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# Section 1 - General Information

## Product Description

The **CPN MC-S Strata Gauge** is a rugged, state-of-the-art microprocessor-based instrument that measures the density and moisture in strata layers down to a depth of 24 inches (600 mm) in increments of 2 inches (50 mm). In Civil/Geotechnical applications it determines the effectiveness of the compaction effort at each depth and one key application is quality control of roller compacted concrete (RCC), also determines the effect of compaction on crop growth.

The **CPN MC-S Strata Gauge** provides fast and accurate measurements, rapidly calculates and converts the data to English or metric engineering units, and displays the results on a liquid crystal display (LCD).

The **CPN MC-S Strata Gauge** complies with the following ASTM standard test methods:

D 2922 - Density of Soil and Soil Aggregate in Place by the Nuclear Method
D 3017 - Moisture Content of Soil and Soil Aggregate by the Nuclear Method

The keypad of the **CPN MC-S Strata Gauge** allows the operator to enter target maximum density values and density and moisture calibration biases. Other keys on the pad permit the operator to record and recall test results and transfer records to either a printer or a computer.

Proper use of the **CPN MC-S Strata Gauge** will impose no radiation hazard on the operator. However, a potential danger does exist if the equipment is improperly used. Operators should read and understand the literature covering radiation safety, and attend a radiation safety and applications training course offered by the manufacturer or other competent instructor.

# CPN MC-S Strata Gauge Features

• Simultaneous, direct readout of all test data and results on an easy-to-read, 160-character liquid crystal display:

Total (wet) density
Total moisture
Dry density
% Compaction - total (wet) or dry
Moisture content (%)
% Air voids
Record and test number
Time and date of test
Maximum values: wet density, dry density and bulk specific gravity
Density and moisture biases

• Memory storage and recall of up to 128 test results by record number

• Serial interface to personal computer or printer

• Operator-selectable time or precision of test

• Programmable maximum values from laboratory compaction tests

• Easy-to-use keyboard functions for all measurement parameters

• Rechargeable NICAD battery pack; up to 600 tests between charges

• Self-calibration (self-coefficient determination)

# Functional Description

The **CPN MC-S Strata Gauge** operates by emitting radiation from two safety-sealed radioactive sources:

- Cesium-137, a gamma emitter for density measurement
- Americium-241:Beryllium, a neutron emitter for moisture measurement.

To determine density, the Cesium-137 source emits gamma radiation into the test material. Some of the gamma radiation will pass through the material and be detected by the Geiger-Mueller detector located within the density detector rod. A material of low density will give a high count per time of test. A material of high density will give a low count for the same period of time, as the high-density material absorbs more gamma radiation.

To determine moisture content, the Americium-241:Beryllium source emits neutron radiation into the test material. The high-energy neutrons are moderated by collision with hydrogen atoms in the moisture of the material. Only low-energy, moderated neutrons are detected by the Helium-3 detector. A material that is wet will give a high count per time of test. A material that is dry will give a low count for the same period of time.

# Standard Equipment

Each **CPN MC-S Strata Gauge** is provided with a durable shipping case and the items shown in Figure 1-1. There are no special instructions for unpacking the gauge**.** It comes fully assembled.

| Item | Part Number |
|---|---|
| **CPN MC-S Strata Gauge** | 119200 |
| Reference Standard, 3 in | 401727 |
| Handle Lock Key | 400925 |
| Guideplate | 401720 |
| Drill Pin | 100035 |
| Lubricant | 704394 |
| Operating Manual | 400747 |
| Leak Test Certificate | 700762 |
| Leak Test Kit | 401197 |
| Radiation Sign Kit | 101085 |
| Padlock and Keys | 700472 |
| Battery Charger, 115/230 VAC | 400950 |
| Shipping Case | 400754 |
| Phillips Screwdriver | 700646 |
| Allen Head (Hex Drive) Wrench | 700760 |
| Hex Ball Driver, 9/64 in | 700764 |
| Cleaning Brush | 702403 |

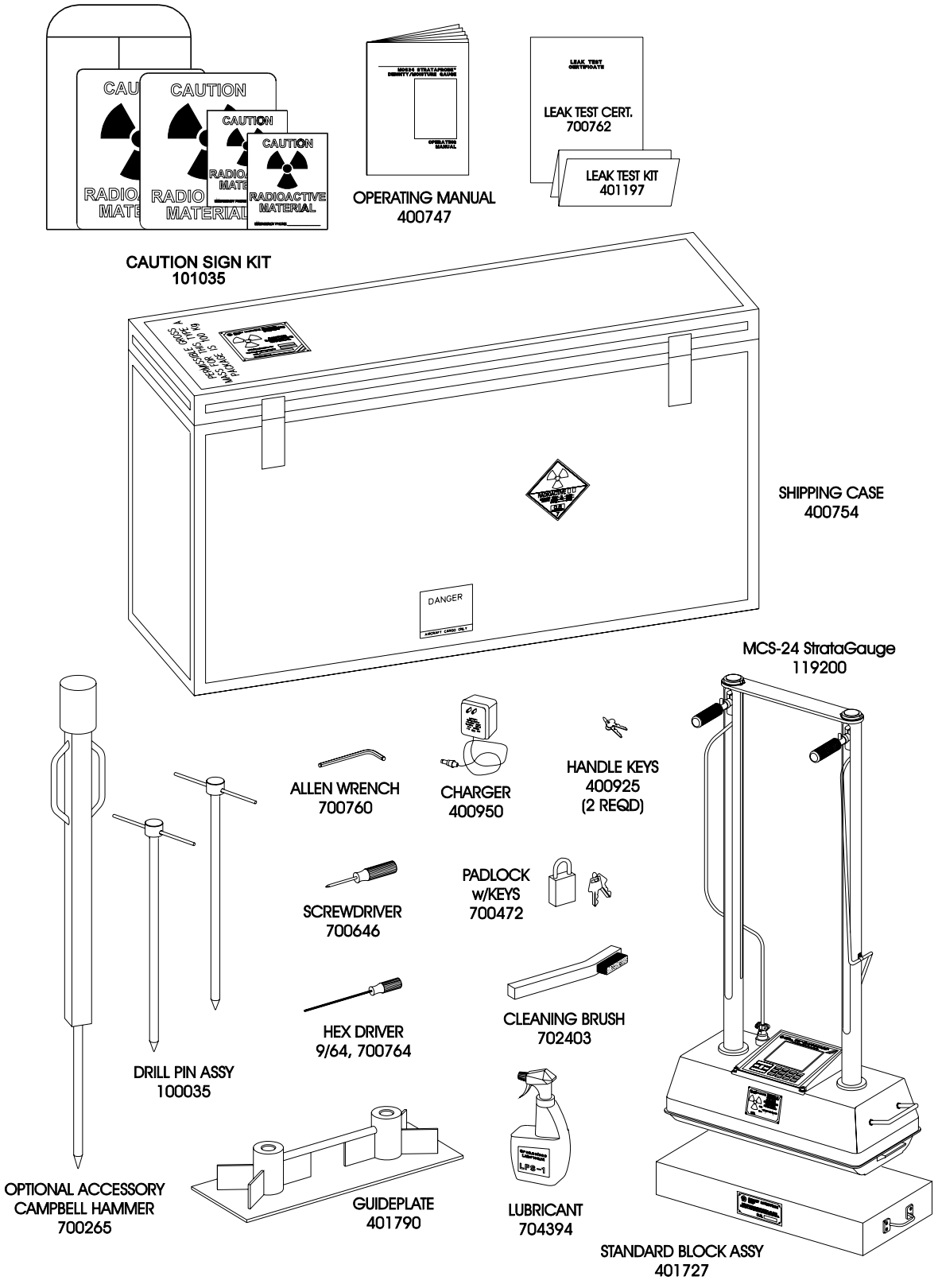



Figure 1-1. **CPN MC-S Strata Gauge** Standard Equipment

# Specifications

## Dimensions/Shipping Weights

| Model | Weight | Length | Width | Height |
|---|---|---|---|---|
| MC-S (gauge only) | 47 lbs/21.2 kgs | 21 in/533 mm | 9.25 in/235 mm | 407 in/1016 mm |
| MC-S (with carrying case) | 180 lbs/81 kgs | 50 in/1270 mm | 16.5 in/419 mm | 27.75 in/705 mm |

### Performance

| | |
|---|---|
| Functions | Sub-surface strata density/moisture measurements to a depth of 24 in (600mm) in 2 in (25mm) increments |
| Density Range | 60 to 180 pcf (0.96 to 2.88 $Mg/m^3$) |
| Moisture Range | 0 to 25 pcf (0 to 40% vol, 0 to .4 Mg/m3, 0 to 4.8 in/ft) |
| Precision | Density: 0.68 pcf at 125 pcf (0.011 at 2.00 $Mg/m^3$)<br>Moisture: 0.5% at 24% at one minute. |
| Display | High resolution display, with readable characters under all light conditions. Incorporates a back-light feature for testing in low light or darkness. |
| Counting Time | Operator - selected precision (± pcf or $g/cm^3$) or time of test. |
| Calibration | Factory calibration; operator entered or automatic determination of calibration coefficients |
| Units of Measurements | Operator selectable: pcf or $g/cm^3$ |
| Memory Storage | Up to 200 readings of all displayed data |
| Data Interface | RS-232-C for upload to computer or printer (300 to 9600 baud) |

### Electrical

| | |
|---|---|
| Power Source | Internal battery pack (8 welded AA NICAD batteries), 5Wh. |
| Battery Life | 500 to 1000 charge-discharge cycles |
| Power Consumption | 12 mA, average (based on 600+ 30-sec. counts) |
| Charging Time | 14 hours at C/10 via charging unit |

# Specifications

## Environmental

| | |
|---|---|
| Operating Temperature | Ambient: 32° to 158° F (0° to 70° C) |
| Storage Temperature | -4° to 140° F (-20° to 60° C) |
| Humidity (non-condensing) | 95% |

## Radiological

| | |
|---|---|
| Gamma Source | 0.37 GBq (10 mCi) Cesium-137 |
| Neutron Source | 1.85 GBq (50 mCi) Americium-241:Beryllium |
| Encapsulation | Double-sealed capsule, CPN-131 |
| Shipping Requirements | Radioactive material, Special form, N.O.S., UN2974, Transport index 0.4<br>Yellow II label, USA DOT 7A, Type A |
| Special Form Approval | GB/24/S and GB/281/S |

An NRC or agreement state license is required for domestic use. Contact Boart Longyear/CPN for assistance in obtaining training for a license.

# Definitions

**DEPTH OF MEASUREMENT:**

The depth through which 95% of the counted photons and thermal neutrons pass before reaching the detectors.

