Manual of Operation

Xplorer 3500

Moisture/Density Gauge

FAST ACCURATE INNOVATIVE

InstroTek® Inc.

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3500 Xplorer Moisture/Density Nuclear Gauge
Operation Manual version 8
Software 7.19-Current

Chapter 1: Introduction and Gauge Components

Introduction

Thank you for your purchase of the InstroTek Model 3500 Xplorer. This gauge is designed to withstand the rugged environment of the construction industry. We asked our customers what features they rated as the most important in the gauge. Reliability, reduced service costs and price were placed on top of the list. We analyzed all other gauges in the market and determined that in order to improve reliability and to reduce service cost, we had to develop and rigorously test electronic modules to assure that they were more robust than existing equipment. For this reason we designed our boards with extremely reliable surface mount components. Furthermore, before completing this gauge, we developed the front panel and the baseboard separately and offered them for upgrade of existing gauges in the market. Over the last two years, we have upgraded hundreds of front panels and baseboards with exceptional performance results. Once we were satisfied with the functionality of these individual boards, we completed the design of the Xplorer.

Our goal in this development was to offer the customers a reliable gauge at a fair price, with useful features that are easy to operate. We stayed away from features that are seldom, if ever, used and ones that would create operator confusion or increase repair costs.

Developing and manufacturing gauges is not new to InstroTek. For the last 25 years we have developed gauges for the construction industry, pulp and paper industry, and the aluminum industry. Our technical staff includes some the most experienced nuclear moisture density gauge developers and engineers in the world. We believe you will be impressed with the Xplorer and its functionality.

Congratulations on your purchase of the Xplorer moisture/density gauge. We look forward to providing you with superior Performance, Expertise and Service.

Model 3500 Xplorer and Standard Accessories

Fig 1.1 Xplorer Nuclear Gauge & Accessories

1. Model 3500 Xplorer
2. Reference standard block
3. Scraper plate
4. Extraction tool
5. Drill rod
6. Type A shipping case
7. AC and DC charger, one each
8. Manual of operation and gauge paperwork

Chapter 2: Getting Started

Operating your Model 3500 Xplorer

This chapter covers the basic operation of your gauge from turning the gauge on to taking a measurement.

Before using this gauge, it is recommended that the user read this manual and understand the operation of the gauge.

Important: In order to use this gauge, the operator is required to meet and understand the provisions of the radioactive materials license under which he/she is authorized to operate this gauge.

Charging the Batteries

The Xplorer contains 2 sets of three D size NiCad battery packs, total of six batteries. Life of rechargeable batteries depends on the number of charge/discharge cycles. For best results, only charge your batteries, when the battery low warning is displayed. A full charge is considered 16 hours (overnight). The low battery warning will display when any key (other than the **OFF** key) is pressed after the gauge's battery power drops below 7.0 volts.

The batteries are charged at the factory prior to calibration. When you first turn the gauge on, check for the low battery warning by pressing the menu key, if the low battery warning does not appear on the display, you do not need to charge the batteries. Go ahead and start using the gauge.

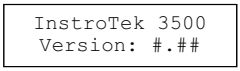
The provided DC charger can be used for emergency charging on the field. Plug this charger into your vehicle cigarette lighter and charge the gauge for 30 minutes. This should provide enough charge to your gauge to complete your testing for the day. Charge the gauge overnight after the day of operation.

During a charging session a "C" will appear in the upper right hand corner of the display. The gauge cannot be turned off, while the charger is plugged in. The gauge is designed with a SmartCharge chip that prevents the battery from over charging.

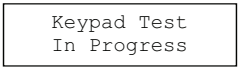
Turning the gauge "On"

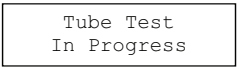
Use the **ON/YES** key to turn the gauge on. When the gauge is turned on the Model 3500 Xplorer will go through the following screens:

*Note: To preserve battery life for extended gauge operations, the gauge will go into a shutdown mode if no key is pressed in one hour. Simply press the **ON** key when you are ready to start again. The gauge will not go through the Self-Test, if shut down was due to an automatic one hour 'inactive gauge shut down' feature.*



Self-Test will take approximately 20 seconds and will check for proper operation of the keypad, density detectors and the moisture detector. To bypass the Self-Test, press and hold the **ON/YES** key.





The Gauge will go to the Ready display after a successful Self-Test. If a failure is detected through Self-Test, one or all of the following messages will display on the screen.

1. Keypad Test Failed - This indicates a faulty keypad or a stuck key. Pressing any key on the keypad during this test will display this error, if a key is pressed by mistake during this test, simply power off and then on the gauge to restart the test, however, if the error is displayed again, contact your InstroTek representative.

2. He-3 Tube Failure - If the gauge is on the reference standard block during self-test, then there is a potential problem with the electronics or the He-3 tube. If the gauge is not on the reference standard block, place it on the reference standard block and repeat this test. Contact your InstroTek representative if self-test fails. If self-test passes the gauge will go into the gauge ready mode. From this screen you can start your gauge operations.

