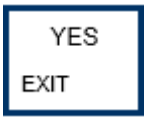
5.1 Retain the value

▶ Press 

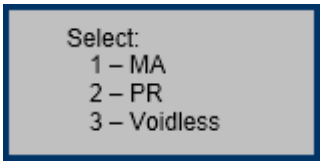
to retain the displayed value of PR.

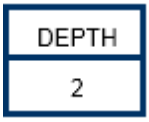
The display will return to <**READY**>. Go to 6.

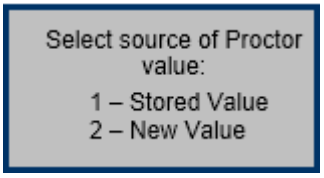
5.2 Change the value

▶ Press 

to change the displayed value of PR.

And the following will be displayed: 

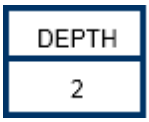
▶ Press 

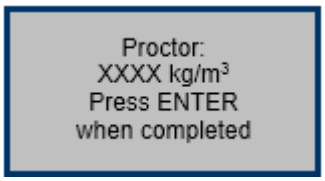
and the following is displayed: 

To enter a new value, go to 5.3.

To select a stored value, go to 5.4.

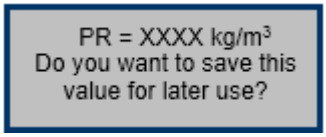
5.3 Enter a new value

▶ Press 

and the following is displayed: 

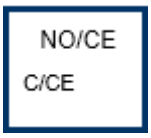
▶ Use the numbered keys to enter the required value to the nearest 1 kg/m³.

▶ Press 

and the following is displayed: 

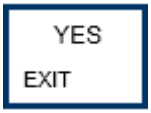
Note: It is not necessary to save the displayed value to enable it.

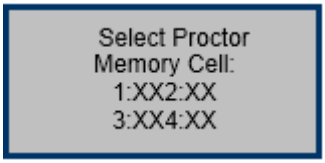
If the value is not to be saved:

▶ Press 

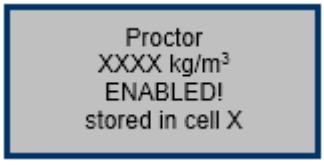
and the display will return to <**READY**>. Go to 6.

To save the displayed value:

▶ Press 

and the following is displayed: 

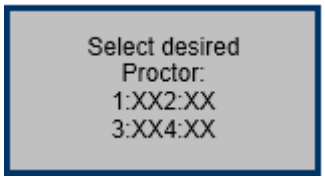
▶ Press the numbered key (1, 2, 3 or 4) to select a memory cell in which to store the value.

And the following will be displayed: 

The display will return to <**READY**>. Go to 6.

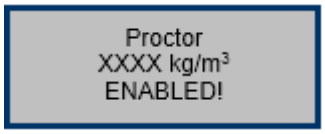
5.4 Select a stored value

▶ Press COUNTS 1 and the following is displayed:



▶ Press the numbered key (1, 2, 3 or 4) to select the required value:

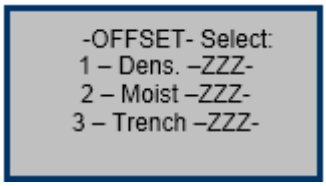
And the following will be displayed:



The display will return to <**READY**>.

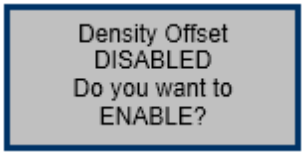
6 Wet density bias

▶ Press OFFSET MR and the following is displayed:

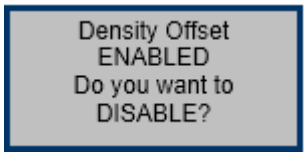


▶ Press COUNTS 1

The following will be displayed:



or



To disable the wet density bias, go to 6.1.

To enable the wet density bias, go to 6.2.

6.1 Disable wet density bias

▶ Press NO/CE C/CE to confirm the density offset is to remain disabled or YES EXIT to disable the density offset.

And the following will be displayed briefly:

The display will return to <**READY**>. Go to 7.

6.2 Enable wet density bias

▶ Press YES / EXIT to enable the density offset or NO/CE / C/CE to confirm the density offset is to remain enabled.

The following will be displayed:

To retain the value, go to 6.2.1.

To change the value, go to 6.2.2.

6.2.1 Retain the value

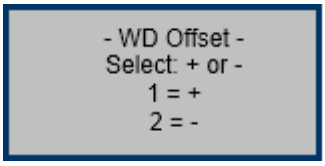
▶ Press NO/CE / C/CE to retain the displayed value of wet density offset.

The following will be displayed briefly:

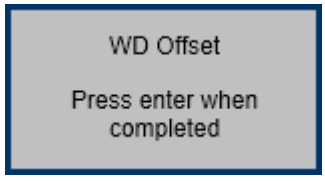
The display will return to <**READY**>.

6.2.2 Change the value

▶ Press YES / EXIT and the following is displayed:



▶ Press COUNT / 1 or DEPTH / 2 and the following is displayed:



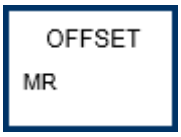
▶ Use the numbered keys to enter the required value to the nearest 1 kg/m³.

▶ Press START/ ENTER / =

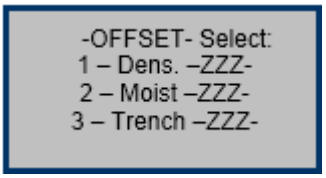
The following will be displayed:

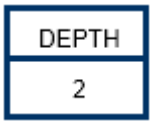
The display will return to <**READY**>.

7 Moisture bias

▶ Press 

and the following is displayed:



▶ Press 

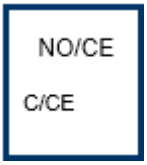
The following will be displayed:

or

To disable the moisture bias, go to 7.1.

To enable the moisture bias, go to 7.2.

7.1 Disable moisture bias

▶ Press 

to confirm the moisture offset is to remain disabled

or 

to disable the moisture offset.

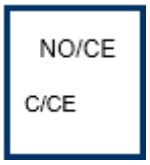
And the following will be displayed briefly:

The display will return to <**READY**>. Go to 8.

7.2 Enable moisture bias

▶ Press 

to enable the moisture offset

or 

to confirm the moisture offset is to remain enabled.

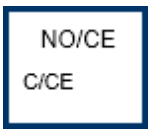
And the following will be displayed:

To retain the displayed K value, go to 7.2.1.

To change the displayed K value to a gauge-derived value, go to 7.2.2.

To change the displayed K value to a stored value, go to 7.2.3.

7.2.1 Retain the value

▶ Press 

to retain the displayed K value.

The following will be displayed:

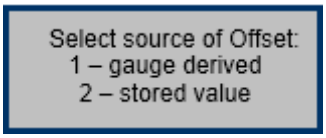
The display will return to <**READY**>. Go to 8.

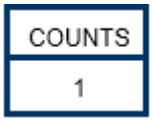
7.2.2 Change to a gauge-derived value

To change the moisture bias to a gauge-derived value:

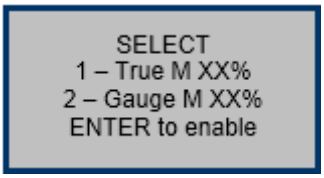
▶ Press 

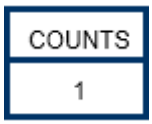
and the following is displayed:



▶ Press 

and the following is displayed:



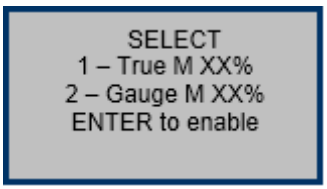
▶ Press 

and the following is displayed:

▶ Use the numbered keys to enter the mean oven-dry moisture content to the nearest 0.1%.

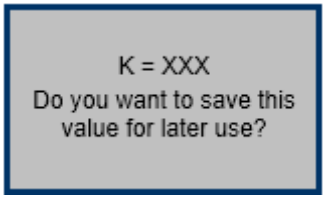
▶ Press 

and the following is displayed:

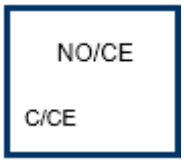


▶ Press 

and the following is displayed:



If the value is not be saved:

▶ Press 

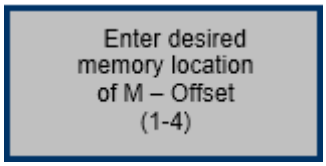
And the following will be displayed:

The display will return to <**READY**>. Go to 8.

To save the displayed value:

▶ Press 

and the following is displayed:



▶ Press a numbered key (1, 2, 3 or 4) to select a memory cell in which to store the value.

▶ Press 

And the following will be displayed:

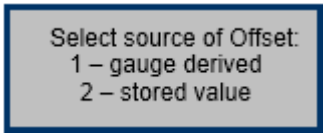
And the following will be displayed briefly:

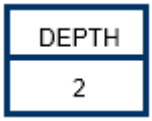
The display will return to <**READY**>. Go to 8.

7.2.3 Change to a stored value

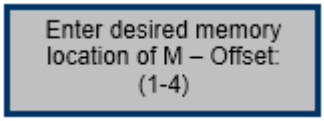
▶ Press 

and the following is displayed:



▶ Press 

and the following is displayed:



▶ Press a numbered key (1, 2, 3 or 4) to select the required memory location.

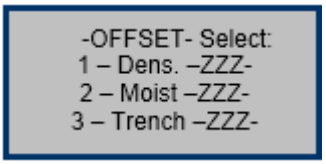
▶ Press 

and the following is displayed:

The display will return to <**READY**>.

8 Trench offset

▶ Press OFFSET MR and the following is displayed:



▶ Press CALC 3 and the following is displayed:

or

▶ Press NO/CE C/CE to disable the trench offset.

The following will be displayed briefly:

The display will return to <**READY**>.

▶ Press OFF if the nuclear gauge is not required for further use.

Operating Instruction N202: Measurement (Soils) Troxler 3440

1 Set-up

▶ Press [ON] and allow the nuclear gauge to complete the self-test routine.

2 Measurement

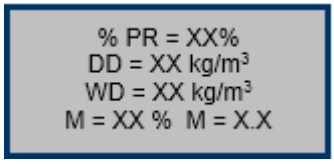
When <**READY**> is displayed:

▶ Press [ENTER]

In the manual depth mode, the gauge will prompt for the source rod depth.

In the automatic mode, the gauge software reads the depth strip on the source rod to determine the depth.

At the end of the counting period, the following will be displayed:



Record the following values:

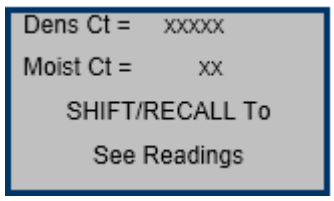
- % PR as the **percent protector** to the nearest 0.1%.
- DD as the **dry density** to the nearest 0.001 t/m³.
- WD as the **wet density** to the nearest 0.001 t/m³.
- M as the **water content (t/m³)** to the nearest 0.001 t/m³.
- % M as the **moisture content (%)** to the nearest 0.1%.