**PRECISION (Pr):**

The statistical precision of the gauge computed at the 68.3% confidence level (± 1 standard deviation). It states that the repeatability of the gauge is such that 68.3% of repeated measurements on the same site will fall within the average ± precision value.

$$\text{Precision (Pr)} = \frac{\sqrt{\text{actual accumulated counts}}}{\text{slope of the calibration curve}}$$

The total density and total water precision values are calculated as follows:

$$\text{Pr, Dwet or Pr, } H_2O = \frac{\sqrt{\text{actual accumulated counts}}}{\text{slope of the calibration curve}}$$

The dry density precision value is calculated as follows:

$$\text{Pr, Dry} = \sqrt{\text{Pr, Dwet}^2 + \text{Pr, } H_2O^2}$$

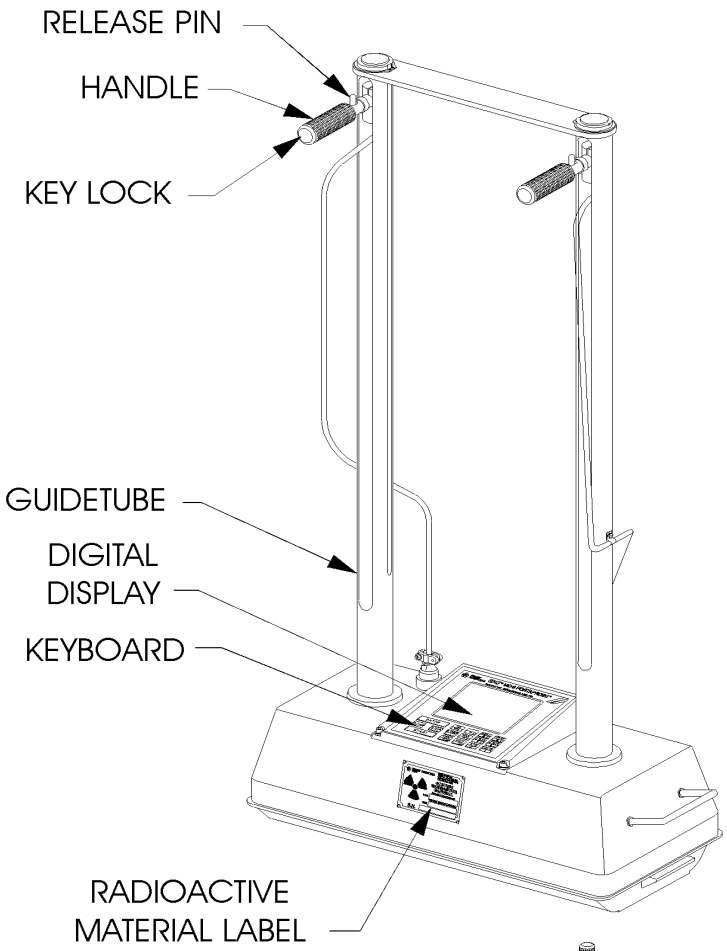
**Boart Longyear/CPN reserves the right to change equipment specifications and/or design to meet industry requirements or improve product performance.**

# CPN MC-S Strata Gauge Inspection

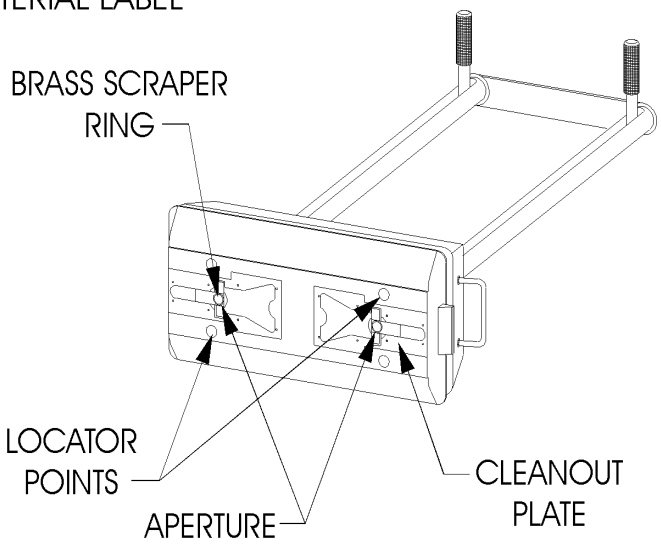
To familiarize yourself with the **MC-S**, perform the following review.

1. Remove the Strata Gauge from shipping case and place on solid flat surface, such as a concrete floor.

2. Examine the keyboard, display screen, handles, and guidetubes.




3. Examine the bottom of the unit. Behind the aperture in the cleanout plate is a carbide shutter block which is spring-mounted and automatically opens and closes when the source rod is lowered and retracted. A brass scraper ring around the opening cleans the source rod as it is retracted.

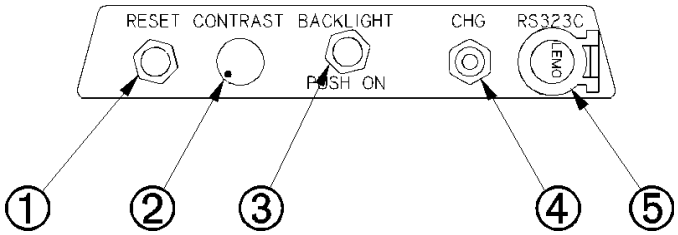



**NOTE**

Both radioactive sources are located in the source rod behind the shutter block. Do not touch the source rod or place yourself in front of unshielded source rod.

# CPN MC-S Strata Gauge Inspection

4. Examine the rear panel.




1. Reset Pushbutton. The power is normally ON. Holding the pushbutton depressed for 5 seconds or longer and then releasing it will act as a master reset. Master reset is only necessary if the gauge locks up.

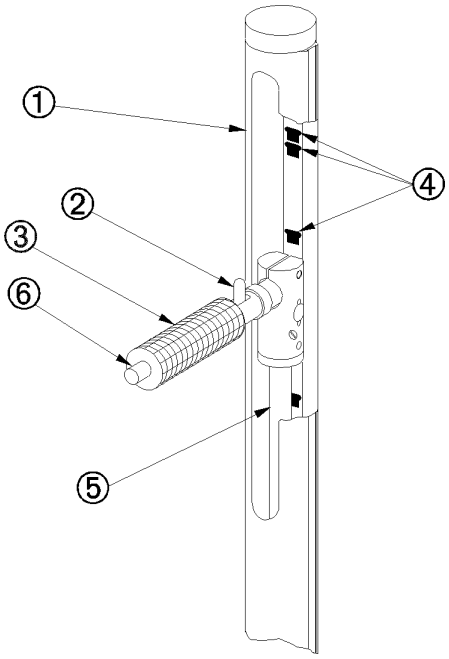
2. Contrast Knob. Adjusts liquid crystal display.

3. Back light pushbutton.

4. Battery Charger Jack.

5. RS-232-C Connector. Port for uploading data to printer or computer.

5. Examine the guide tubes assembly.




1. Guide Tube.

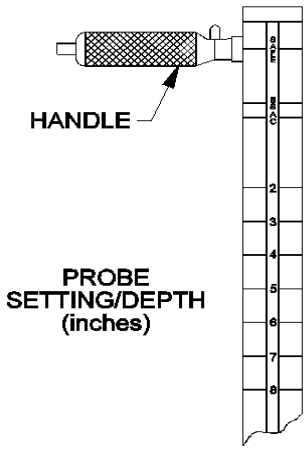
2. Release Pin.

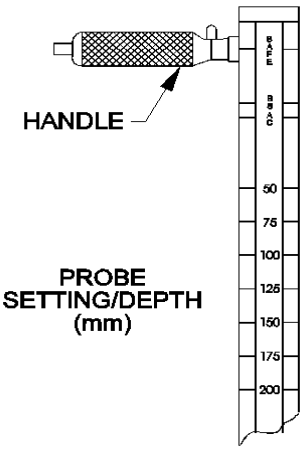
3. Probe Handle.

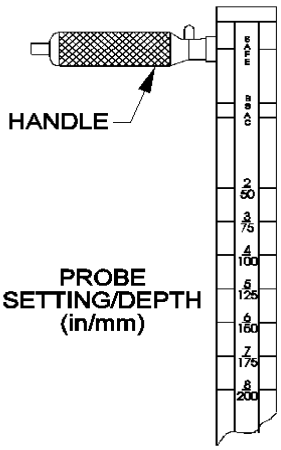
4. Locking Recesses.

5. Source Rod (gamma and neutron sources at bottom).

6. Button Key Lock.

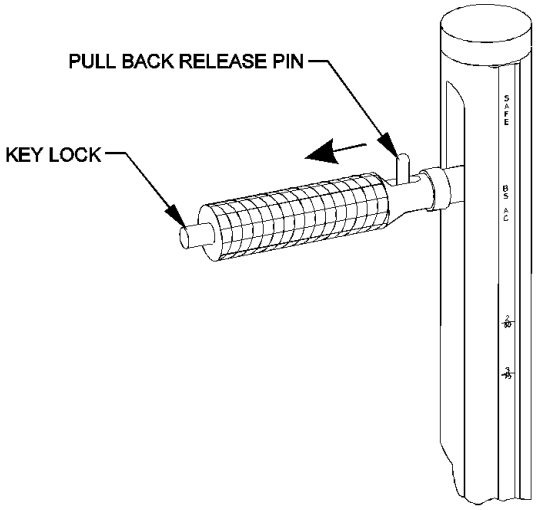


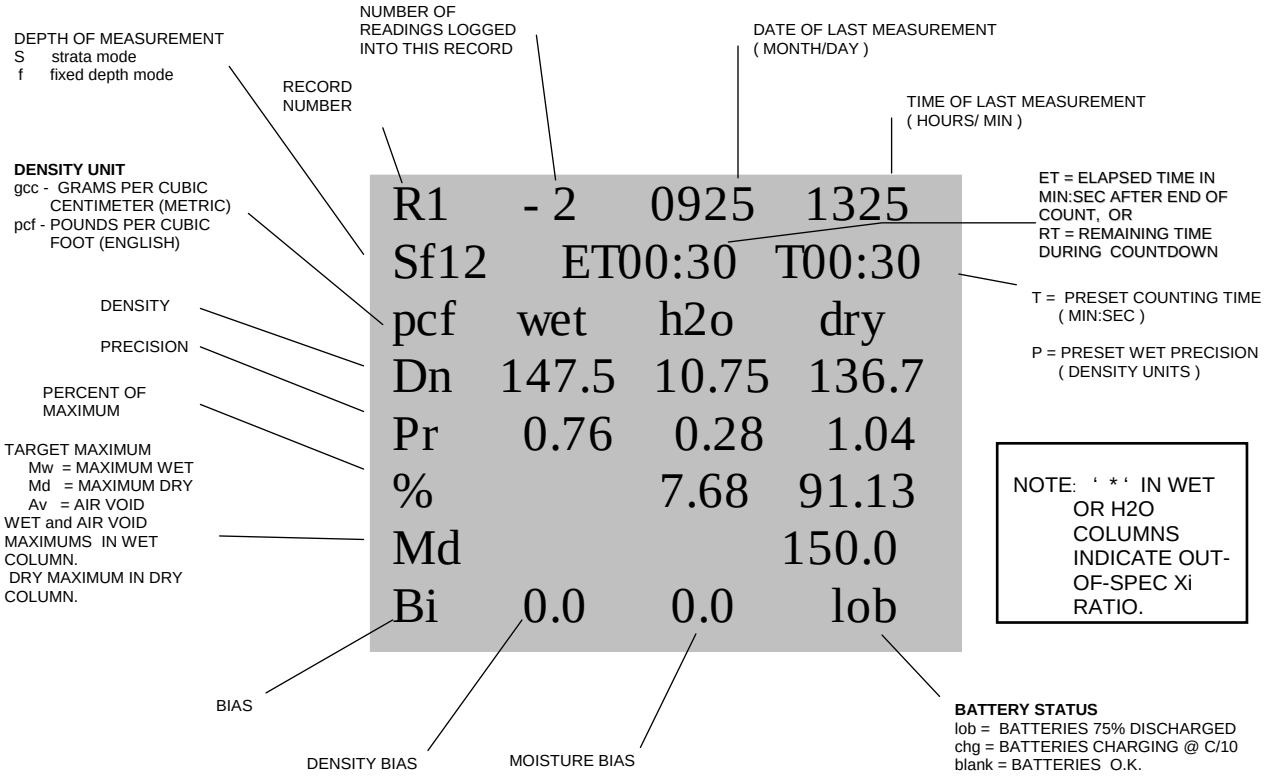
## Learning to Use the CPN MC-S Strata Gauge

1. Use key to unlock handles. Pull back release pins, and set handles to the desire position.
   Instrument is now set up to perform a measurement.



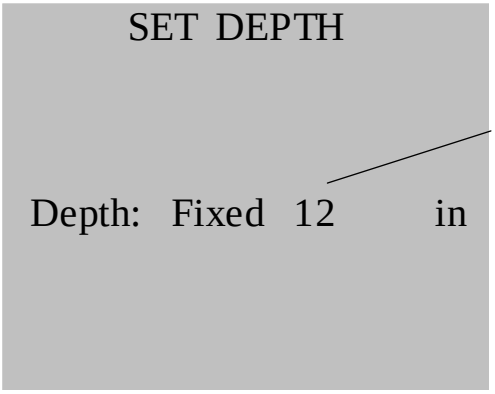

2. Press **CLEAR** key.

Screen displays results of factory test measurement made with **CPN MC-S Strata Gauge** prior to shipment.