(To convert from kg/m³ to t/m³, divide the displayed value by 1000).

▶ Press [SHIFT]

▶ Press [COUNTS]

And the following will be displayed:



Record the following values as appropriate:

- Dens Ct as the **density count**.
- Moist Ct as the **moisture count**.

▶ Press [NO/CE] and the display will return to <**READY**>.

▶ Press [OFF] if the nuclear gauge is not required for further use.

Operating Instruction N203: Test Parameters (Soils) Troxler 3430

1 Set-up

▶ Press [ON / YES] and allow the nuclear gauge to complete the self-test routine.

2 Units

When <**READY**> is displayed:

▶ Press [SPECIAL] and the following is displayed: - RECALL - (↑↓ or ENTER)

▶ Press [↓] repeatedly until the following is displayed: - SET UNITS - (↑↓ or ENTER)

▶ Press [START / ENTER] and the following is displayed: Units: kg/m³ (↑↓ or ENTER)

▶ Press [↓] to set the desired unit.

▶ Press [ON / YES] and the display will return to <**READY**>.

3 Count time

▶ Press [TIME] and the following is displayed: TIME: X min (↑↓ or ENTER)

▶ Press [↓] to set the desired count time.

▶ Press [ON / YES] and the display will return to <**READY**>.

4 Depth

▶ Press [DEPTH] and the following is displayed: DEPTH: X min (↑↓ to CHANGE)

▶ Press [↓] repeatedly until the required test depth is displayed.

▶ Press [ON / YES] and display will return to <**READY**>.

5 Soil mode and maximum dry density

▶ Press MA/PR and the following is displayed:

▶ Press ↓ until PR is displayed.

To retain the displayed value, go to 5.1.

To change the displayed value, go to 5.2.

5.1 Retain the value

▶ Press OFF/NO to retain the displayed value of PR.

The display will return to <**READY**>. Go to 6.

5.2 Change the value

▶ Press ON/YES to change the displayed value of PR.

The following is displayed:

For each digit:

▶ Press ↓ repeatedly until the required number is displayed.

▶ Press START/ENTER to confirm each number.

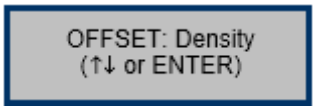
The display will return to <**READY**>.

6 Wet density bias

▶ Press SPECIAL and the following is displayed:

▶ Press ↓ and the following is displayed:

▶ Press START/ENTER and the following is displayed:



▶ Press START/ENTER and the following is displayed:

Dens. Offset OFF
Want to enable?

or

Dens. Offset ON
Want to disable?

To disable the wet density bias, go to 6.1.

To enable the wet density bias, go to 6.2.

6.1 Disable wet density bias

▶ Press OFF/NO to confirm the density offset is to remain disabled or ON/YES to disable the density offset.

And the following will be displayed:

Dens. Offset OFF

The display will return to <**READY**>. Go to 7.

6.2 Enable wet density bias

▶ Press ON/YES to enable the density offset or OFF/NO to confirm the density offset is to remain enabled.

And the following will be displayed:

D off=XXX kg/m³
(↑↓ or ENTER)

To retain the displayed value, go to 6.2.1.

To change the displayed value, go to 6.2.2.

6.2.1 Retain the value

▶ Press START/ENTER

The following will be displayed briefly:

Dens. Offset ON

The display will return to <**READY**>. Go to 7.

6.2.2 Change the value

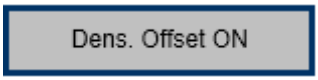
▶ Press ↓ to enter a negative or wet density bias. or ↑ to enter a positive wet density bias.

For each digit:

▶ Press  until the required number is displayed.

▶ Press START/ENTER to confirm each number.

And the following will be displayed:



The display will return to <**READY**>.

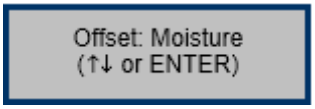
7 Moisture bias

▶ Press SPECIAL and the following is displayed:

▶ Press  and the following is displayed:

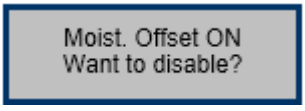
▶ Press START/ENTER and the following is displayed:

▶ Press  and the following is displayed:



▶ Press START/ENTER and the following is displayed:

or



To disable the moisture bias, go to 7.1.

To enable the moisture bias, go to 7.2.

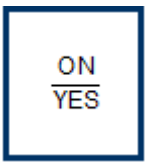
7.1 Disable moisture bias

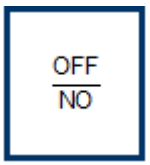
▶ Press OFF/NO to confirm the moisture offset is to remain disabled or ON/YES to disable the moisture offset.

And the following will be displayed:

The display will return to <**READY**>. Go to 8.

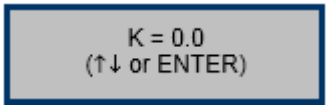
7.2 Enable the moisture bias

▶ Press 

to enable the moisture offset or 

to confirm the moisture offset is to remain enabled.

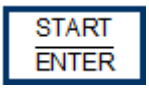
And the following will be displayed:



▶ Press 
to enter a negative K value or 
to enter a positive K value

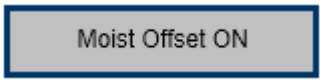
For each digit:

▶ Press 
until the required number is displayed.

▶ Press 

to confirm each number.

And the following will be displayed:



The display will return to <**READY**>.

8 Trench offset

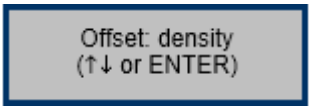
▶ Press 

and the following is displayed:

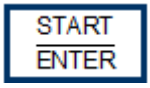
▶ Press 
and the following is displayed:

▶ Press 

and the following is displayed:



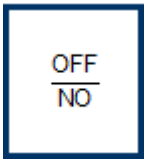
▶ Press 
repeatedly until the following is displayed:

▶ Press 

The following will be displayed:

or 

▶ Press 

to confirm the trench offset is to remain disabled or 

to disable the trench offset.

And the following will be displayed briefly:

The display will return to <**READY**>.

Operating Instruction N204: Measurement (Soils) Troxler 3430

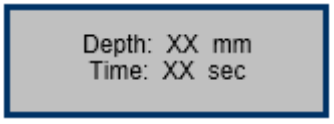
1 Set-up

▶ Press [ON / YES] and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

▶ Press [START / ENTER] and the following is displayed:



At the end of the counting period:

▶ Press [↓] repeatedly until the required values are displayed.

Record the following values:

- WD as the **wet density** to the nearest 0.001 t/m³.
- DD as the **dry density** to the nearest 0.001 t/m³.
- % PR as the **relative compaction** to the nearest 0.1%.
- Moist as the **water content (t/m³)** to the nearest 0.001 t/m³.
- % Moist as the **moisture content (%**) to the nearest 0.1%.
- M Count as the **moisture count**.
- D Count as the **density count**.

(To convert from kg/m³ to t/m³, divide the displayed value by 1000.)

▶ Press [ON / YES] and the display will return to <**READY**>.

▶ Press [OFF / NO] if the nuclear gauge is not required for further use.

Operating Instruction N211: Test Parameters (Soils) Humboldt 5001EZ

1 Start-up

- Press [PWR] and allow the nuclear gauge to complete the initialising routine.

The following will be displayed:

```
*DATA                XX/XX/XX
*SET UP              XX:XX:XX
*ENGINEERING
                     DEPTH=SAF
```

- Press [F2] and the following will be displayed:

```
*SET UP 2
*SET MEASUREMENT MODES
*SET TRNCH COR.
*SET TARGETS
```

2 Measurement units

- Press [F1] and the following will be displayed:

```
*SET DATE
*SET TIME
*UNITS = PCF/SI
```

- Press [F3] repeatedly until '**SI**' flashes.
- Press [MAIN MENU] and the display will return to the main menu.

3 Count time

- Press [F2] [F2]

The following will be displayed:

```
MEAS =  FAST/NORM/SLOW
STD  =  4MIN/16MIN
TYPE =  ASPH/SOIL/THIN
DEPTH =  AUTO/MANUAL
```

- Press [F1] repeatedly until '**NORM**' flashes.

4 Soil mode

▶ Press F3 repeatedly until '**SOIL**' flashes.

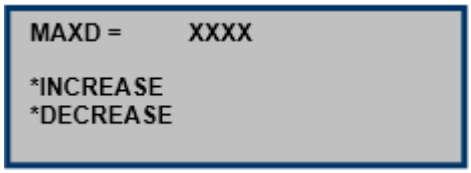
5 Depth

▶ Press F4 repeatedly until '**AUTO**' flashes.

▶ Press MAIN MENU and the display will return to the main menu.

6 Maximum dry density

▶ Press MAX "D" and the following will be displayed:



▶ Press F3 **OR** F4 to increase or decrease the displayed value until the required value (within the range 900 kg/m³ to 3000 kg/m³) is obtained.

(To convert from t/m³ to kg/m³, multiply the maximum dry density by 1000.)

▶ Press MAIN MENU and the display will return to the main menu.

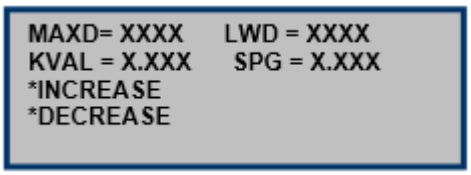
7 Wet density bias

There is no facility to set a wet density bias using the keypad.

8 Moisture bias

▶ Press F2 and the following will be displayed:

▶ Press F4 and the following will be displayed:



▶ Press F2 repeatedly until the '**KVAL**' value flashes.

▶ Press F3 **OR** F4 to increase or decrease the displayed value until the required K value is obtained.

A maximum value of 0.20 (in increments of 0.10) and a minimum value of -0.10 (in increments of 0.01) may be set.

To disable the moisture bias, set a value of "**0.0**".

▶ Press MAIN MENU and the display will return to the main menu.

▶ Press PWR if the nuclear gauge is not required for further use.

Operating Instruction N212: Measurement (Soils) Humboldt 5001EZ

1 Start-up

▶ Press PWR and allow the nuclear gauge to complete the initialising routine.

2 Measurement

▶ Press MEAS and the following will be displayed:

```
TAKING MEASUREMENT
TIME REMAINING     X.XX
DC = X
MC = X             DEPTH=XXX
```

At the end of the counting period, the following will be displayed:

```
DD   = XXXX.X     %M     = XX.X
WD   = XXXX.X     M      = XXX.X
%PR = XXX.X       MAXD   = XXXX
*NEXT             MDEPTH = XXX
```

Record the following values as appropriate:

- DD as the **dry density** to the nearest 0.001 t/m³.
- WD as the **wet density** to the nearest 0.001 t/m³.
- % PR as the **relative compaction** to the nearest 0.1%.
- % M as the **moisture content** to the nearest 0.1%.
- M as the **water content** to the nearest 0.001 t/m³.

To convert from kg/m³ to t/m³, divide the displayed value by 1000.)