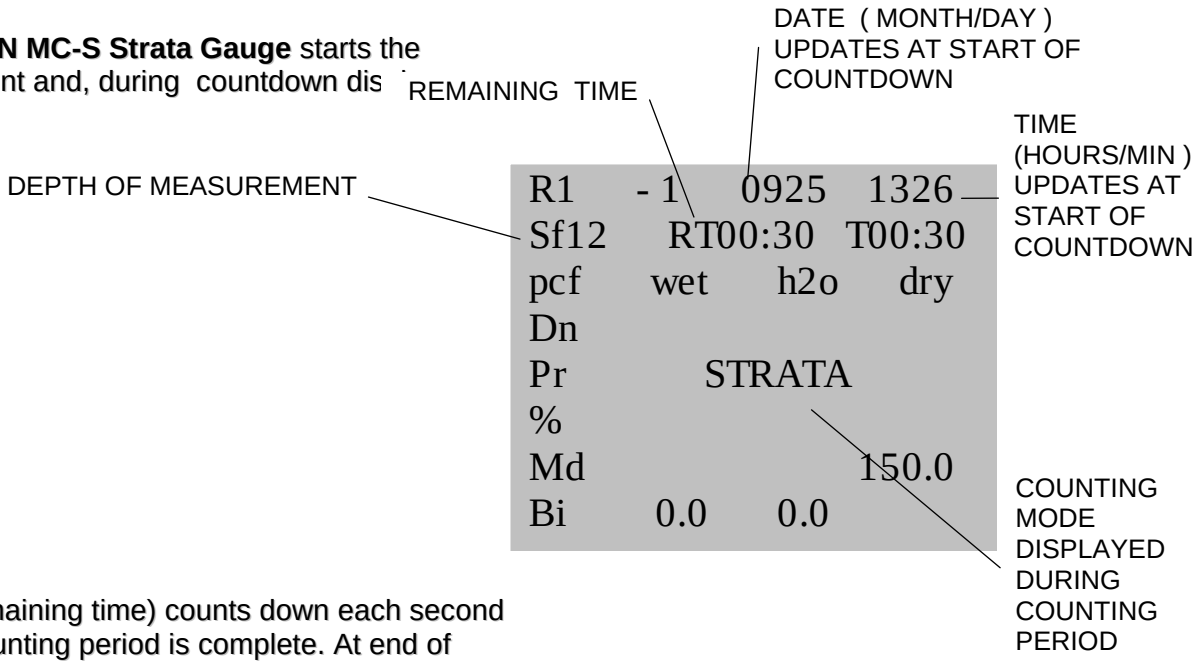


# Learning to Use the CPN MC-S Strata Gauge

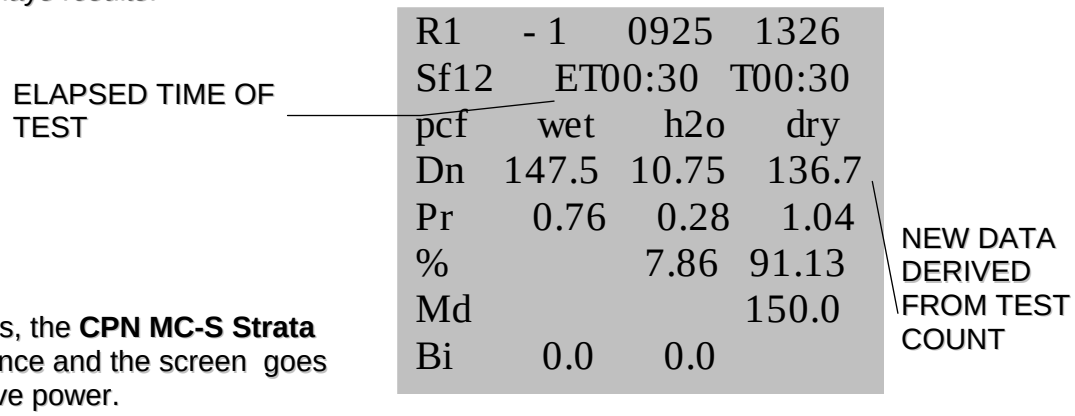
3. Press **START** to begin a test. After **START** is pressed the **CPN MC-S Strata Gauge** shows the following screen. With the numeric key in the depth at which the count is going to be taken and press **ENTER** to start the count.




The **CPN MC-S Strata Gauge** starts the test count and, during countdown dis




**RT** (remaining time) counts down each second until counting period is complete. At end of count, **CPN MC-S Strata Gauge** beeps twice and screen displays results:




After 60 seconds, the **CPN MC-S Strata Gauge** beeps once and the screen goes blank to conserve power.

Press **CLEAR** key to display data again.

Figure 2-1. shows the keyboard of the **CPN MC-S Strata Gauge**

| Key | Function |
|---|---|
| **START** | Starts a count. |
| **STEP** | Acts as shift key.<br>Steps cursor to next parameter or display. |
| **CLEAR** | Clears operator-entered data if pressed before ENTER key. Stops in-progress measurements. Displays previous display or (from a blank screen) most recent measurement. |
| **ENTER** | Stores data in memory.<br>Steps to next display. |
| **ID** | Sets record identification for logging data. |
| **RECALL** | Displays stored records from logging memory. |
| **PRINT** | Displays PRINT menu. |

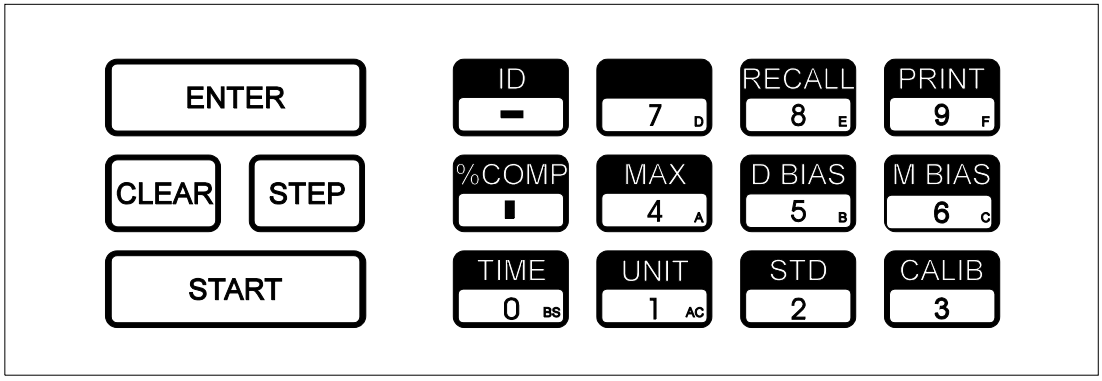



Figure 2-1. **CPN MC-S Strata Gauge** Keyboard

# Keyboard Functions

| Key | Function |
|---|---|
| **%COMP** | Selects percent compaction to be calculated:<br>Mw: Maximum wet density.<br>Md: Maximum dry density.<br>Av: Air void ratio. |
| **MAX** | Prompts for entering the maximum compaction values in pcf or $g/cm^3$. |
| **D BIAS** | Prompts for entering density bias value (+ or - pcf or $g/cm^3$). |
| **M BIAS** | Prompts for entering moisture bias value (+ or - pcf or $g/cm^3$). |
| **TIME** | Prompts for setting counting to:<br>Fixed time or constant precision mode.<br>New time or precision value. |
| **UNIT** | No action. |
| **STD** | Displays density and moisture standard counts and prompts for new standard counts.<br>Takes new standard counts. |
| **CALIB** | prompts for setting the depth. |

# Keyboard Functions

The following functions are initiated by pressing the STEP key and holding it pressed while pressing a second key (i.e. the STEP key acts as a shift key).

| Key | Function |
|---|---|
| **STEP + TIME** | Prompts for setting realtime clock (time/date). |
| **STEP + UNIT** | Displays menu to select between English (pcf and inches) or metric (gcc and mm) measurement units and select between density screen and counts per minute (cpm) screen. |
| **STEP + CALIB** | Displays menu to select displaying/entering coefficients, self-calibration, or setting fixed or automatic depth of measurement. (See Appendix B: Troubleshooting Guide.) |
| **STEP + CLEAR** | Master clear. Restores main screen display directly from any other display. |
| **ID, then STEP + ID** | Clears entire record space of stored data. |
| **STEP + ENTER** | Displays monitor program, information used by a Boart Longyear/CPN service technician. |

# Configuring CPN MC-S Strata Gauge for Measurements

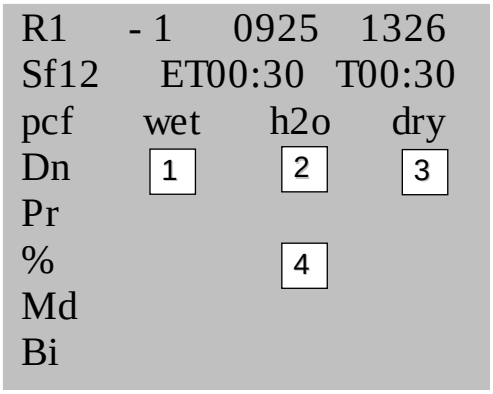
The **CPN MC-S Strata Gauge** displays the following direct measurements after all tests.

1. Dn wet: Wet or total density (pcf or g/cm$^3$).

2. Dn $H_2O$: Total moisture (pcf or g/cm$^3$).

3. Dn dry: Dn wet - Dn $H_2O$ (pcf or g/cm$^3$).

4. % $H_2O$: (Dn $H_2O$ / Dn dry) x 100

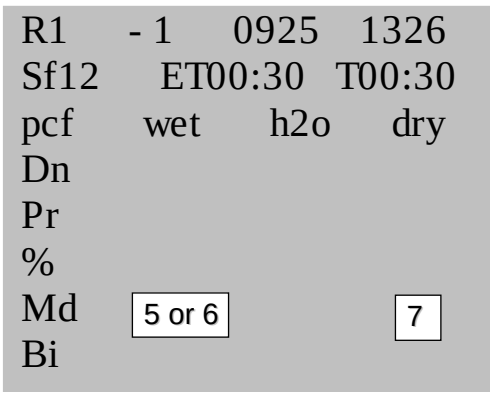



The operator may enter target maximum values determined by standard laboratory tests (ASTM or comparable) before or after a test is taken.

5. Mw: The maximum wet density of a soil-aggregate or bulk specific gravity of a material in pcf or g/cm$^3$.

6. Av: The theoretical maximum specific gravity of a material in pcf or g/cm$^3$.

7. The maximum dry density of a soil-aggreagte in pcf or g/cm$^3$ (ASTM D 1557).



# Configuring CPN MC-S Strata Gauge for Measurements

The **CPN MC-S Strata Gauge** will now calculate and display relative (%) compactions.

For asphalt pavements and soils using total or wet maximum values:

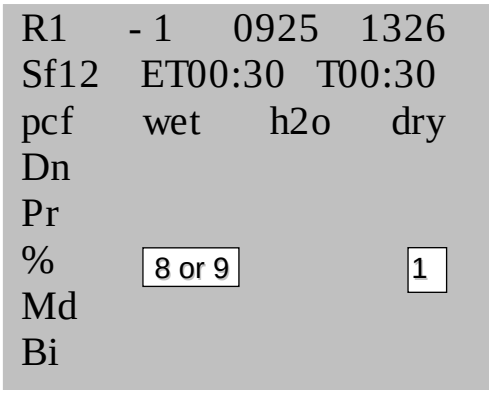
8. $\%\ Mw = ( Dn\ wet / Mw ) \times 100$

For materials using maximum specific gravity values:

9. $\%\ Av = \frac{Av - Dn\ wet}{Av} \times 100$

For soil/aggregates using dry maximum values:

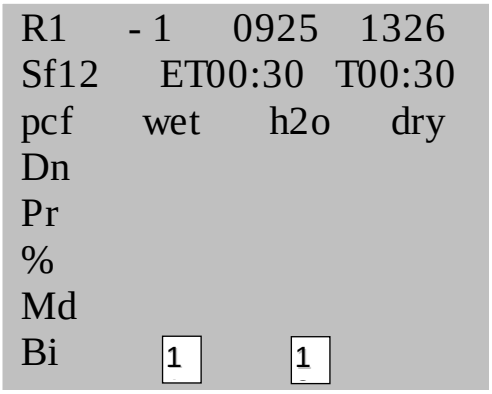
10. $\%\ Md = ( Dn\ dry / Md ) \times 100$




The operator may enter density and moisture bias values as needed.