▶ Press F4 and the following will be displayed:

```
DC = XXXX.X       DS      = XXXX.X
MC = XX.X         MS      = XXX.X
VR = XX.XX        %AV     = X.XX
*LAST             MDEPTH= XXX
```

Record the following values as appropriate:

- DC as the **density count**.
- MC as the **moisture count**.

▶ Press MAIN MENU and the display will return to the main menu.

▶ Press PWR if the nuclear gauge is not required for further use.

Operating Instruction N217: Test Parameters (Soils) Instrotek Xplorer 3500

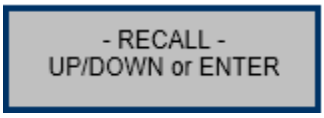
1 Set-up

- Press [ON / YES] and allow the nuclear gauge to complete the self-test routine.

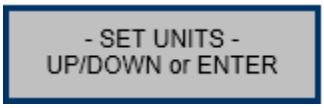
2 Units

When <**READY**> is displayed:

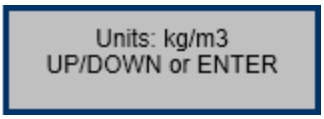
- Press [MENU] and the following is displayed:



- Press [DOWN] repeatedly until the following is displayed:



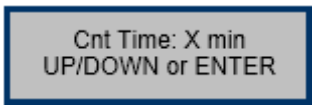
- Press [START / ENTER] and the following is displayed:



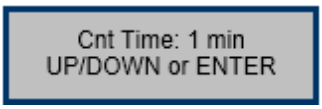
- Press [DOWN] to set the desired unit.
- Press [ON / YES] and the display will return to <**READY**>.

3 Count time

- Press [TIME] and the following is displayed:



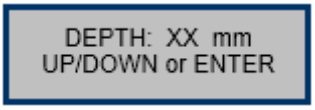
- Press [DOWN] to set the desired count time.



- Press [ON / YES] and the display will return to <**READY**>.

4 Depth

- Press [DEPTH] the following is displayed:



- Press [DOWN] repeatedly until the required test depth is displayed.

▶ Press ON/YES and display will return to <**READY**>.

5 Soil mode and maximum dry density

▶ Press MA/PR and the following is displayed:

▶ Press START/ENTER and the following is displayed:

To retain the displayed value, go to 5.1.

To change the displayed value, go to 5.2.

5.1 Retain value

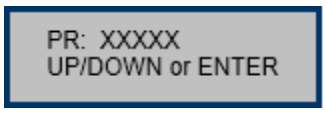
▶ Press OFF/NO to retain the displayed value.

The display will return to the <**READY**> screen. Go to 6.

5.2 Change the value

▶ Press ON/YES to change the displayed value of PR.

The following is displayed:



For each digit:

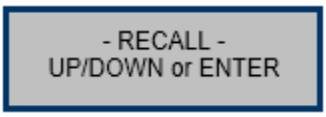
▶ Press DOWN repeatedly until the required number is displayed.

▶ Press START/ENTER to confirm each number.

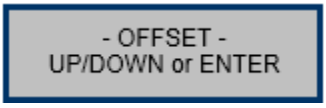
The display will return to <**READY**>. Go to 6.

6 Wet density bias

▶ Press MENU and the following is displayed:



▶ Press DOWN and the following is displayed:



▶ Press START/ENTER and the following is displayed:

Offset: Density
UP/DOWN or ENTER

▶ Press START/ENTER and the following is displayed:

Density Offset OFF
Want to enable?

or

Density Offset ON
Want to disable?

To disable the wet density bias, go to 6.1.

To enable the wet density bias, go to 6.2.

6.1 Disable wet density bias

▶ Press ON/YES to disable the density offset.

or

▶ Press OFF/NO to confirm the density offset is to remain disabled.

The following will be displayed briefly:

Density Offset Disabled

The display will return to <**READY**>. Go to 7.

6.2 Enable wet density bias

▶ Press ON/YES to enable the density offset.

or

▶ Press OFF/NO to confirm the density offset is to remain enabled.

And the following will be displayed:

D Off = XXXX kg/m^3
UP/DOWN or ENTER

To retain the displayed value, go to 6.2.1.

To change the displayed value, go to 6.2.2.

6.2.1 Retain the value

▶ Press START/ENTER and the following will be displayed:

The display will return to <**READY**>. Go to 7.

6.2.2 Change the value

▶ Press UP for a positive value.

or

▶ Press DOWN for a negative value.

For each digit:

▶ Press DOWN until the desired number is displayed.

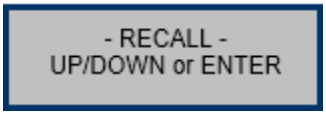
▶ Press START/ENTER to confirm each number.

And the following will be displayed:

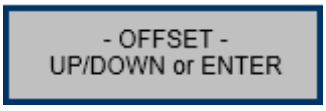
The display will return to <**READY**>.

7 Moisture bias

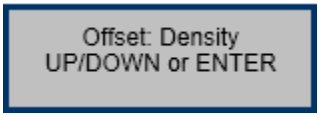
▶ Press MENU and the following is displayed:



▶ Press DOWN and the following is displayed:



▶ Press START/ENTER and the following is displayed:



▶ Press DOWN and the following is displayed:

▶ Press START/ENTER and the following is displayed:

Moist Offset OFF
Want to enable?

or

Moist Offset ON
Want to disable?

To disable the moisture bias, go to 7.1.

To enable the moisture bias, go to 7.2.

7.1 Disable the moisture bias

▶ Press ON/YES to disable the moisture offset.

or

▶ Press OFF/NO to confirm the moisture offset is to remain disabled.

The following will be displayed:

Moisture Offset
Disabled

The display will return to <**READY**>. Go to 8.

7.2 Enable the moisture bias

▶ Press ON/YES to enable the moisture offset.

or

▶ Press OFF/NO to confirm the moisture offset is to remain enabled.

The following will be displayed:

K=XX.X
UP/DOWN or ENTER

To retain the displayed value, go to 7.2.1.

To change the displayed value, go to 7.2.2.

7.2.1 Retain the value

▶ Press START/ENTER and the following is displayed:

Moisture Offset
Enabled

The display will return to <**READY**>. Go to 8.

7.2.2 Change the value

▶ Press UP for a positive value.

or

▶ Press DOWN for a negative value.

For each digit:

▶ Press DOWN until the required number is displayed.

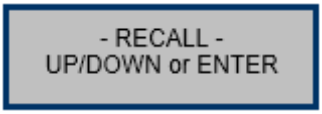
▶ Press START/ENTER to confirm each number.

And the following will be displayed:

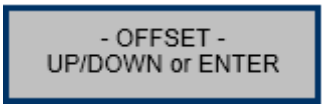
The display will return to <**READY**>.

8 Trench offset

▶ Press MENU and the following is displayed:



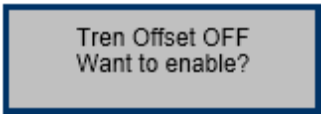
▶ Press DOWN and the following is displayed:



▶ Press START/ENTER and the following is displayed:

▶ Press DOWN repeatedly until the following is displayed:

▶ Press START/ENTER and the following is displayed:



or

▶ Press ON/YES to disable the trench offset.

or

▶ Press OFF/NO to confirm the trench offset is to remain disabled.

The following will be displayed:

The display will return to <**READY**>.

Operating Instruction N218: Measurement (Soils) Instrotek Xplorer 3500

1 Set-up

▶ Press [ON / YES] and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

▶ Press [START / ENTER] and the following is displayed:

```
Time = XX  sec
Depth:  XX  mm
```

At the end of the counting period:

▶ Press [DOWN] repeatedly until the required values are displayed.

Record the following values as appropriate:

- WD as the **wet density** to the nearest 0.001 t/m³.
- DD as the **dry density** to the nearest 0.001 t/m³.
- % PR as the **relative compaction** to the nearest 0.1%.
- Moist as the **water content (t/m³)** to the nearest 0.001 t/m³.
- % M as the **moisture content (%)** to the nearest 0.1%.
- M Count as the **moisture count**.
- D Count as the **density count**.

(To convert from kg/m³ to t/m³, divide the displayed value by 1000.)

▶ Press [ON / YES] and the display will return to <**READY**>.

▶ Press [OFF / NO] If the nuclear gauge is not required for further use.

Operating Instruction N219: Test Parameters (Soils) Troxler 3440P

1 Start up

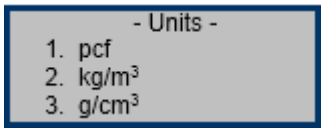
- Turn the power switch on and allow the nuclear gauge to complete the self-test routine.

2 Measurement units

When <**READY**> is displayed:

- Press SETUP
- Press 2

The following will be displayed:



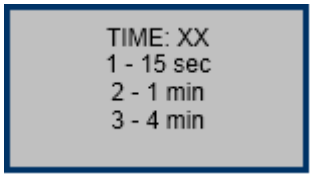
- Press 2

The following will be displayed:

The display will return to <**SETUP**>.

3 Count time

- Press SETUP
- Press 1 and the following is displayed:



- Press 2

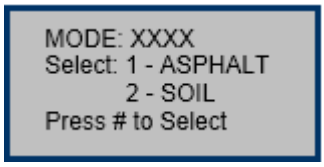
The following will be briefly displayed:

The display will return to <**READY**>.

4 Soil mode

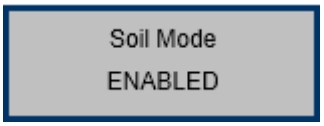
▶ Press MODE

The following will be displayed:



▶ Press 2

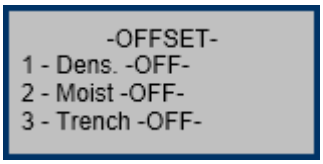
The following will be displayed briefly:



The display will return to <**READY**>.

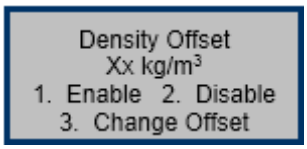
5 Wet density bias

▶ Press OFFSET the following is displayed:



▶ Press 1

The following will be displayed:



To disable the wet density bias, go to Step 5.1.

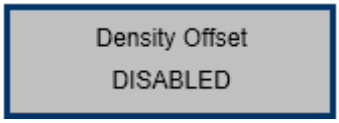
To enable the wet density bias, go to Step 5.2.

To change the wet density bias, go to Step 5.3.

5.1 Disable wet density bias

▶ Press 2

The following will be displayed briefly:



The display will return to <**READY**>. Go to 7.

5.2 Enable wet density bias

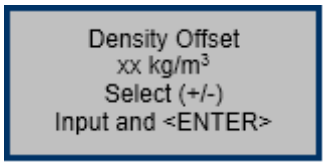
▶ Press 

The following will be displayed:

5.3 Change wet density bias

▶ Press 

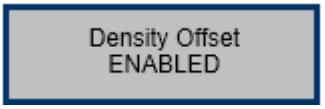
the following is displayed:



▶ Use the numbered keys to enter the required value to the nearest 1 kg/m³.
(To convert from t/m³ to kg/m³, multiply the wet density bias by 1000.)