11. ± density value (pcf or g/cm$^3$).

12. ± moisture value (pcf or g/cm$^3$)



# Configuring CPN MC-S Strata Gauge for Measurements

The following parameters can be configured for the **CPN MC-S Strata Gauge** to meet your needs.

| Parameter | Factory Configuration | Range |
|---|---|---|
| units | pcf | pcf, g/cm$^3$ or cpm. |
| time or precision | T01:00 | user selectable mode: time or precision, and value: ± pcf or g/cm$^3$. |
| % compaction | Md | Mw, Md, or Av |
| **maximums** | | |
| Mw | 150.0 | |
| Md | 150.0 | 0 to 999.9 |
| Av | 150.0 | |
| **biases** | | |
| density | 0.0 | +99.9 to -99.9 |
| moisture | 0.0 | |

Enter the **CPN MC-S Strata Gauge** parameters according to the following instructions.

| Action | Result |
|---|---|
| **UNITS Parameters** | |
| 1. Press **STEP + UNIT**. | Displays menu to select units. |
| 2. Press **ENTER**. | Toggles units between pcf and g/cm$^3$, displaying current selection on screen. |
| 3. Press **CLEAR**. | Displayed units selected. |
| 4. Press **STEP**. | |
| 5. Press **ENTER**. | Toggles between density and counts-per-minute (cpm) screen, displaying current selection on screen. |
| 6. Press **CLEAR**. | Display option selected. |

# Configuring CPN MC-S Strata Gauge for Measurements

| Action | Result |
|---|---|
| **TIME and PRECISION Parameters** | |
| 1. Press **TIME** | Cursor moves to time field on screen. |
| 2. Press **STEP** to toggle between time and precision. | Time or precision mode, as toggled, is displayed on screen. |
| 3. Key in new time or precision value and press **ENTER**. | Value is displayed and stored (any previous value is replaced). |
| **COMPACTION % and MAXIMUM Parameters** | |
| 1. Press **% COMP** | Compaction field rolls through Mw, Av, and Md. Continue pressing until desired maximum is displayed. |
| 2. Press **MAX.** | Prompts for new maximum value. |
| 3. Key in maximum value and press **ENTER**. | Value displayed and stored (any previous value is replaced). |
| **DENSITY and MOISTURE BIAS Parameters** | |
| 1. Press **D BIAS** | Cursor moves to first digit in density bias field. |
| 2. Key in density bias value and press **ENTER**. | Value is displayed and stored (any previous value is replaced). |
| 3. Press **M BIAS.** | Cursor moves to first digit in $H_2O$ bias field. |
| 4. Key in moisture bias value and press **ENTER**. | Value is displayed and stored (any previous value is replaced). |
| **Date and Time Reset** | |
| 1. Press **STEP + TIME**. | Screen displays date and time and prompts for entering the year. |
| 2. Key in each prompted value and press **ENTER**. | Each value is stored; date and time updated. |
| 3. Press **START.** | Clock begins again. |

# Standard Counts

Because the radioactive sources in the **CPN MC-S Strata Gauge** decay slowly over time, the user must periodically take a standard count on the reference standard provided. When this is done, the previous standard count is replaced and the **CPN MC-S Strata Gauge** program uses the new standard to calculate the field count/standard count ratio to compensate for source decay.

"Xi" is displayed and signifies the chi-squared distribution of the counts. This is the ratio of the actual distribution of the counts compared to the expected distribution. A ratio near 1.0, and small changes between previous and new counts, indicate that the **CPN MC-S Strata Gauge** is working properly.

While standard counts need only be taken monthly to account for source decay, it is recommended that a new standard be taken daily to check "Xi" and changes in counts. The Xi ratio should be between 0.75 and 1.25, and the change between the present and previous standard counts should be smaller than the square root of the average count (1 standard deviation). This will verify the performance of the Strata Gauge every day of use. If the Xi value is outside of expected limits, repeat the standard count. If the statistics are again poor, consult the Troubleshooting Guide (Appendix B).

### Standard Count Procedure

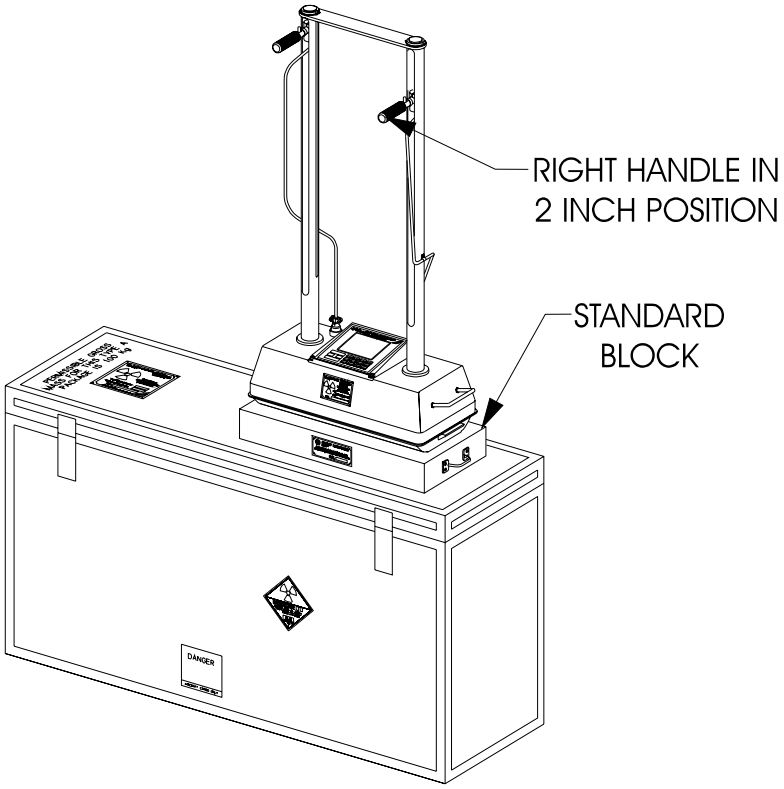
| Action | Result |
|---|---|
| 1. Place the reference standard block on top of the shipping case. Seat the gauge on the block with the gauge and the block serial numbers to the front. Put the right hand rod in the 2 inches position. |  |

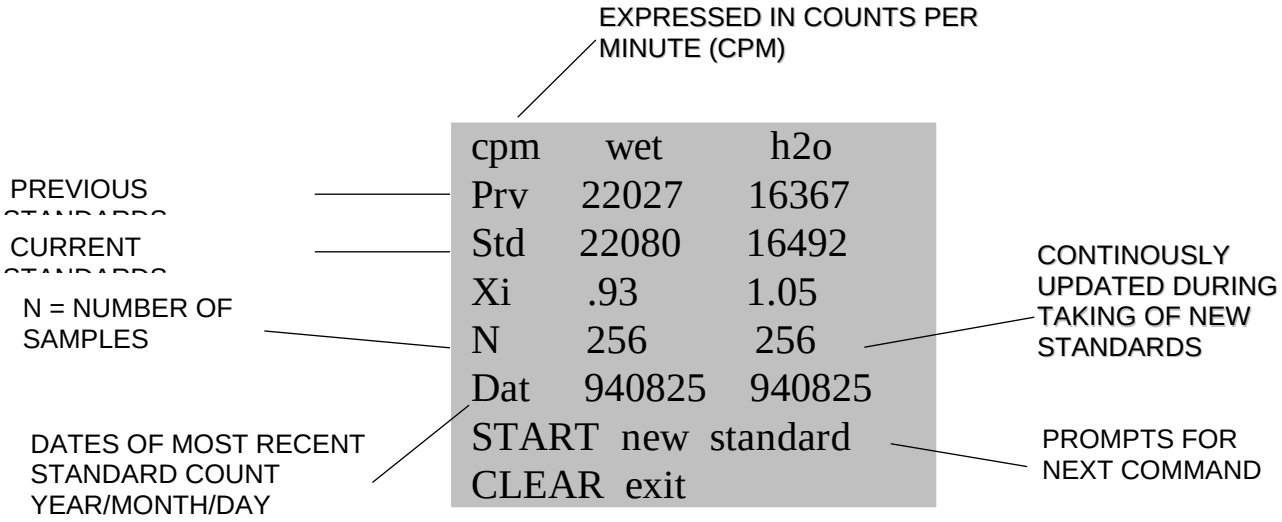
Figure 2-2. Standard Count Procedure

**Action**

2. Press STD.

**Result**

Screen displays existing standard count data:




3.Press **START** key.

The Strata Gauge starts a standard count of 256 1-second samples. As each sample is taken, the sample number from 1 to 256 is displayed. A standard count takes approximately 4.4 minutes.

**NOTE**

To terminate the count and exit while the standard count is in progress, press **CLEAR**.
To stop the count early, press **STEP** (count is terminated and values stored).

At the end of the count, the **CPN MC-S Strata Gauge** displays and stores the new standard count data, replacing previous values.

# Taking a Test

To take a field test, perform the following:

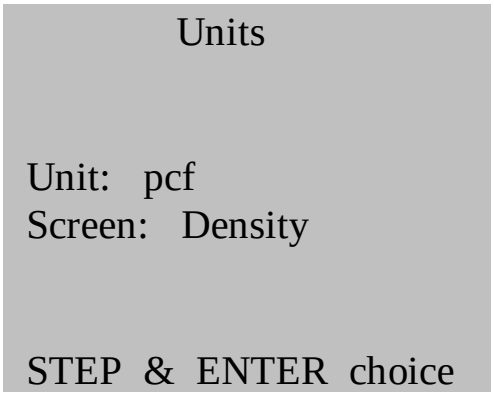
| Action | Result |
|---|---|
| 1. Configure the **CPN MC-S Strata Gauge** (see **Configuring CPN MC-S Strata Gauge for Measurements** instructions). | **CPN MC-S Strata Gauge** configured. |
| 2. Prepare the site to be tested (see site preparation instructions in **Field Use** section). | Site prepared for testing. |
| 3. Set the **CPN MC-S Strata Gauge** on the site to be tested and set the handles to the position (depth) in which the test will be performed. | **CPN MC-S Strata Gauge** prepared for testing. |
| 4. Press **START**. | Current calibration depth setting is displayed. |
| 5. Press **ENTER** or key in a new **DEPTH** setting and then press **ENTER**. | Test counting begin.<br>Typical test display: |

| | | | |
|---|---|---|---|
| R1 | -1 | 0925 | 1326 |
| Sf12 | ET00:30 | | T00:30 |
| pcf | wet | h2o | dry |
| Dn | 147.5 | 10.75 | 136.7 |
| Pr | 0.76 | 0.28 | 1.04 |
| % | | 7.86 | 91.13 |
| Md | | | 150.0 |
| Bi | 0.0 | 0.0 | |

**To Change Units**

From pcf (pounds per cubic foot) to gcc (grams per cubic centimeter)
From gcc (grams per cubic centimeter) to pcf (pounds per cubic foot)

| **Action** | **Result** |
|---|---|
| 1. Press **STEP + UNIT** | Screen displays units menu. |

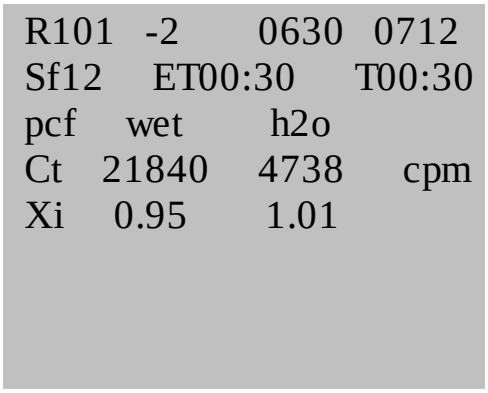



| | |
|---|---|
| 2. Press **ENTER** one or more times. | Display alternates between pcf and gcc units. |
| 3. Press **CLEAR**. | Units displayed is now selected. Screen returns to **READY.** |

**To Change Screen Results**

From density (pcf or gcc) to cpm (count per minute
From cpm (counts per minute) to density (pcf or gcc)

| **Action** | **Result** |
|---|---|
| 1. Press **STEP + UNIT** | Screen displays units menu, as above. |
| 2. Press **STEP.** | Cursor moves to screen result options. |
| 3. Press **ENTER** one or more times. | Display alternates between density and cpm screen results. If the cpm screen has been selected, the **CPN MC-S Strata Gauge** will count and display results as in the example: |




| | |
|---|---|
| 4.Press **CLEAR**. | Screen result displayed is now selected. Screen returns to **READY**. |

# Calibration

Each **CPN MC-S Strata Gauge** is calibrated at the Boart Longyear/CPN factory. A typical computer printout of the calibration data is shown in Figure 2-3. If you require a different calibration, perform the following steps.