▶ Press 

The following will be displayed briefly:

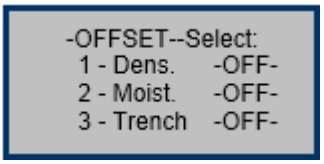


The display will return to <**READY**>.

6 Moisture bias

▶ Press 

the following is displayed:



▶ Press 

The following will be displayed:

6.1 Disable moisture bias

▶ Press 

The following will be displayed:

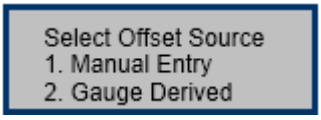
The display will return to <**READY**>. Go to Step 8.

6.2 Enable the moisture bias

▶ Press the number corresponding to any of the stored values.

6.3 Change a moisture bias value

▶ Press [5] the following is displayed:

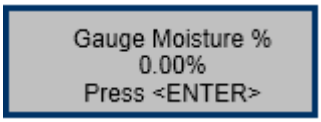


For manual entry:

▶ Press [1] the following is displayed:

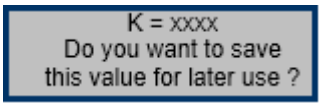
Use the numbered keys to enter the mean oven-dry moisture content to the nearest 0.01%.

▶ Press [ENTER START] the following is displayed:



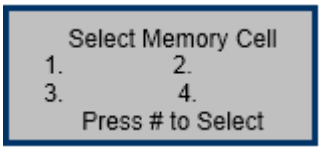
Use the numbered keys to enter the mean nuclear gauge moisture content to the nearest 0.01%.

▶ Press [ENTER START] the following is displayed:



To save the displayed value:

▶ Press [YES] the following is displayed:



▶ Press a numbered key (1, 2, 3 or 4) to select a memory location in which to save the value.

The following will be displayed briefly:

If the value is not to be displayed:

▶ Press [NO]

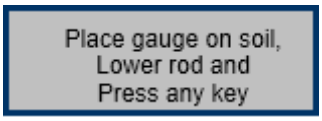
The display will return to <**READY**>.

For gauge derived:

▶ Press [2] the following is displayed:

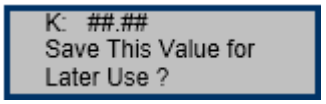
Use the numbered keys to enter the true moisture content to the nearest 0.01%.

▶ Press ENTER START the following is displayed:



Place the gauge on the measurement site and press any key.

At the completion of the counting period, the following will be displayed:



To save the value:

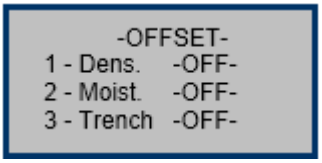
▶ Press YES

To enable the value without storing:

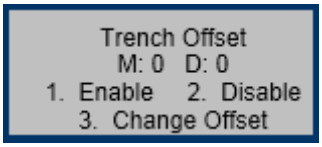
▶ Press NO

7 Trench offset

▶ Press OFFSET the following is displayed:



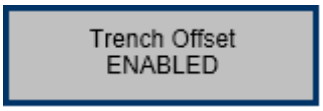
▶ Press 3 the following is displayed:



To enable the trench offset:

▶ Press 1

The following is displayed:



To disable the trench offset:

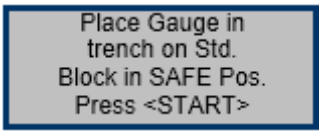
▶ Press 2

The following is displayed:

To change the trench offset:

- Press 

The following is displayed:



- Press 

At the end of the counting period, the display will return to <**READY**>.

- Turn the power switch off if the nuclear gauge is not required for further use.

Operating Instruction N220: Measurement (Soils) Troxler 3440P

1 Start up

▶ Turn the power switch on and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

▶ Press ENTER START the following is displayed:

```
Depth:  XX mm
PR:  XXXX kg/m³
Time:  XX sec.
```

In the manual depth mode, the gauge will prompt for the source rod depth. In automatic mode, the gauge software reads the depth strip on the source rod to determine the depth.

At the end of the counting period, the following will be displayed:

```
% PR = XX%
DD = XX kg/m³
WD = XX kg/m³
M = XX %  M = X.X
```

Record the following values as appropriate:

- % PR as the **relative compaction** to the nearest 0.1%.
- DD as the **dry density** to the nearest 0.001 t/m³.
- WD as the **wet density** to the nearest 0.001 t/m³.
- M as the **water content (t/m³)** to the nearest 0.001 t/m³.
- % M as the **moisture content (%)** to the nearest 0.1%.

(To convert from kg/m³ to t/m³, divide the displayed value by 1000.)

▶ Press ESC

▶ Press RECALL

▶ Press ↓

The following will be displayed:

```
DC = xxxx
MC = xx
```

Record the following values as appropriate:

- DC as the **density count**.
- MC as the **moisture count**.

▶ Press ESC and the display will return to <**READY**>.

▶ Turn the power switch off if the nuclear gauge is not required for further use.

Operating Instruction N221: Test Parameters (Soils) Troxler 3430P

1 Start up

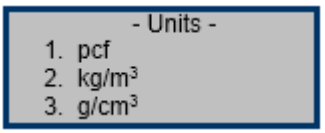
- Turn the power switch on and allow the nuclear gauge to complete the self-test routine.

2 Measurement units

When <**READY**> is displayed:

- Press SETUP
- Press 2

The following will be displayed:



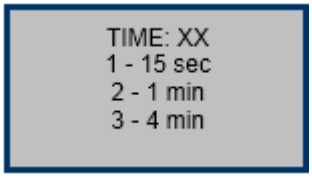
- Press 2

The following will be displayed briefly:

The display will return to <**SETUP**>.

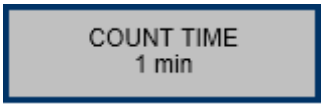
3 Count time

- Press SETUP
- Press 1 and the following is displayed:



- Press 2

The following will be displayed briefly:

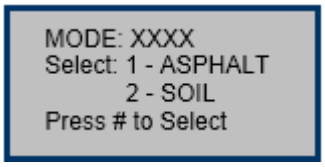


The display will return to <**READY**>.

4 Soil mode

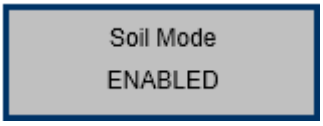
▶ Press MODE

The following will be displayed:



▶ Press 2

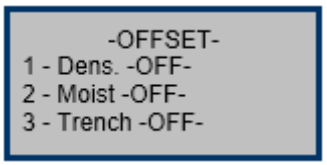
The following will be displayed briefly:



The display will return to <**READY**>.

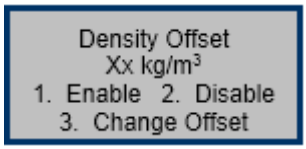
5 Wet density bias

▶ Press OFFSET the following is displayed:



▶ Press 1

The following will be displayed:



To disable the wet density bias, go to Step 5.1.

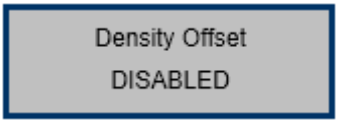
To enable the wet density bias, go to Step 5.2.

To change the wet density bias, go to Step 5.3.

5.1 Disable wet density bias

▶ Press 2

The following will be displayed briefly:

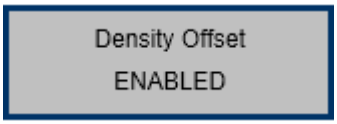


The display will return to <**READY**>. Go to 7.

5.2 Enable wet density bias

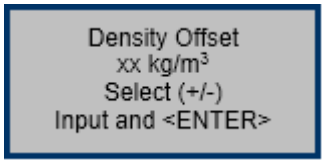
- Press [1]

The following will be displayed:



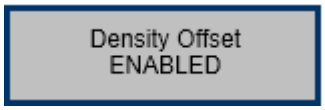
5.3 Change wet density bias

- Press [3] the following is displayed:



- Use the numbered keys to enter the required value to the nearest 1 kg/m³.
  (To convert from t/m³ to kg/m³, multiply the wet density bias by 1000.)
- Press [ENTER START]

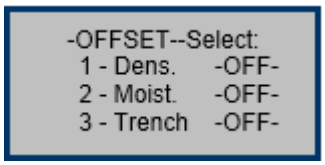
The following will be displayed briefly:



The display will return to <**READY**>.

6 Moisture bias

- Press [OFFSET] the following is displayed:



- Press [2]

The following will be displayed:

6.1 Disable moisture bias

- Press [6]

The following will be displayed:

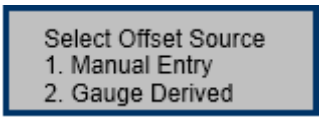
The display will return to <**READY**>. Go to Step 8.

6.2 Enable the moisture bias

▶ Press the number corresponding to any the stored values.

6.3 Change a moisture bias value

▶ Press [5] the following is displayed:

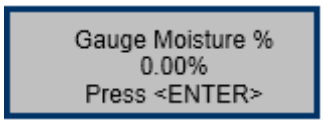


For manual entry:

▶ Press [1] the following is displayed:

Use the numbered keys to enter the mean oven-dry moisture content to the nearest 0.01%.

▶ Press [ENTER START] the following is displayed:



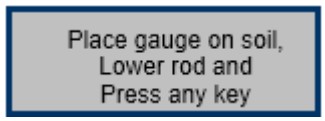
Use the numbered keys to enter the mean nuclear gauge moisture content to the nearest 0.01%.

For gauge derived:

▶ Press [2] the following is displayed:

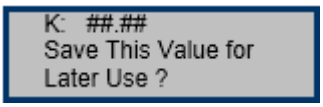
Use the numbered keys to enter the true moisture content to the nearest 0.01%.

▶ Press [ENTER START] the following is displayed:



Place the gauge on the measurement site and press any key.

At the completion of the counting period, the following will be displayed:



To save the value:

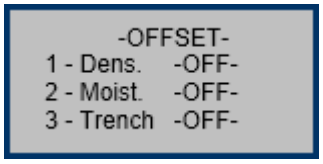
▶ Press [YES]

To enable the value without storing:

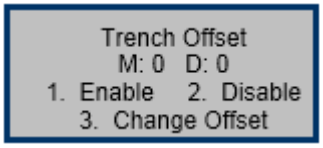
▶ Press [NO]

7 Trench offset

▶ Press OFFSET the following is displayed:



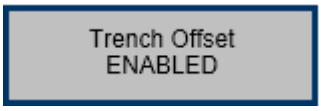
▶ Press 3 the following is displayed:



To enable the trench offset:

▶ Press 1

The following is displayed:



To disable the trench offset:

▶ Press 2

The following is displayed:

To change the trench offset:

▶ Press 3

The following is displayed:

▶ Press ENTER/START

At the end of the counting period, the display will return to <**READY**>.

▶ Turn the power switch off if the nuclear gauge is not required for further use.