Figure 2-3. Computer Calibration Printout

```
Boart Longyear/CPN                CALIBRATION

SERIAL NO: 2103          MODEL: MCSA-00B

DENSITY STANDARD COUNT:  8919  DATE: 940712
CALIBRATION DATE: 940712

                      -----COUNT AT--------
DEPTH 107.2   133.6    164.3          --- A ---  --- B ---        -- C ---
                      ------ lb / ft^3  ------

  2       4686    2499     1225          7.07559              40.94229
                    .00943
  4       5204    2662     1300          10.44992             36.48533
                    .03004
  6       5316    2738     1280          9.06413              39.24758
                    .00572
  8        5363   2693     1288          11.57744             35.64698
                    .0291
TO
  24
                                                        A
  WHERE:  DENSITY IN  lb / ft^3  =  B * Ln(---------)
                                                      R - C
                      COUNT
        R = RATIO = -----------
                     STD CNT

MOISTURE STANDARD COUNT:  2117   DATE: 940712
 CALIBRATION DATE: 940712

           ---COUNT AT----
          0.0       33.0          --- A ---                  -- B ---
            ---  lb / ft^3  ---

  2       153      1411          55.69393       40.94229
  4       138      5283          13.61768       .88781
  6        170     9395          7.59572        .61004
  8        188     10572         6.7472         .59926
TO
  24

  WHERE: MOISTURE IN  lb / ft^3  = (A * R) - B
```

## Edit Coefficient

The wet density and $H_2O$ coefficients allow the operator to edit (view/change/enter) density and moisture calibration coefficients. Write down factory calibration coefficients before overwriting with new ones in the **CPN MC-S Strata Gauge** so they can be reentered later.

| Action | Result |
|---|---|
| 1. Press **STEP + CALIB**. | Screen displays calibration menu with cursor prompting wet coefficients: |

Calibration

wet coefficients
h2o coefficients
wet selfcal
h2o selfcal

STEP & ENTER choice

| Action | Result |
|---|---|
| 2. Press **ENTER**. | **CPN MC-S Strata Gauge** displays Wet calibration screen with cursor prompting depth field (2 in initially). |
| 3. Press **STEP** until desired depth and calibration | Depths field rolls through 2, 4, 6, etc. (Current coefficients are displayed for each depth), example: |

```
Wet cal          2 in

A 10.65422
B 81.63265       pcf
C -.220318

STEP & ENTER depth
CLEAR twice to exit
```

| | |
|---|---|
| 4. Press **ENTER**. | Cursor moves to A coefficient field and prompts for entry of new value. |
| 5. Enter the **A** coefficient value and press **ENTER**. Pressing **ENTER** will store the current value and a new value is not entered. | Value displayed in A coefficient field and stored. Cursor moves to B coefficient field and prompts for entry of new value. |
| 6. Repeat step 5 for **B** and **C** coefficients. | B and C coefficient values are displayed and stored. Cursor then moves to top of screen and prompts for next depth. |
| 7. Repeat steps 3 through 6 for each depth. | Wet calibration coefficients are entered in **CPN MC-S Strata Gauge** memory. |
| 8. Press **CLEAR** twice to exit Wet calibration coefficients screen. | Calibrations menu is displayed with cursor prompting. |
| 9. Press **STEP** to move cursor $H_2O$ field. | Cursor prompts $H_2O$ coefficients. |
| 10. Press **ENTER**. | $H_2O$ calibration coefficients screen is displayed. Cursor prompts for entry in the A coefficient field. |

```
h2o cal          2 in


A  64.26693       pcf
B  4.78088        pcf

Enter coefficients
CLEAR twice to exit
```

# Calibration

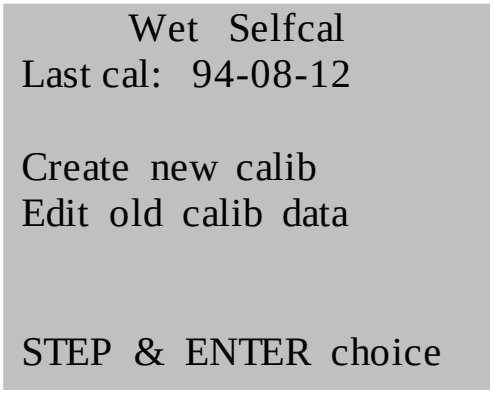
| Action | Result |
|---|---|
| 11. Enter **A** coefficient value and press **ENTER.** | Value displayed in A coefficient field. Cursor moves to B coefficient field and prompts for entry of new value. |
| 12. Enter **B** coefficient value and press **ENTER**. | Value displayed in B coefficient field. $H_2O$ calibration coefficients are entered in **CPN MC-S Strata Gauge** memory and calibration menu is displayed. |
| 13. Press **CLEAR** twice to exit $H_2O$ calibration coefficients screen. | Calibration menu is displayed with cursor prompting. |
| 14. Press **CLEAR** to return to main menu. | Main screen is displayed. |

## Self Calibration

The wet selfcal and $H_2O$ selfcal options allow the operator to calibrate the **CPN MC-S Strata Gauge** on a set of three standards of known density (low, intermediate, and high) and two standards of known equivalent moisture (low and high). Calibration coefficients are automatically computed and stored in the **CPN MC-S Strata Gauge**.

| Action | Result |
|---|---|
| 1. Take a standard count. | |
| 2. Press **STEP + CALIB**. | Screen displays calibration menu with cursor prompting wet coefficients. |
| 3. **STEP** to wet selfcal, then **ENTER**. | Screen displays option: create a new calibration or edit old calibration data. |

**NOTE**
Selecting the **Create new calib** option will erase the previous calibration counts.




4. Press **ENTER** to create a new

calibration and  move to step 6, or move to step 5 to edit calibration data.

| Action | Result |
|---|---|
| 5. Press **STEP,** then **ENTER** to edit old calibration data. Selecting "edit" retains previous calibration counts but allows one or more of them to be changed. | The existing density values of three wet density calibration blocks or two $H_2O$ density calibration blocks will be displayed. For example:<br>Wet Selfcal<br>Block Weights<br><br>Low: 107.2<br>Med: 133.6<br>High: 164.3<br><br>Key weight & ENTER |
| 6. The wet density of $H_2O$ density block values may be left unchanged by pressing **ENTER** on each value or keying in a new value followed by **ENTER**. | The **CPN MC-S Strata Gauge** will then display the density value of one of the calibration blocks and the last count for the selected depth.<br>Wet Selfcal<br>107.2 pcf BLOCK<br>2 in *.* cpm<br><br>Minus to roll depth<br>STEP to roll block<br>START to count<br>or enter a value |
| 7. Press **STEP** to select or change the calibration block density. Move the source rod to the next desired depth. Press **START** to take a calibration count (automatically four minutes).<br><br>If prior calibration data is known, place the gauge in the **FIXED** Depth Mode via the **STEP+CALIB** menu and follow the above sequence except press "-" to advance to a new depth and key in the count data as appropriate. | When all three blocks have counts for a depth, the **CPN MC-S Strata Gauge** will compute the coefficients for that depth. While computing, a term will be displayed which will reduce to a small number before the gauge accepts the solution. |
| 8. When the coefficients are displayed, press **ENTER** to accept them or **CLEAR** to abort and start over. | |

# Data Logging

The **CPN MC-S Strata Gauge** can log up to 128 tests in record numbers chosen by the operator. The information can be reviewed on the display screen at a later time or transferred to a computer or printer.

### Storing Test Results

| Action | Result |
|---|---|
| 1. Pick a record number between 0 and 65535. | |
| 2. Press **ID**, then enter record number chosen. Entering a previously used record number allows user to append test results to end of that record. If no number is picked, the previous record will be used. | **CPN MC-S Strata Gauge** sets up record number, or positions user at end of existing record. |
| 3. After a test, press **ENTER** to store contents of main test screen. If a reading has already been stored, the Strata Gauge will abort storage and await another command. | Test results are stored in new record or appended to existing record. Number-of-tests counter on screen changes. **CPN MC-S Strata Gauge** beeps twice and displays RECS FULL when record space is full. |
| 4. To clear entire record space, first review and print out stored data (see Data Transfer section), press **ID** and then hold down **STEP** and press **ID**. | Record space and site numbers are all erased. Data that has been erased cannot be recovered from the Strata Gauge. The gauge beeps twice and displays RECS EMPTY. |

## Reviewing Test Results

| Action | Result |
|---|---|
| 1. Press **RECALL**. User can now move to next record with **STEP,** but not to next test within record. | Because a test may be stopped before completion by the operator, the **TIME/PRECISION** value is omitted. |
| . 2. Enter desired record number, then press **ENTER.** If first record displayed is desired, press **ENTER** to recall results within record. | User is now in desired record and first test result is displayed. |
| 3. Move from test to test within record with **STEP.** | Test results are displayed in order they were taken. At the end of a record, **STEP** moves user to next record. |
| 4. To move from within a record to the next record, press **CLEAR** once. | User can now move to next record with **STEP**, or to any record by entering record number and pressing **ENTER**. |
| 5. To return to main screen (most recent results) from the first test in a record, press **CLEAR** once. To return from a test within a record, press **CLEAR** twice. | User has left **RECALL** mode. |

# Operation Summary

## To take a Count

| | | |
|---|---|---|
| Standard Count | **STD, START** | handle in SAFE position |
| | **STEP** | early finish |
| | **CLEAR** | abort |
| Field Count | **START** | handle in desired depth |
| Display last reading | **CLEAR** | |

## To Program

| | | |
|---|---|---|
| Time/Precision | **TIME** (T), xxxx (min/sec) or **TIME, STEP** (P),xx.xxx (pcf or gcc) | |
| % Compaction | **% COMP** | Press to display compaction calculation<br>Mw: Wet/wetmax x 100<br>Md: Dry/drymax x 100<br>Av: (Avmax - wet)Avmax x 100 |
| Maximum | **MAX, xxx.x, ENTER** | |
| Density bias | **D BIAS, xxx.x, ENTER** | |
| Moisture bias | **M BIAS, xxx.x, ENTER** | |
| Units | **STEP + UNIT** | units menu displayed |
| | **STEP** | selects units or screen display |
| | **ENTER** | toggles units between pcf and gcc, and screen between density and counts |
| | **CLEAR** | display units selected |

## Record Operation

| | | |
|---|---|---|
| Clear memory | **ID, STEP + ID** | |
| Identify site | **ID, xxxxxx, ENTER** | |
| Store last reading | **ENTER** | stores last reading into record once after each START, up to 128 readings per site number, 128 readings maximum |
| Display log | **RECALL, xxxxxx, ENTER** or **STEP...STEP, ENTER,** then **STEP** | to view readings within a site number |
| Printer dump | **PRINT, ENTER** | display screen format |
| Computer dump | **PRINT, STEP, ENTER** | data compressed and separated by commas |

## Miscellaneous

| | | |
|---|---|---|
| Real time clock | **STEP + TIME** | follow prompt to set date/time |
| Display counts/min | **STEP + UNIT, STEP**, **ENTER, CLEAR** | repeat to return to nomal display |
| Calibrate | **STEP + CALIB** | select choice from calibration menu and follow instructions on display |
| Abort (one level) | **CLEAR** | clear entry, abort, stop |
| Abort (master) | **STEP + CLEAR** | clears to most recent reading on screen |

For your convenience, this Operation Summary is printed on the clipboard provided in the shipping case

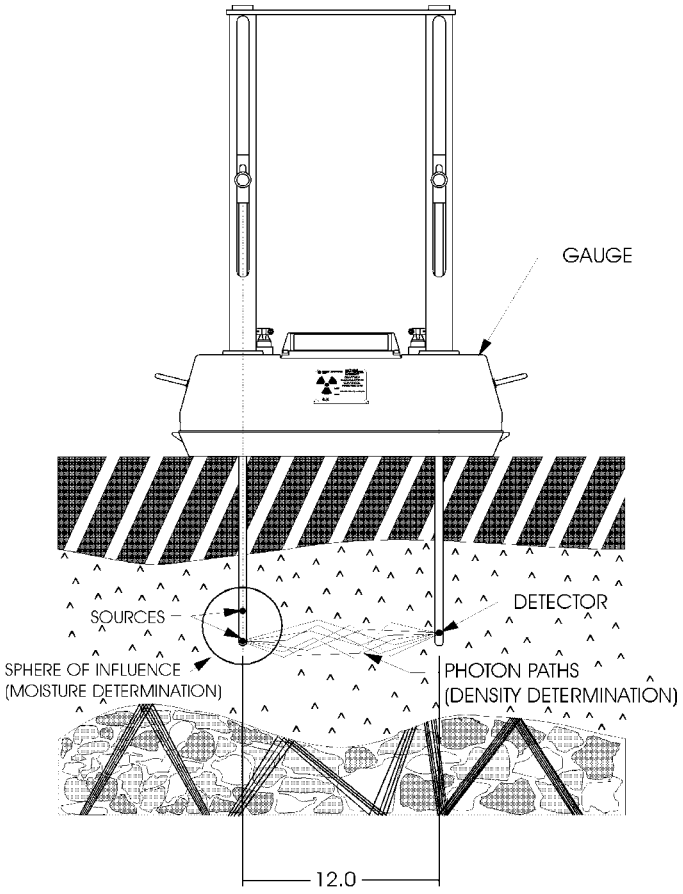
# Section 3 - Field Use

## Soils / Agregates

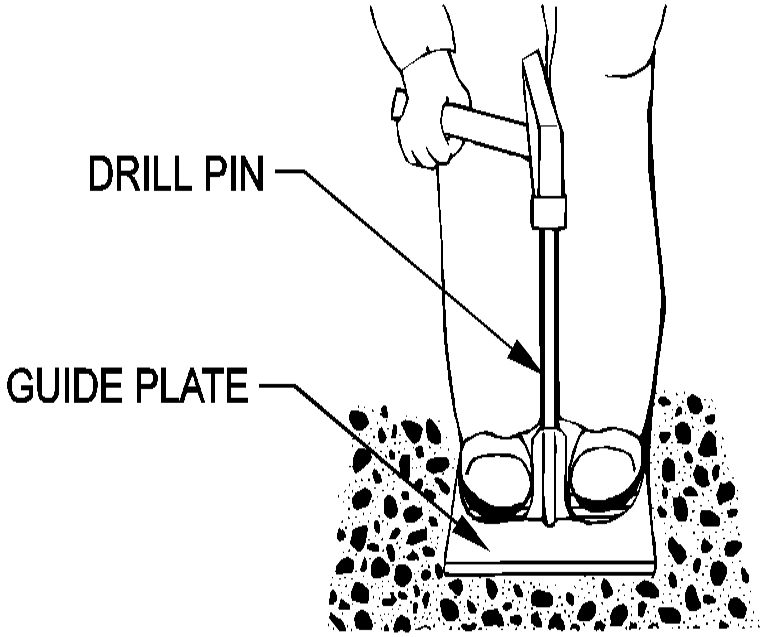
### Transmission Measurements

The transmission mode of the **CPN MC-S Strata Gauge** measures density of soils and aggregates to depths of 2 to 24 in (50 to 200 mm).

Density measurements are made with the **CPN MC-S Strata Gauge** set to one of the transmision mode depths. Measurements performed on soils require no special preparation other than preparing a surface that is level and relatively smooth, and drilling a hole for inserting the source rod.



The guideplate can be used to smooth loose soil on an uneven surface. For soft soils, the hole can be drilled with the drill pin and a hammer or mallet, using the guideplate as a template. Extract the pin while standing on the guideplate to ensure undisturbed holes. Do not use the guideplate as a tool to remove the drill pin.



# Soils/Aggregates

## Transmission Measurements

For hard soils, a Campbell hammer (optional accesory) may be required, as shown in Figure 3-2. The weighted hammer is used to both drive and extract the pin while the operator stands on the guideplate. Drill the holes a minimum of 2 in (50 mm) deeper than the intended depth of measurement.

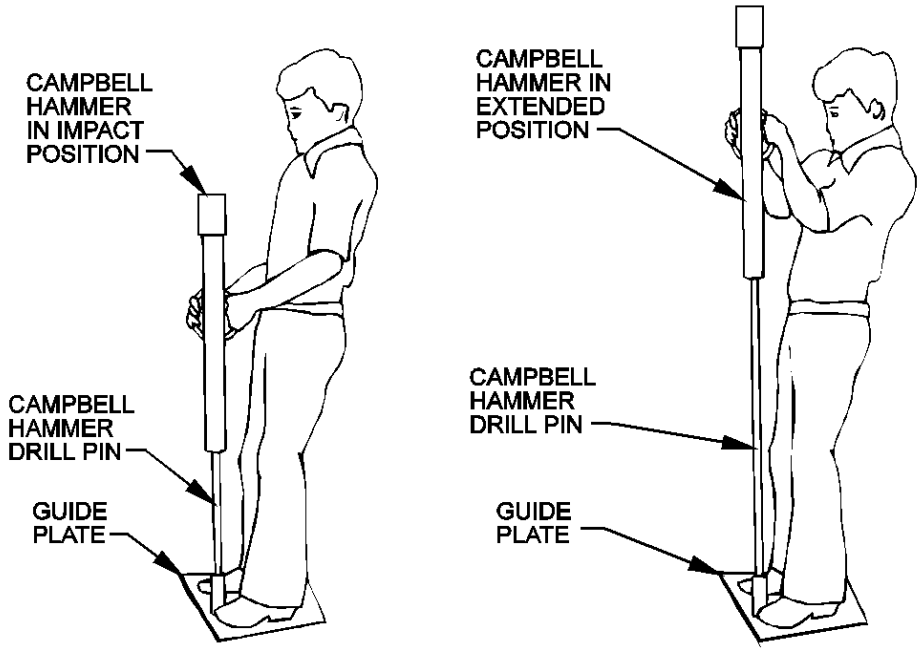



Figure 3-2. Using the Campbell Hammer

After drilling the transmission hole, place the gauge in place and lower the two rods to the desired position. Select the appropiate calibration and press START to begin a test.

## Moisture Measurements

Moisture measurements are taken simultaneously with density measurements by the **CPN MC-S Strata Gauge**. The center of moisture measurement is the depth of source (right) rod setting. The volume of measurement is approximately spherical with a radius of measurement that averages 6 in. (15 cm) in a soil at 15 pcf (0.240 g/cm3) moisture. The **CPN MC-S Strata Gauge** moisture mode measures all hydrogen in the material. In most soils and aggregates this hydrogen is in free water. Serpentine soils, clays, organic matter, and lime-treated soils, which contain bound hydrogen, produce higher moisture readings on the **CPN MC-S Strata Gauge**.

To establish the correct bias in such a soil, use the following procedure, condensed from ASTM D-3017:

1. On a compacted soil having a uniform moisture content, determine the total density (Dw) and moisture $H_2O$) using the **CPN MC-S Strata Gauge**.
2. Obtain one or more soil samples (150 to 200 g) from the site of the nuclear gauge test.
3. Weigh each sample, oven dry to a constant weight at 110 C, and weigh each dry sample. Compute the average moisture content as follows:

$$\frac{\text{Weight of water x 100}}{\text{Weight of dry soil sample}} = \text{MC, \% moisture, dry weight basis}$$

4.Determine the actual moisture in pounds per cubic foot follows:

$$M = \frac{MC \times Dw}{MC + 100}$$

where: M = moisture, pcf
MC = moisture content, % of dry weight (step 3)
Dw = wet density, pcf (from step 1)

5. Determine the correction factor to be entered into the M BIAS:

$$\text{M BIAS} = \text{M, oven dry} - H_2O\text{, nuclear gauge}$$

6. This value can be used for all field testing of the same soil type.

Example:
**MC-S** test results: Dw = 130.0 pcf
H2O = 12.5 pcf
Oven dry MC = 9.0%

$$\text{Then, } M = \frac{9.0 \times 130.0}{9.0 + 100} = 10.73 \text{ pcf}$$

$$\text{M BIAS} = 10.73 - 12.50 = -1.77 \text{ pcf}$$

## Over-sized Rock Correction

Often rocky, natural soils are tested for density. The **CPN MC-S Strata Gauge** will measure the total density of the material under test, including rocks. For this reason, a series of random tests on this material will show a greater deviation around the average than on an area of processed uniform material. A number of separate soil volumes can be tested at one prepared site by rotating the gauge 90 or 180 degrees around the transmission hole and recording the average density value. This procedure should be used whenever the material requires a rock correction in the laboratory test of

moisture-density relationships, whenever 10 to 30 percent of the material is retained on the ¾ inch sieve.

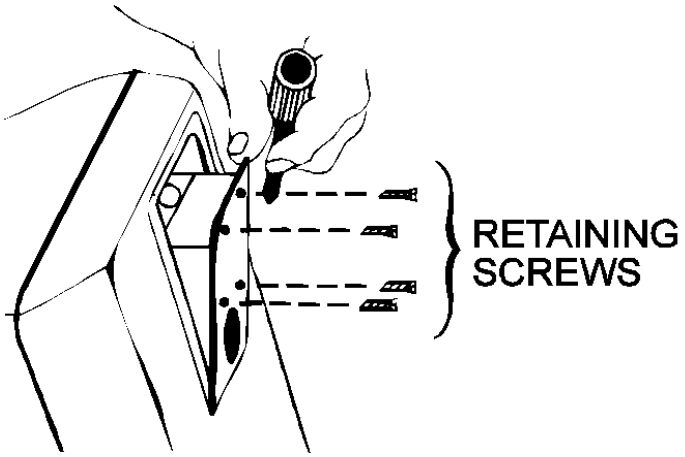
# Section 4 - Maintenance

## Clean and Lubricate Shutter Mechanism

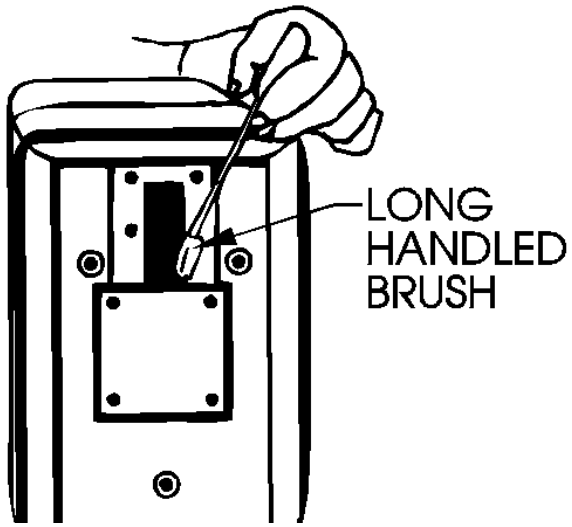
The shutter should be cleaned and lubricated weekly during use, or whenever the source rod becomes dirty and begins to stick.

1. Remove the four screws securing shutter plate block assembly.

2. Remove shutter assembly.




**CAUTION**
Radioactive source is located in base cavity. Do not touch the source rod tip and do not place yourself in front of the opening after the shutter block is removed.