Operating Instruction N222: Measurement (Soils) Troxler 3430P

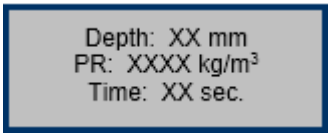
1 Start up

▶ Turn the power switch on and allow the nuclear gauge to complete the self-test routine.

2 Measurement

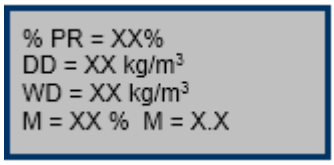
When <**READY**> is displayed:

▶ Press ENTER START the following is displayed:



In the manual depth mode, the gauge will prompt for the source rod depth. In automatic mode, the gauge software reads the depth strip on the source rod to determine the depth.

At the end of the counting period, the following will be displayed:



Record the following values as appropriate:

- % PR as the **relative compaction** to the nearest 0.1%.
- DD as the **dry density** to the nearest 0.001 t/m³.
- WD as the **wet density** to the nearest 0.001 t/m³.
- M as the **water content (t/m³)** to the nearest 0.001 t/m³.
- % M as the **moisture content (%)** to the nearest 0.1%.

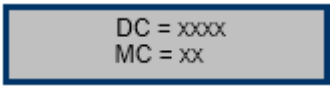
(To convert from kg/m³ to t/m³, divide the displayed value by 1000.)

▶ Press ESC

▶ Press RECALL

▶ Press ↓

The following will be displayed:



Record the following values as appropriate:

- DC as the **density count**.
- MC as the **moisture count**.

▶ Press ESC and the display will return to <**READY**>.

▶ Turn the power switch off if the nuclear gauge is not required for further use.

Operating Instruction N225: Test Parameters (Soils) CPN MC1 and MC3 Elite

1 Set-up

▶ Press [ON / YES] and allow the nuclear gauge to complete the self-test routine.

2 Units

▶ Press [MENU] the first screen will be:

```
1. Recall
2. Set depth
UP/DOWN for next
Select #, ESC exit
```

▶ Press [DOWN] the following is displayed:

```
11. Auto scroll
12. Set units
UP/DOWN for next
Select #, ESC exit
```

▶ Press [12] (button **1**, then **2**)

```
1. PCF
2. kg/m3
3. GCC
Select #, ESC exit
```

▶ After selecting the unit of measurement, the gauge returns to the menu screen.

```
11. Auto scroll
12. Set units
UP/DOWN for next
Select #, ESC exit
```

▶ Press [ESC] returns to the ready screen

```
GAUGE READY
COUNT TIME: # min
Depth: ###    Offset: N
<date>        <time>
```

3 Count time

▶ Press [TIME] and the following is displayed:

```
Cnt Time: ## min.
UP/DOWN TO CHANGE
YES to Accept
ESC to Exit
```

▶ Press UP and DOWN to set the desired count time.

▶ Press [YES] returns to the ready screen

```
GAUGE READY
COUNT TIME: # min
Depth: ###    Offset: N
<date>        <time>
```

4 Depth

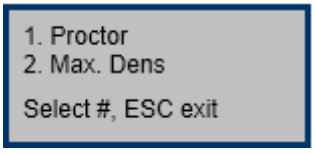
The Elite gauge is equipped with an automatic non-magnetic depth indicator. The depth is automatically read as you lower the source into the measure position and the appropriate constants are selected to calculate the density.

The gauge can be placed into manual depth mode by disabling the Automatic depth mode from the MENU functions.

5 Soil mode and maximum dry density

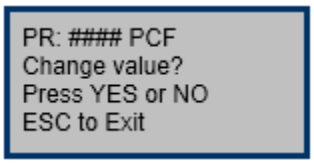
▶ Press 

and the following is displayed:

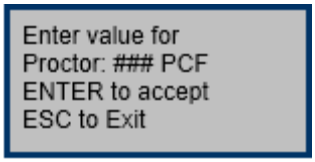


▶ Press 

for Proctor.



▶ Press 



Use the number buttons to change the value. Once you have entered the PR value, the gauge will return to ready screen.

6 Offset

There are three offset options for the gauge: density, moisture, and trench.

To use the offset mode:

▶ Press 

▶ Press 

▶ Scroll **UP** and **DOWN** to select the offset you want to enable.

▶ For entering a negative number, use the **DOWN** button; for a positive number, use the **UP** button.

Note: When an offset is enabled, a **Y** on the gauge ready screen will appear next to the offset.

Operating Instruction N226: Measurement (Soils) CPN MC1 and MC3 Elite

1 Set-up

▶ Press [ON / YES] and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When the ready screen is displayed:

▶ Press [START / ENTER] and the following is displayed.

```
Depth:  XX  mm

Time:  XX  sec
```

At the end of the counting period, the gauge will display:

▶

```
M Count: ###
D Count: ###
MCR: ###    DCR: ###
Press UP/DOWN
```

▶

```
WD: #### kg/m3
%MA: ####
%VOIDS: ####
Press UP/DOWN
```

▶

```
Moist: #### kg/m3
DD: #### kg/m3
% Mois: #.#   %PR: #.#
Press UP/DOWN
```

Record the following values:

- WD as the **wet density** to the nearest 0.001 t/m³.
- DD as the **dry density** to the nearest 0.001 t/m³.
- % PR as the **relative compaction** to the nearest 0.1%.
- Moist as the **water content (t/m³)** to the nearest 0.001 t/m³.
- % Moist as the **moisture content (%)** to the nearest 0.1%.
- M Count as the **moisture count**.
- D Count as the **density count**.

(To convert from kg/m³ to t/m³, divide the displayed value by 1000.)

▶ Press [ON / YES] and the display will return to the ready screen.

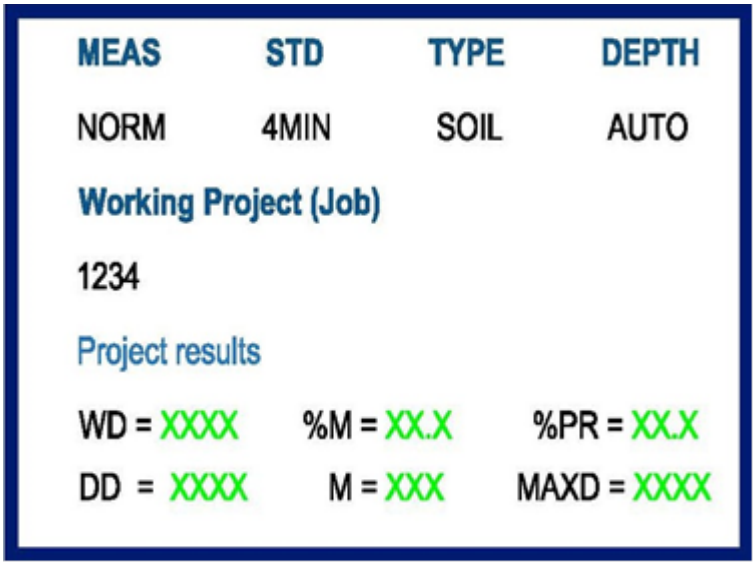
▶ Press [OFF / NO] if the nuclear gauge is not required for further use.

Operating Instruction N227: Test Parameters (Soils) Humboldt 5001SD

1 Start-up

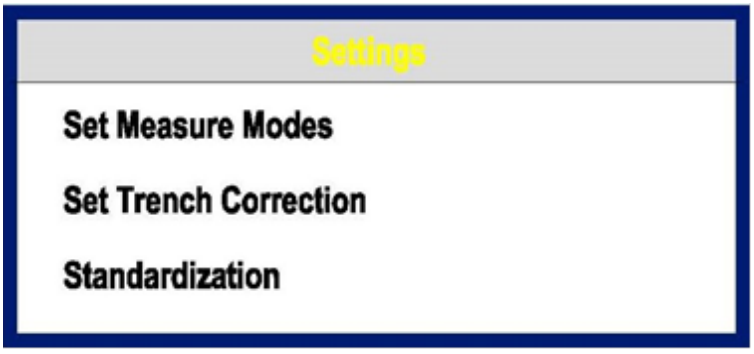
▶ Press ON/OFF and allow the nuclear gauge to complete the initialising routine.

The following will be displayed:



▶ Press SETUP

The following will be displayed:



2 Measurement units

▶ Press 

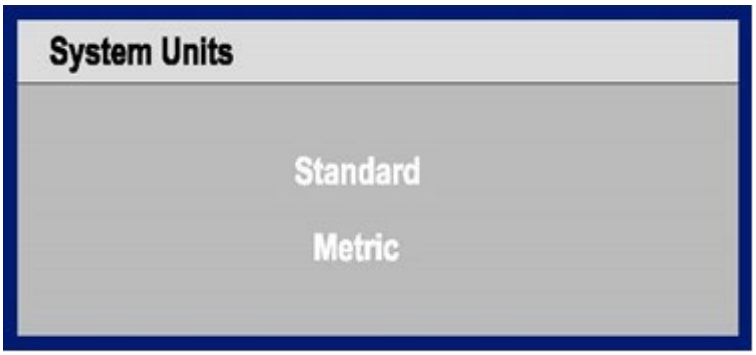
or

until the following is displayed:

Select **'System Units'.**

▶ Press 

The following will be displayed:



Select **'Metric'.**

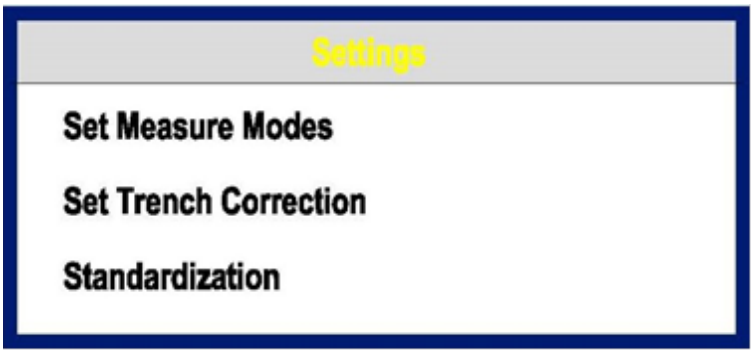
▶ Press 

▶ Press MENU and the display will return to the main menu.

3 Count time

▶ Press SETUP

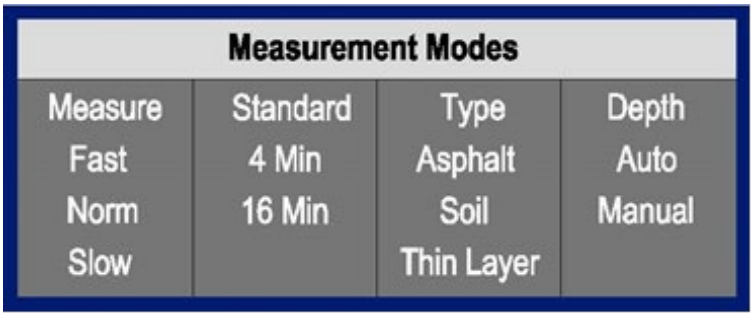
The following will be displayed:



Select **'Set Measure Modes'.**

▶ Press OK

The following will be displayed:



Select **'Norm'.**

4 Soil mode

Select **'Soil'.**

5 Depth

Select **'Auto'.**

▶ Press MENU and the display will return to the main menu.

6 Maximum dry density

▶ Press MAX D

Enter the value by using the displayed keyboard.

(To convert from t/m³ to kg/m³, multiply the maximum dry density by 1000).

▶ Press MENU and the display will return to the main menu.

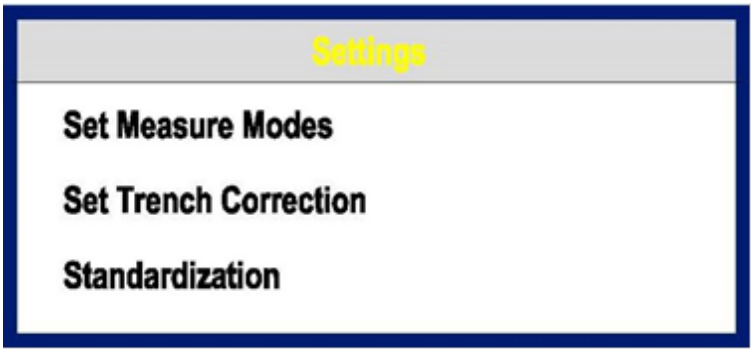
7 Wet density bias

There is no facility to set a wet density bias using the keyboard.

8 Moisture bias

▶ Press SETUP

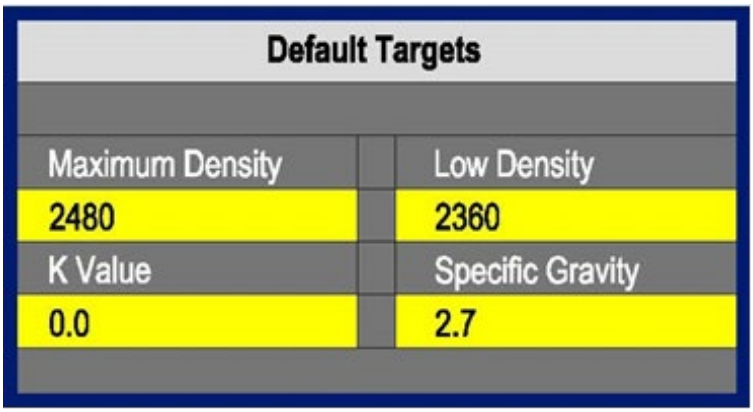
The following will be displayed:



Select **'Set Default Targets'.**

▶ Press 

The following will be displayed:



Select **'K Value'.**

Enter the value by using the displayed keyboard.

To disable the moisture bias, set a value of **'0.0'**.

▶ Press 

and the display will return to the main menu.

▶ Press 

if the nuclear gauge is not required for further use.

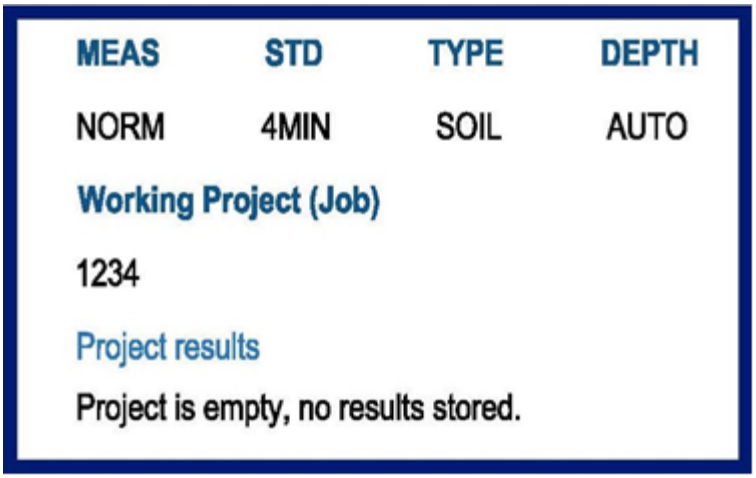
Operating Instruction N228: Measurement (Soils) Humboldt 5001SD

1 Start-up

▶ Press 

and allow the nuclear gauge to complete the initialising routine.

The following will be displayed:



2 Measurement

▶ Press 

The following will be displayed:

At the end of the counting period, the following will be displayed:

Project abcd Test Results		
Dry Density	xxxx	(kg/m³)
Moisture	x.xx	(%)
Wet Density	xxxx	(kg/m³)
Moisture	xxx	
Compaction	xx.x	(%)
Maximum Density	xxxx	(kg/m³)
Depth = XX		

Record the following values as appropriate:

- **Dry Density** to the nearest 0.001 t/m³.
- **Wet Density** to the nearest 0.001 t/m³.
- Compaction as **relative compaction** to the nearest 0.1%.
- Moisture as the **moisture content** to the nearest 0.1%.
- Moisture as the **water content** to the nearest 0.001 t/m³.

(To convert from kg/m³ to t/m³, divide the displayed value by 1000.)

▶ Press 

or

The following will be displayed:

Project abcd Test Results		
Density Count	xxxx.x	
Density Standard	xxxx.x	
Moisture Count	xxx.x	
Moisture Standard	xxx.x	
Voids Ratio	x.x	
Air Voids	xx.x	(%)
Depth = BS		

Record the following values as appropriate:

- **Density count**.
- **Moisture count**.

▶ Press 

and the display will return to the main menu.

▶ Press 

if the nuclear gauge is not required for further use.

Operating Instruction N229: Test Parameter (Soils) Instrotek Xplorer 2 3500

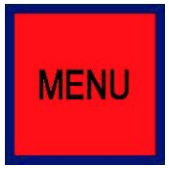
1 Set up

▶ Press 

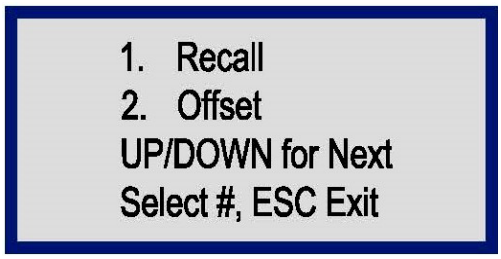
and allow the nuclear gauge to complete the self-test routine.

2 Units

When **<GAUGE READY>** is displayed:

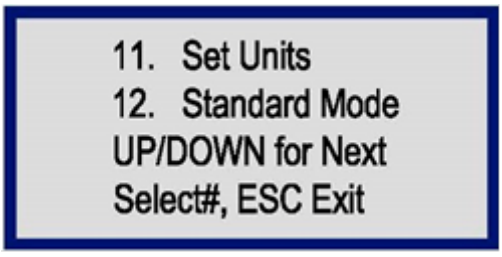
▶ Press 

and the following is displayed:

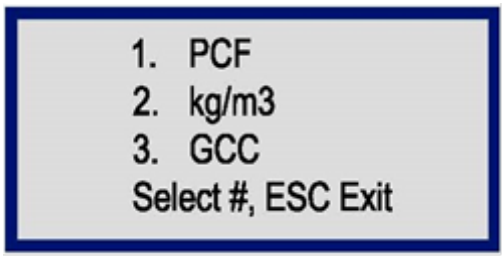


▶ Press 

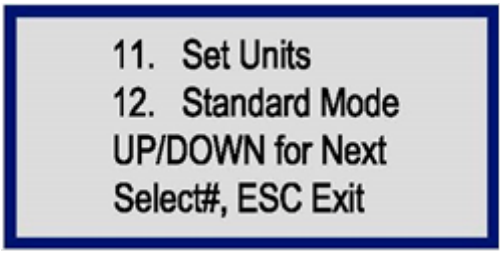
repeatedly until the following is displayed:

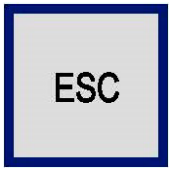


▶ Press **11** and the following is displayed:



▶ Press **2** and the following is displayed

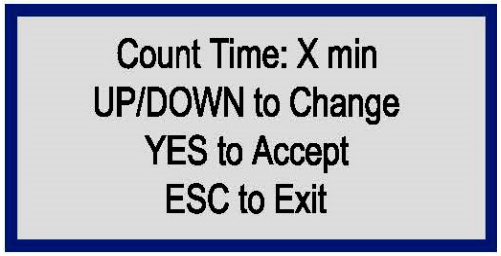


▶ Press 

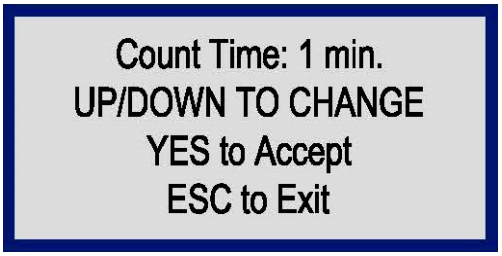
and the display will return to <**GAUGE READY**>.

3 Count time

▶ Press TIME and the following is displayed:



▶ Press DOWN to set the desired count time, 1 minute.



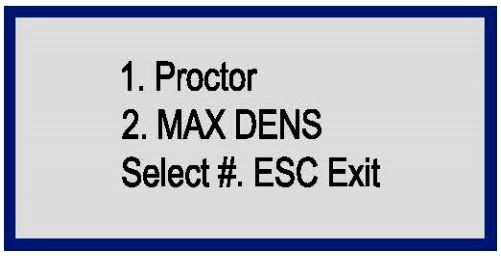
▶ Press YES ON and the display will return to <**GAUGE READY**>.

4 Depth

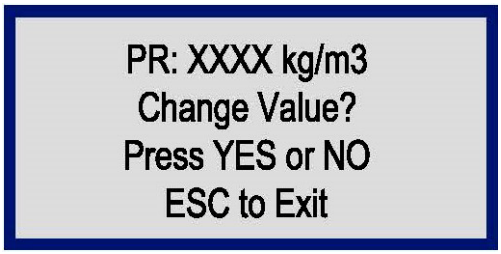
The Xplorer 2 gauge is designed and equipped with an automatic non-contact depth indicator. The depth is automatically sensed as you lower the source rod into a measurement position and the appropriate calibration constants are selected for calculation of density.

5 Soil mode and maximum dry density

▶ Press MAX/PR and the following is displayed:



▶ Press **1** and the following is displayed:



To retain the displayed value, go to 5.1.

To change the displayed value, go to 5.2.

5.1 Retain value

▶ Press 

to retain the displayed value.

The display will return to <**GAUGE READY**>. Go to 6.

5.2 Change the value

▶ Press 

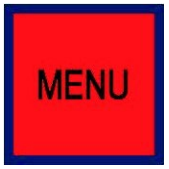
and the following is displayed:

▶ Use the numbered keys to enter the required value to the nearest 1 km/m³

▶ Press 

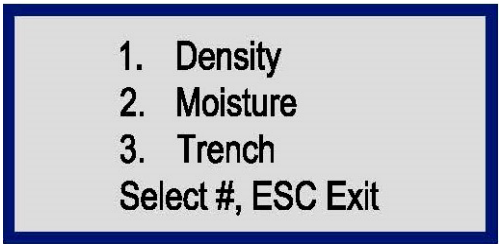
The display will return to <**GAUGE READY**>.