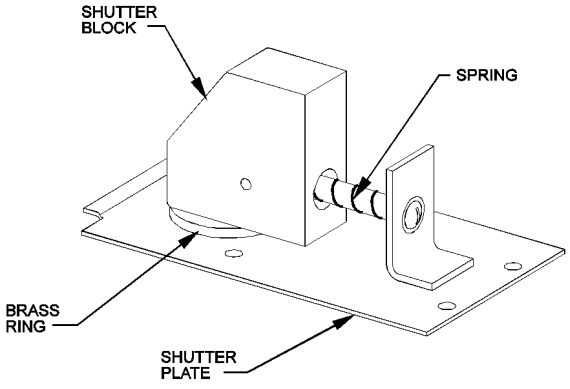

3. Stand behind the gauge and use a long-handled brush or compressed air to clean exposed area inside
**CPN MC-S Strata Gauge**.

4. Clean entire shutter assembly and spray with the greaseless silicone lubricant provided.

5. Allow assembly to dry, then reinstall shutter block and plate.

6. Check **CPN MC-S Strata Gauge** handle to ensure it slides freely in guidetube.

**Cleaning and lubrication completed.**



# Handle Assembly Inspection

Inspect the handle assembly monthly for wear.

1. Loose 5/32 in Allen head hex screw on side of guide tube ONLY until handle is free. Do not remove screw.

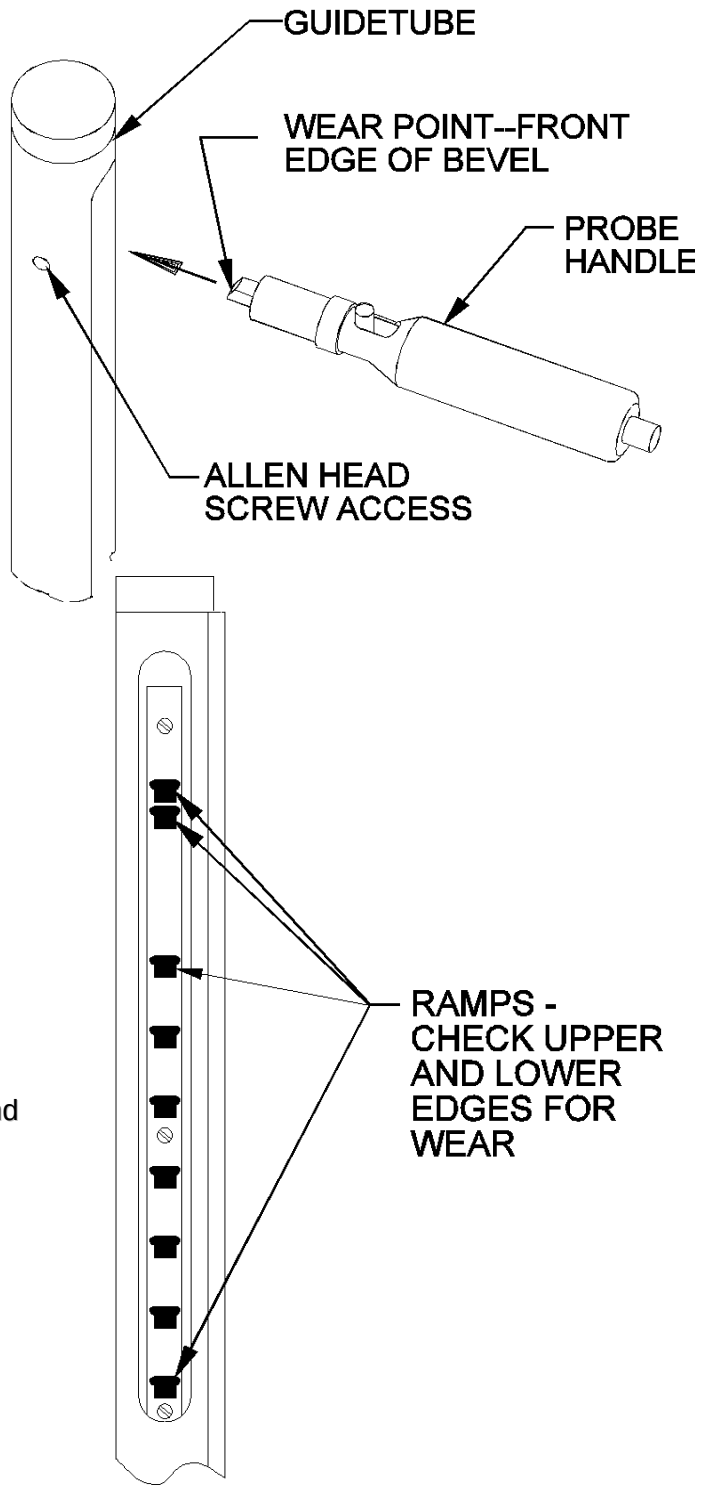
2. Pull handle away from guide tube.

3. Check beveled front edge of handle latch for excessive wear.

4. Check notches inside guide tube for excessive wear.

**NOTE**
If wear on the notches or latch appears to be excessive, contact your Boart Long year/CPN service representative for assistance.

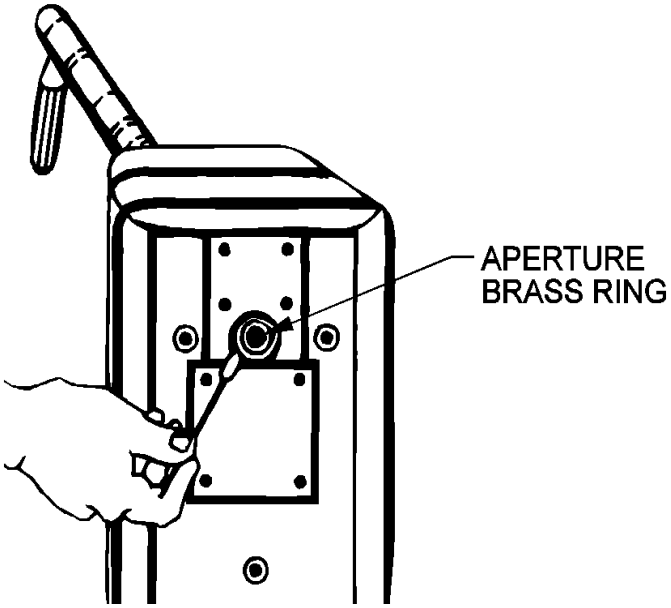
5. Reassemble handle to guide tube assembly and tighten Allen screw.



# Leak Test

The leak test is required every six months or yearly. Check your Radioactive Materials license for the time interval.

1. Use the CPN TD-11 LTK Leak Test Kit to perform this required test for leakage of the source material from its capsule. Set handle to SAFE position.




2. Use the cotton swab in the kit to swab around cleanout plate ring on the aperture. This will pick up any removable contamination from either Am -241/Be sealed sources.

3. Break swab stick in half and place in plastic envelope. Complete form and staple envelope to it; mail to address on the kit. Within approximately six weeks you will receive notification of results.

## Charging Battery Pack

A battery pack of 8 welded AA rechargeable nickel cadmium batteries is located beneath the keyboard/display electronics package.

When "lob" appears in the lower right hand corner of the main screen, the instrument will take approximately 100 more 30-second tests before it will go into cutoff. Test for the presence of the "lob" by pressing the **CLEAR** key. This should be done before going into the field, preferably the evening before to allow time to recharge if necessary.

1. Set Strata Gauge handle to SAFE position.

2. Connect battery charger power cord to 120 VAC power outlet.

3. Connect battery charger to jack on rear panel. Press any key to update the screen.

4. Main display screen message "lob" is replaced with "chg", indicating batteries are being charged at C/10 charge rate. Full charge time is 12 to 14 hours.

> **NOTE**
> Prolonged overcharging or failure to allow the battery pack to discharge to “lob” condition may cause a loss of battery capacity which will be difficult to recover.

## Storage

To protect the **CPN MC-S Strata Gauge**, store it in the shipping case when not in use. The normal 8 year shelf life of the internal memory keep-alive lithium battery will be reduced to 4 years if the NICAD battery is not kept charged or is disconnected. For long term storage, charge the gauge before placing in storage and recharge every 3 months.
Close and latch the lid of the shipping container when not in use to prevent moisture intrusion.

INTENTIONALLY
BLANK

# Appendix A

## Display Messages and Prompts

| Message: | Meaning: | Action: |
|---|---|---|
| chg | Battery charging at C/10. | None. |
| lob | Low battery condition 25% charge remaining. | Charge battery. |
| **START** new standard<br>**CLEAR** exit | Message displayed on standard count screen. | Press **START** to initiate a standard count. Press **CLEAR** to return to main display. |
| Put rod in **SAFE** and press **START** | Standard count attempted when probe is set to a depth other than **SAFE** position. | Set the handle to **SAFE** position and press **START**. |
| Press **STEP** to stop<br>Press **CLEAR** to abort | Message displayed during a stan dard count. | No action required unless operator wishes to stop the standard count in progress. To stop the count and store the count taken to that point, press **STEP.** To abort the count, press **CLEAR**. |
| Bad depth:<br>Put handle in proper position and press **START.** | Test attempted when source rod is set to an unprogrammed depth position. | Set rod depth to correct depth position and press **START.** |

# Appendix B

## Troubleshooting Guide

The **CPN MC-S Strata Gauge** can generally be repaired by isolating the problem and replacing the defective component. Only the tools supplied in the shipping case are needed for component exchange.

| Problem | Action |
|---|---|
| Display remains blank. No beep, no response to keyboard commands. | 1. Push the reset button on the rear panel.<br>2. Batteries are discharged below cutoff voltage and require charging.<br>**OR**<br>3. Batteries are dead and require replacement. |
| Same condition as above, except batteries are fully charged. | Replace main electronic assembly. |
| **CPN MC-S Strata Gauge** operational but no change in density readings. Xi = 0.0 in count mode, wet* displayed. | 1. Replace density detector assembly.§<br>2. Replace wire harness.<br>3. Replace main electronic assembly. |
| **MC-S** operational but no change in moisture readings. Xi = 0.0 count mode, $H_2O$* displayed. | 1. Replace moisture detector.§<br>2. Replace wire harness.<br>3 Replace main electronic assembly. |
| On all counts wet* displayed. On standard counts Xi value is out of limits. | Replace density detector assembly.§ |
| On all counts $H_2O$* displayed. On standard counts Xi value is out of limits. | Replace moisture detector assembly.§ |

§ Involves recalibration. Contact the Boart Longyear/CPN Service Center for further information.