6 Wet density bias

▶ Press 

and the following is displayed:

▶ Press **2** and the following is displayed:



▶ Press **1** and the following is displayed:

To disable the wet density bias, go to 6.1.

To enable the wet density bias, go to 6.2.

6.1 Disable wet density bias

▶ Press NO OFF to disable the density offset.

or

▶ Press YES ON to confirm the density offset is to remain disabled.

The following will be displayed:

The display will return to <**GAUGE READY**>.

6.2 Enable wet density bias

▶ Press YES ON to enable the density offset.

or

▶ Press NO OFF to confirm the density offset is to remain enabled.

The following will be displayed:

To retain the displayed value, go to 6.2.1.

To change the displayed value, go to 6.2.2.

6.2.1 Retain the value

▶ Press 

and the following will be displayed:

The display will return to <**GAUGE READY**>.

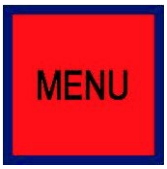
6.2.2 Change the value

▶ Press 

and the following will be displayed briefly:

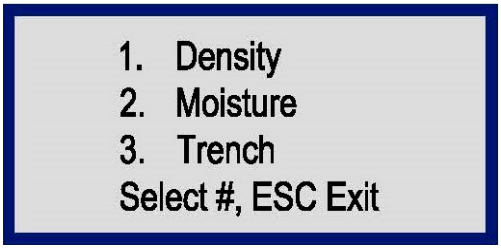
The display will return to <**GAUGE READY**>.

7 Moisture bias

▶ Press 

and the following is displayed:

▶ Press **2** and the following is displayed:



▶ Press **1** and the following is displayed:

To disable the moisture bias, go to 7.1.
To enable the moisture bias, go to 7.2.

7.1 Disable the moisture bias

▶ Press NO OFF to disable the moisture offset.

or

▶ Press YES ON to confirm the moisture offset is to remain disabled.

The following will be displayed:

The display will return to <**GAUGE READY**>. Go to 8.

7.2 Enable the moisture bias

▶ Press YES ON to enable the moisture offset.

or

▶ Press NO OFF to confirm the moisture offset is to remain enabled.

The following will be displayed:

To disable the displayed value, go to 7.2.1.

To change the displayed value, go to 7.2.2.

7.2.1 Retain the value

▶ Press 

and the following is displayed:

The display will return to <**GAUGE READY**>. Go to 8.

7.2.2 Change the value

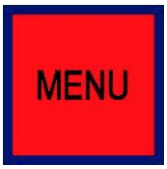
▶ Use the numbered keys to enter the required value to the nearest 0.01%.

▶ Press 

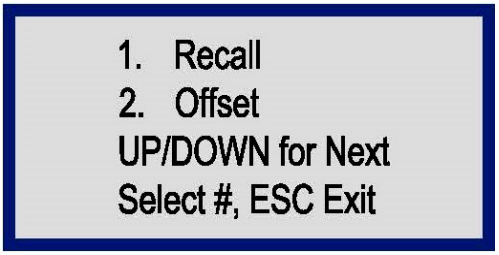
and the following will be displayed briefly:

The display will return to <**GAUGE READY**>.

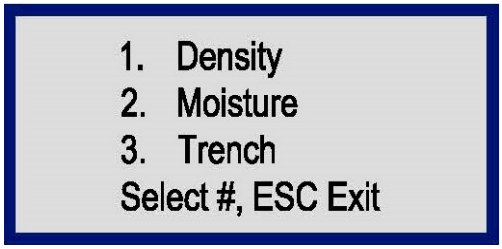
8 Trench offset

▶ Press 

and the following is displayed:



▶ Press **2** and the following is displayed:



▶ Press **3** and the following is displayed:

To disable the trench offset, go to 8.1.

To enable the trench offset, go to 8.2.

8.1 Disable trench offset

▶ Press NO OFF to disable the trench offset.

or

▶ Press YES ON to confirm the trench offset is to remain disabled.

The following will be displayed:

The display will return to <**GAUGE READY**>.

8.2 Enable trench offset

▶ Press YES ON to enable the trench offset.

or

▶ Press 

to confirm the trench offset is to remain enabled.

The following will be displayed:

To disable the displayed value, go to 8.2.1.
To change the displayed value, go to 8.2.2.

8.2.1 **Retain the value**

▶ Press 

and the following is displayed:

The display will return to <**GAUGE READY**>.

8.2.2 **Change the value**

▶ Use the numbered keys to enter the required value to the nearest 1 k/m³ for a positive value.

▶ Press 

and the following will be displayed briefly:

The display will return to <**GAUGE READY**>.

Operating Instruction N230: Measurement (Soils) Instrotek Xplorer 2 3500

1 Set up

▶ Press 

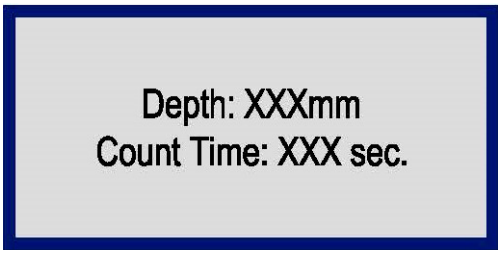
and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When **<GAUGE READY>** is displayed:

▶ Press 

and the following is displayed:



At the end of the counting period:

▶ Press 

repeatedly until the required values are displayed.

Record the following values as appropriate:

- WD as the **wet density** to the nearest 0.001 t/m³.
- DD as the **dry density** to the nearest 0.001 t/m³.
- % PR as the **relative compaction** to the nearest 0.1%.
- Moist as the **water content (t/m³)** to the nearest 0.001 t/m³.
- % MOIS as the **moisture content (%)** to the nearest 0.1%.
- M Count as the **moisture count**.
- D Count as the **density count**.

To convert from kg/m³ to t/m³, divide the displayed value by 1000).

▶ Press 

and the display will return to <**GAUGE READY**>.

▶ Press 

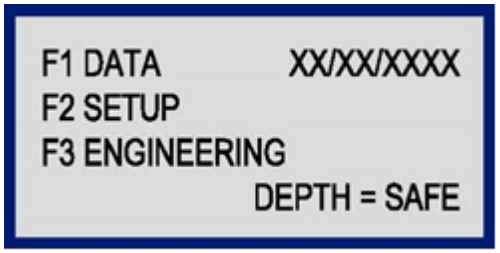
if the nuclear gauge is not required for further use.

Operating Instruction N231: Test Parameters (Soils) Humboldt 5001EZ-2

1 Start-up

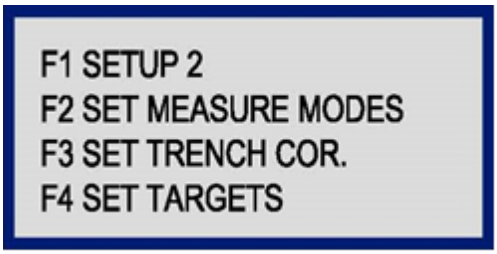
▶ Press POWER and allow the nuclear gauge to complete the initialising routine.

The following will be displayed:



▶ Press F2

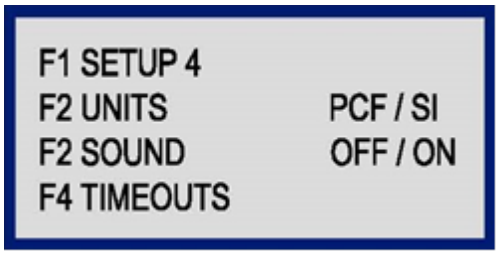
The following will be displayed:



2 Measurement units

▶ Press F1

The following will be displayed:



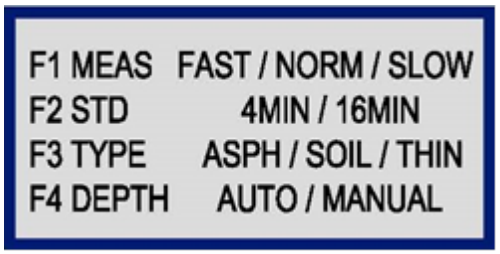
▶ Press F2 repeatedly until **'SI'** flashes.

▶ Press MAIN MENU and the display will return to the main menu.

3 Count time

▶ Press F2 F2

The following will be displayed:



▶ Press F1 repeatedly until **'NORM'** flashes.

4 Soil mode

▶ Press F3 repeatedly until **'SOIL'** flashes.

5 Depth

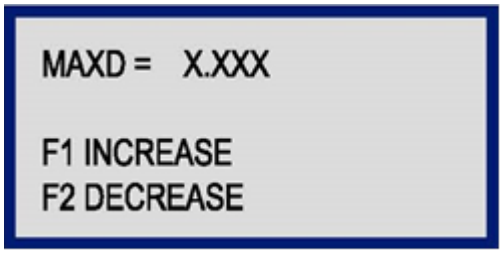
▶ Press F4 repeatedly until **'AUTO'** flashes.

▶ Press MAIN MENU and the display will return to the main menu.

6 Maximum dry density

▶ Press MAX "D"

The following will be displayed:



▶ Press F1

or

F2 to increase or decrease the displayed value until the required value (within the range 900 kg/m³ to 3000 kg/m³) is obtained.

(To convert from t/m³ to kg/m³, multiply the maximum dry density by 1000).

▶ Press MAIN MENU and the display will return to the main menu.

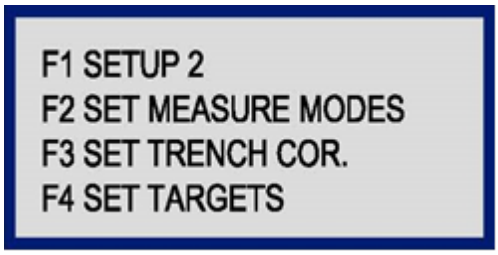
7 Wet density bias

There is no facility to set a wet density bias using the keypad.

8 Moisture bias

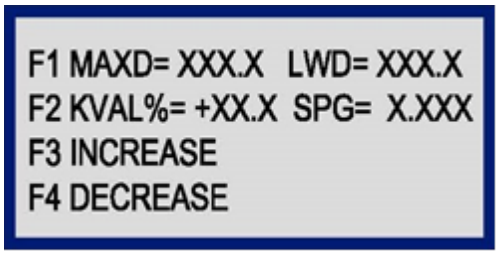
▶ Press F2

The following will be displayed:



▶ Press F4

The following will be displayed:



▶ Press F2 repeatedly until the **'KVAL'** value flashes.

▶ Press 

or

to increase or decrease the displayed value until the required K value is obtained.

A maximum value of 0.20 (in increments of 0.10) and a minimum value of -0.10 (in increments of 0.01) may be set.

To disable the moisture bias, set a value of **'0.0'**.

▶ Press 

and the display will return to the main menu.

▶ Press 

if the nuclear gauge is not required for further use.

Operating Instruction N232: Measurement (Soils) Humboldt 5001EZ-2

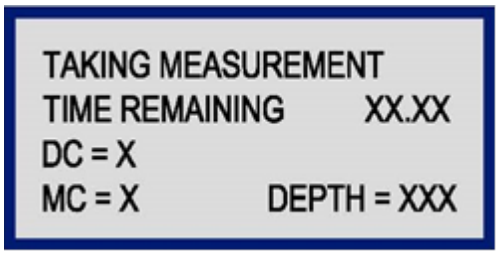
1 Start-up

▶ Press POWER and allow the nuclear gauge to complete the initialising routine.

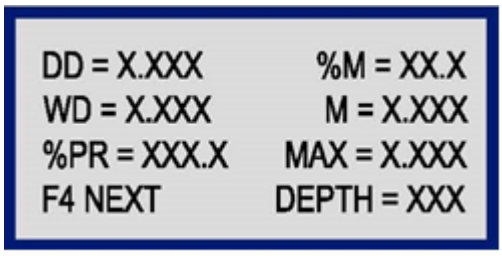
2 Measurement

▶ Press MEASURE

The following will be displayed:



At the end of the counting period, the following will be displayed:



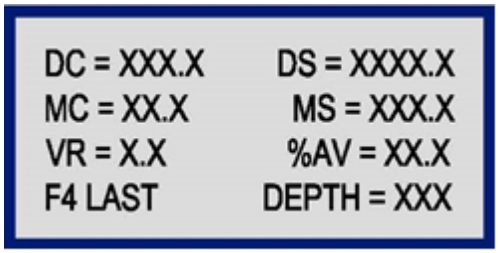
Record the following values as appropriate:

- DD as the **dry density** to the nearest 0.001 t/m³.
- WD as the **wet density** to the nearest 0.001 t/m³.
- % PR as the **relative compaction** to the nearest 0.1%.
- % M as the **moisture content** to the nearest 0.1%.
- M as the **water content** to the nearest 0.001 t/m³.

(To convert from kg/m³ to t/m³, divide the displayed value by 1000.)

▶ Press F4

The following will be displayed:



Record the following values as appropriate:

- DC as the **density count**.
- MC as the **moisture count**.

▶ Press MAIN MENU and the display will return to the main menu.

▶ Press POWER if the nuclear gauge is not required for further use.

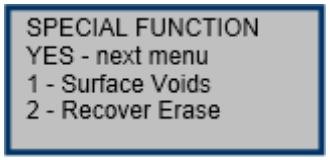
Operating Instruction N307: Test Parameters Troxler 4640B

1 Start-up

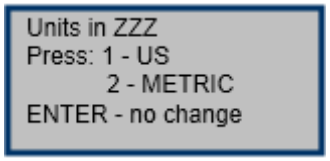
▶ Press [ON] and allow the nuclear gauge to complete the self-test routine.

2 Measurement units

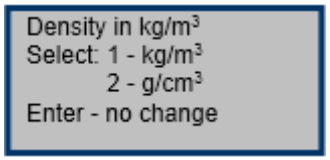
▶ Press [SHIFT x] [SPECIAL 9] and the following will be displayed:



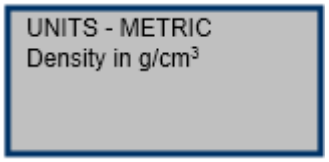
▶ Press [STATUS 7] and the following will be displayed:



▶ Press [OFFSET 2] and the following will be displayed:



▶ Press [OFFSET 2] and the following will be displayed:

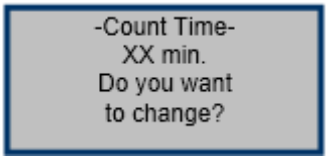


(Units of g/cm³ are equivalent to t/m³).

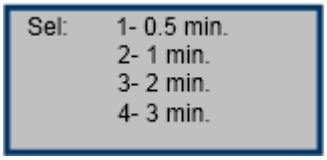
The display will return to <**READY**>.

3 Count time

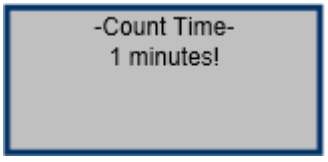
▶ Press [TIME -] and the following will be displayed:



▶ Press [YES EXIT] and the following will be displayed:



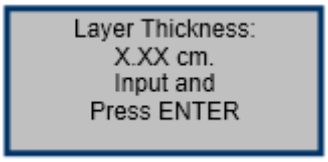
▶ Press [OFFSET 2] and the following will be displayed:



The display will return to <**READY**>.

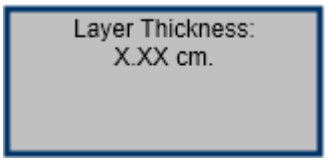
4 Layer thickness

▶ Press THICK MR and the following will be displayed:



▶ Use the numbered keys to enter the layer thickness to the nearest 0.1 cm.
(The minimum value that can be set is 2.54 cm).

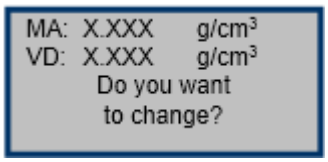
▶ Press START/ ENTER = and the following will be displayed briefly:



The display will return to <**READY**>.

5 Marshall and maximum (voidless) density

▶ Press MA/ VOIDLESS and the following will be displayed:



If MA and VD values of "**0.000 g/cm³**" are displayed:

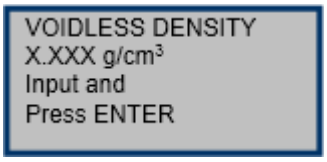
▶ Press NO/CE C/CE

If values other than "**0.000 g/cm³**" are displayed:

▶ Press YES EXIT and the following will be displayed:

▶ Press RECALL 0

▶ Press START/ ENTER = and the following will be displayed:



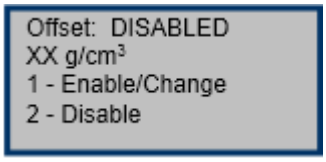
▶ Press RECALL 0

▶ Press START/ ENTER = and the display will return to <**READY**>.

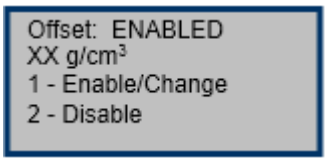
6 Asphalt density bias

▶ Press 

The following will be displayed:



or



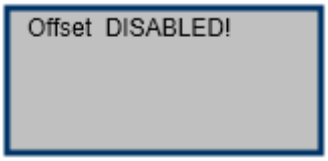
To disable the asphalt density bias, go to Step 6.1.

To enable the asphalt density bias, go to Step 6.2.

6.1 Disable asphalt density bias

▶ Press 

and the following will be displayed briefly:

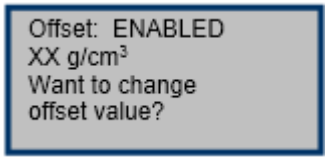


The display will return to <**READY**>.

6.2 Enable asphalt density bias

▶ Press 

and the following will be displayed:



To retain the displayed value, go to Step 6.2.1.

To change the displayed value, go to Step 6.2.2.

6.2.1 Retain the value

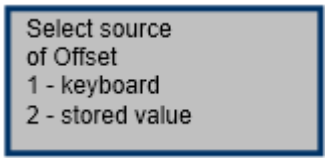
▶ Press 

The display will return to <**READY**>.

6.2.2 Change the value

▶ Press 

and the following will be displayed:

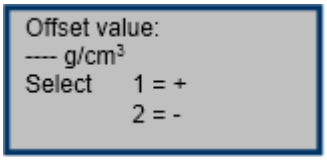


To enter a new value, go to Step 6.2.2.1.

To select a stored value, go to Step 6.2.2.2.

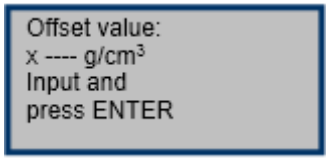
6.2.2.1 Enter a new value

- Press [SP. CAL. 1] and the following will be displayed:

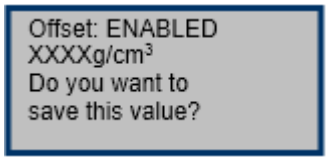


- Press [SP. CAL. 1] to enter a positive bias. or [OFFSET 2] to enter a negative bias.

The following will be displayed:



- Use the numbered keys to enter the asphalt density bias to the nearest 0.001 g/cm³.
- Press [START/ ENTER =] and the following will be displayed:



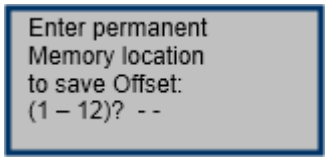
Note: It is not necessary to save the displayed value to enable it.

If the value is not to be saved:

- Press [NO/CE C/CE] and the display will return to <**READY**>.

To save the displayed value:

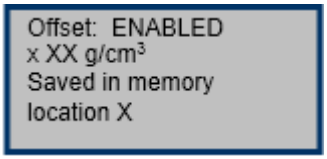
- Press [YES EXIT] and the following will be displayed:



- Use the numbered keys to enter the memory location.

Note: Record the memory location and bias to facilitate subsequent retrieval of saved values.

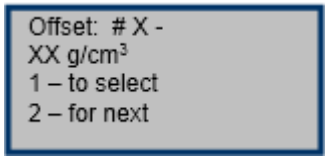
- Press [START/ ENTER =] and the following will be displayed briefly:



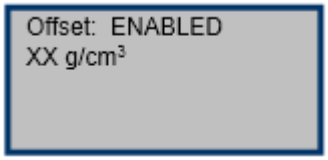
The display will return to <**READY**>.

6.2.2.2 Select a stored value

- Press [OFFSET 2] and the following will be displayed:



- Press OFFSET / 2 repeatedly until the required memory location and value is displayed.
- Press SP. CAL. / 1 and the following will be displayed briefly:



The display will return to <**READY**>.

- Press OFF if the nuclear gauge is not required for further use.

Operating Instruction N308: Measurement (Asphalt) Troxler 4640B

1 Start-up

▶ Press [ON] and allow the nuclear gauge to complete the self-test routine.

2 Measurement

When <**READY**> is displayed:

▶ Press [START/ ENTER =]

The following will be displayed:

MA: XXXX g/cm³ Thick: XX.XX cm Avg: XX Time: XX secs	or	MA: XXXX g/cm³ Thick: XX.XX cm Avg: XX, Offset Time: XX secs.
(asphalt density bias disabled)		(asphalt density bias enabled)

At the end of the counting period, the following will be displayed:

Dens: XXXX kg/m³ %MA: XX.XX% 100-%MA: XXX.XX% %VOID: X.XX%

Record Dens as the **wet density** to the nearest 0.001 t/m³.

▶ Press [SHIFT x] [RECALL 0] and the following will be displayed:

Dens: XXX.X kg/m³ %MA: XX.XX% %VOID: X.XX% Cnts XXXX XXXX

Record Cnts as the **density count** values for System 1 and System 2.

▶ Press [NO/CE C/CE] and the display will return to <**READY**>.

▶ Press [OFF] if the nuclear gauge is not required for further use.