# Appendix B

## Troubleshooting Guide

| Problem | Action |
|---|---|
| **PRINT or DUMP** reports fails to operate but screen displays **"PRINTING REPORTS"** or **"DUMPING REPORTS".** | 1. Check for proper baud rate setting in MENU field. Printers are usually 9600 BPS and computers can be 300, 600, 900, 1200, or 9600 BPS.<br><br>2. Check RS232 serial cable pin connectors. Check pins 2, 3, and 7 on 25-pin connector and handshake pins. If necessary check device manual or call CPN Service Center. |
| **PRINT or DUMP** reports fails to operate. NO "Printing Reports" or "Dumping Reports" appear on **CPN MC-S Strata Gauge** screen. | Record Log is empty. Data must be taken. |

# Appendix C

## Data Transfer

### Printing Records

To transfer (upload) stored data from the **CPN MC-S Strata Gauge**, you will need a printer or computer with the following characteristics:

Asynchronous RS-232-C data interface (ASCII format)
300- to 9600-bps baud rate (to which the **CPN MC-S Strata Gauge** will be set)
11-bit character length (1 start bit, 7 data bits, 1 space parity bit, 2 stop bits)

| **Action** | **Result** |
|---|---|
| 1. Connect RS-232-C cable to printer and **CPN MC-S Strata Gauge**. | |
| 2. Press **PRINT**. | Screen displays printer menu with cursor prompting: |
| 3. Press **STEP** until prompt is at baud rate, then press **ENTER**. | Ready to select baud rate. |
| 4. Press **STEP** until desired baud rate is displayed, then press **ENTER**. | Baud rate selected. |
| 5. Press **STEP** until prompt is on control characters, then press **ENTER**. Follow prompted instructions on screen to select control characters. | Printer control characters set. |

```
PRINT

Print  reports
Dump reports
Baudrate  =  9600
Control  characters
Print  coeffs
STEP  &  ENTER  choice
```

| Action | Result |
|---|---|
| 6. Press **STEP** to select the printout format. | Either Print reports or Dump reports is selected. Print reports is a formatted output with headings identical to the test screen display. Dump reports is a condensed format with all numerical data separated by commas. |

**DUMP REPORT FORMAT**

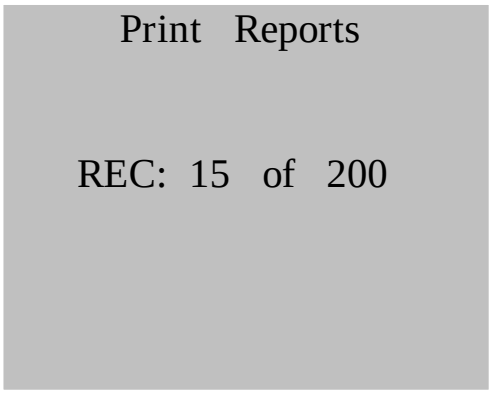
```
101, 1, 10, 16, 13, 44                    ID, TESTS, MONTH, DAY, HOUR, MIN
pcf, Da, 8, 00, 30                        UNITS, DEPTHMODE, DEPTH, ELAPSED MIN, ELAPSED SEC
134.6,0.44,0.0                            DWET, DWET PREC, DWET BIAS
14.2,0.25,0.0                             H2O, H2O PREC, H2O BIAS
120.4,0.69                                DRY, DRY PREC
11.8, Md, 125.5, 96.0                     WATER%, COMPACTION TEST, MAXIMUM VALUE, % COMPACTION
8160,0.95,4738,1.01                       DCOUNT, DXi, MCOUNT, MXi
```

**PRINT REPORT FORMAT**

```
R101    -1    1016   1344          ID, TESTS, MONTH/DAY, HOUR/MIN
Da8     ET00:30                    DEPTHMODE,/DEPTH, ELAPSED TIME
pcf     wet     h2o    dry         UNITS, WET HEADER H2O HEADER, DRY HEADER
Dn    134.6  14.2   120.4          DENSITY ROW, WET DENSITY, H2O DENSITY, DRY DENSITY
Pr     0.44   0.25   .7                  PREC ROW, DWET PREC, H2O PREC, DRY PREC
%             11.8   96.0          % ROW, WATER %, % COMPACTION
Md                   125.5         COMPACTION TEST, MAXIMUM VALUE
Bi   0.0      0.0                  BIAS ROW, DWET BIAS, H2O BIAS

R101    -1    1016   1344          ID, TESTS, MONTH/DAY, HOUR/MIN
Da8     ET00:30                    DEPTHMODE/DEPTH, ELAPSED TIME
pcf     wet     h2o                      UNITS, WET HEADER, H2O HEADER
Ct     8160    4738                COUNTS ROW, DWET COUNT, H2O COUNT
Xi      0.95    1.01               Xi ROW, DWET Xi, H2O Xi
```

| | |
|---|---|
| 7. Press **ENTER**. | Printer starts printout and the **CPN MC-S Strata Gauge** screen displays: |




Line numbers on display will vary according to number of records stored in **CPN MC-S Strata Gauge** memory and currently being printed.

| | |
|---|---|
| 8. Press **STEP + CLEAR** to stop upload or to exit from print mode. | Printer stops printing and **CPN MC-S Strata Gauge** screen returns to print menu. |

# Appendix C

## Data Transfer

### Print Calibration Coefficients

To print calibration coefficients, proceed as follows:

| Action | Result |
|---|---|
| 1. Set correct baudrate and control characters as above. | |
| 2. Press **STEP** until prompt is at print coefficients option, then press **ENTER**. | Printer starts printout and screen displays line number currently being printed.<br><br>Upon completion, or by pressing **STEP + CLEAR** to stop transfer, screen returns to print menu. |

# Appendix C

## Data Transfer

## MC-3 Dump Software

This is an optional software supplied by CPN in a 3½ in diskette (P/N 704506) or in a 5¼ in diskette (P/N 704507). Two programs are included in those diskettes MC3DUMP.EXE and LOTUSMC3.EXE and both are intended to be used with all versions of **CPN MC-S Strata Gauge** nuclear gauges.

Both programs perform the same basic function; they establish a link to the **CPN MC-S Strata Gauge** through one of the PC's COM ports, send commands to the gauge to retrieve stored records, and output the data to a file on the PC. The only difference between them is in the format of the file produced.

The **CPN MC-S Strata Gauge** outputs its data in "Print Reports" format or "Dump Reports" format ( see the description of these formats in Step 6 of Printing Records), the MC3DUMP program copies the data in either of these formats to the output file. The data as it appears in the output file is unaltered by the MC3DUMP program. The LOTUSMC3 program reads the data from the **CPN MC-S Strata Gauge** in the native "Dump Reports" format, and then modifies the data to a comma and quote delimited ASCII format before outputting it to the file.

If you will be using a spreadsheet or database program such as Lotus 1-2-3, Borland Quattro Pro, Microsoft Excel, dBase, Paradox, or similar application for your reports, it is recommended that you use the LOTUSMC3 program. This program formats the data in the output file MC3LOTUS.PRN to accommodate the File Import feature of most spreadsheet and database applications. When importing the MC3LOTUS.PRN file into the application, it is sometimes necessary to specify to the application program that the data format is ASCII, with fields (columns) delimited by a comma, text delimited by quotes (""), and records (rows) terminated by a carriage return <CR>.

In Lotus 1-2-3, the keystrokes required to import a file are /FIN (mnemonic /File:Import:Numbers). If you use a program other than Lotus 1-2-3, refer to the program documentation to determine the exact procedure for importing a comma and quote delimited ASCII file.

The **CPN MC-S Strata Gauge** connects to one of the COM ports on your computer via a serial cable fitted with a miniature LEMO connector on one end (for connection to the **CPN MC-S Strata Gauge**) and a DB-25S (P/N 501516) or an AT-style DB-9S (P/N 500658) on the other end (for connection to your computer). Both MC3DUMP and LOTUSMC3 will work with either COM1 or COM2 on your computer.

**NOTE**
To use special upload options, contact Boart Longyear/CPN for assistance.

# Appendix D

## Accesories

| Part Number | Description |
|---|---|
| 101050 | Campbell Hammer, impact type |
| 702815 | Cable, 6 ft (1.8m), battery charger, equipped with cigarette lighter connector |
| 702816 | Cable, 6 ft (1.8m), battery charger, equipped with battery clips |
| 700496 | Survey Meter (GM detector) |
| 501544 | Cable, 6 ft (1.8m), equipped with RS-232-C/DP25P connectors (computer uploading) IBM PC |
| 501516 | Cable, 6 ft (1.8m), equipped with RS-232-C/DP25S connectors (computer uploading) Apple, etc. |
| 500658 | Cable, 6 ft (1.8m), equipped with RS-232-C/DP9S connectors (computer uploading) IBM, AT, PORTABLES |
| 501575 | Cable, 6 ft (1.8m), equipped with unterminated RS-232-C connector |
| 700126 | Connector, LEMO, 7-pin |
| 702632 | Printer Set (Cable-Asy, Printer-transformer, Batt Pack) |
| 702685 | Printer, hand-held, IMP-24, 24 characters per line, battery or line powered |
| 702683 | Printer, hand-held, IMP-24, 24 characters per line, battery or line powered (European) |
| 702678 | Printer Set (Cable-asy, Printer-transformer, Batt Pack (European)) |
| 701439 | Battery Pack, IMP-24 |
| 702726 | Cable, 6 ft (1.8m), equipped with RS-232-C connector (printer uploading) |
| 704507 | Prgm, MC3DMP, MSDOS, 5 1/4 in Disk |
| 704506 | Prgm, MC3DMP, MSDOS, 3½ in Disk |

# Appendix E

## Conversion Factors

| Multiply | By | To Obtain |
|---|---|---|
| inches (in) | 25.4 | millimeters* |
| millimeters (mm) | 0.03937 | inches |
| pounds per cubic foot (pcf) | 16.01846 | kilograms per cubic meter |
| kilograms per cubic meter ($kg/m^3$) | 0.06243 | pounds per cubic foot |
| pounds per cubic foot (pcf) | 0.01601846 | grams per cubic centimeter |
| grams per cubic centimeter ($gr/cm^3$)** | 62.428 | pounds per cubic foot |

* On the source rod depth settings of the **CPN MC-S Strata Gauge** guidetube, 1 inch equals 25.0 millimeters.
** The **CPN MC-S Strata Gauge** displays grams per cubic centimeter as gcc.

# Glossary

**ASTM:** American Society of Testing and Materials. Publish standard test methods for all materials, including moisture and density determination of soil- aggregates and pavements.

**COMPACTION (DENSITY) CONTROL:** The testing of soil and aggegate mixtures during field construction to assure that specified compaction levels are obtained relative to laboratory-determined values. The following ASTM standard test methods are used to obtain the maximum values to be entered into the **CPN MC-S Strata Gauge** for relative (%) compaction determinations.

D 1557: Moisture-Density Relations of Soils and Soil-Aggregate Mixtures Using 10-lb (4.54 kg) Rammer and 18-in (457 mm) Drop.

**DRY DENSITY (Dn Dry):** Mass of soil, after drying for 24 hours at 110° C, contained in a unit volume of undried soil, expressed in pcf or g/cm$^3$. Calculated by the **CPN MC-S Strata Gauge** as follows:

Dn wet - Dn $H_2O$ = Dry Density.

**DRY DENSITY-MOISTURE CONTENT RELATIONSHIP:** The relationship between dry density and moisture content of a soil under a given compactive effort. Commonly known as a Proctor Test after its originator, R.R. Proctor.

**MAXIMUM BULK SPECIFIC GRAVITY (Av):** the maximum bulk specific gravity of a material. Determined by laboratory test and programmable into the **CPN MC-S Strata Gauge** for percent air void calculations (%Av).

**MAXIMUM DRY DENSTIY (Md):** The dry density obtained using a specified amount of compaction at the optimum moisture content. Commonly known as the Proctor value and programmable into the **CPN MC-S Strata Gauge**.

**MAXIMUM WET DENSITY (Mw):** The maximum density of a material. Determined by laboratory test and commonly known as Marshall value. Programmable into the **CPN MC-S Strata Gauge** for relative compaction calculations (%Mw).

**MOISTURE CONTENT: (%H2O):** The mass of water in a soil expressed as a percent of the dry soil mass. Calculated by the **CPN MC-S Strata Gauge** as:

Dn $H_2O$/Dn dry x 100.

**OPTIMUM MOISTURE CONTENT (OMC):** The moisture content of a soil at which a specified amount of compaction will produce the maximum dry density, expressed as % moisture.

**PERCENT AIR VOIDS (%Av):** The volume of air voids in a soil or paving mixture expressed as a percentage of the total volume of the material. Calculated by the **CPN MC-S Strata Gauge** as:

((Av - Dn wet)/Av) x 100.

**RELATIVE or % COMPACTION, PAVEMENTS (%Mw):** The percentage ratio between the total density of an in-place pavement (Dn wet) and its maximum total density (Mw) as determined by a specified laboratory compaction test.

**RELATIVE or % COMPACTION, SOILS (%Md or Av):** The percentage ratio between the dry density of an in-place soil (Dn dry) and its maximum dry density (Md), determined by a specified laboratory compaction test.

**TOTAL MOISTURE (Dn H2O):** The mass of water in a unit volume of soil, expressed in pcf or g/cm3. A direct measurement of the **CPN MC-S Strata Gauge**.

**WET DENSITY (Dn wet):** Mass of bulk soil, including solids, water, and air, contained in a unit volume, expressed in pcf or g/cm$^3$. A direct measurement of the **CPN MC-S Strata Gauge**.

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