3. GM tube failure - This indicates if one or both GM tubes are not operational. Contact you InstroTek representative.

Important: It is always a good idea to turn the gauge on allow the self-test to complete before leaving for a jobsite in order to verify operation. Place the gauge on the reference standard block and check the results of the Self-Test and make sure there are no failures. After Self-Test, press ***Start/Enter*** *to make sure WARNING: BATTERY LOW is not indicating on the display. Charge the batteries if needed by the provided AC or DC charger. Refer to section on Charging Batteries.*

Setting Units of Measurement

The default for the gauge is lb/ft^3 (PCF). You may change the units to kg/m^3 or g/cc by going through the following steps.

Press the **MENU** button, the first screen will be:

```
   - Recall -
UP/DOWN or ENTER
```

Scroll **DOWN** 5 screens

```
  - SET UNITS -
UP/DOWN or ENTER
```

Press **ENTER**

```
Units: PCF
UP/DOWN or ENTER
```

Using the **UP/DOWN** buttons select PCF (pounds per cubic foot), kg/m^3, or g/cc.

Press **ENTER** to return to the gauge ready screen.

```
<Ready> 15 sec.
  Depth: 0 in
```

Setting Test Time

The gauge provides three different testing times, 15 seconds, 30 seconds, 1 minute, and 4 minutes. The gauge precision improves with increased test time. In general, a one minute count will result in a precision that is two times better than a 15 second

count and a four minute count precision is twice as good as a one minute count. Refer to your local specifications for selection of an appropriate testing time.

Press the **TIME** button on the front panel

```
Cnt Time: 15sec.
UP/DOWN or ENTER
```

Scroll **UP** or **DOWN** to set a desired count time
(15 seconds, 30 seconds, 60 seconds, or 240 seconds)

Press **ENTER** when you have chosen the time. You will be returned to the gauge ready screen.

```
<Ready> 15 sec.
  Depth: 0 in
```

Setting Depth of Measurement

You may set the depth of measurement from 0 to 12 inch (0 to 300 mm). Zero depth or BS (Backscatter) is usually used for testing asphalt pavements. Depths 2 to 12 are usually used for testing soil, aggregate, and granular materials.

Press the **DEPTH** button on the front panel

```
DEPTH: ## in.
UP/DOWN or ENTER
```

Scroll **UP** or **DOWN** to your desired depth. (0 in. or 0 mm is Backscatter)

Press **ENTER** when you have chosen the depth. You will be returned to the gauge ready screen.

```
<Ready> 15 sec.
  Depth: 0 in
```

Taking a Daily Standard Count

It is very important that a minimum of one daily standard count is taken at each job site. The moisture standard count should be within 2% and density standard count should be within 1% of the average of the previous four standard counts. If the average of the

previous four standard counts is taken more than three months from the current standard count, take four new standard counts and generate a new average for comparison. You may also check to make sure the density standard count is within the range of the expected standard count provided with the calibration paperwork.

The standard count is used to correct for decay in the radioactive source, especially for the Cs-137 density source. Keeping a log of the daily standard counts is a good indicator of gauge operation from day to day. To obtain the most representative standard count in the field, allow the gauge to stabilize to the field environment for a minimum of 15 minutes. Remember the following steps, when taking standard counts:

1. Find a level location close to the test site and setup your polyethylene reference standard block.

2. Place the gauge on top of the standard block on a level surface; the keypad end of the gauge should be butted up against the metal butt plate. *See Fig 2.1*

3. Make sure the reference standard block is placed on a dense material, such as soil, asphalt, or concrete. Do not take standard counts on truck tailgates, tables, or non-solid floors.

4. When you place the source rod in the “SAFE” position notch, gently tap it down without pulling the trigger to make sure the handle plunger is properly seated inside the notch. Make sure the handle is reasonably parallel with the gauge.

Fig 2.1 Reference standard count position

Press the **STD** button on the front panel. The Standard Count will display with your previous standard count.

```
DS= ### MS= ###
New STD Count?
```

Press the **ON/YES** button to take a new count or press OFF/NO to cancel and go to the gauge ready display.

```
Standard Count
Press START
```

Press the **START/ENTER** button.

The time will begin to count down from 240 seconds (4 minutes).

```
Time = 240 sec.
```

After 240 seconds the results of your standard count will be displayed

```
DS= ### MS= ###
Use New STD CNT?
```

Log these numbers into your Daily Standard Log Record (notebook), and then press the **ON/YES** button

The gauge ready screen will appear and you are now ready to begin testing.
Note: If there are no standard counts in the gauge, a message will display indicating "Invalid Std" take a new standard count prior to testing.

Setting Target/Laboratory Density Values

The gauge is capable of calculating and displaying percent compaction based on user defined laboratory values. Pressing the MA/PR button allows you to enter the laboratory value. Select PR (Proctor) for soil/aggregate materials and MA (Marshall) for percent compaction on asphalt materials. %MA and %PR will be calculated and displayed automatically after each measurement.

Press the **MA/PR** button.

```
ENTER selects PR
DOWN selects MA
```

If you are setting the soil target value PR (Proctor), press the **START/ENTER** button. If you are setting asphalt target value MA (Marshall), press the **DOWN** button.

Proctor

```
PR: #####
Change value?
```

Press the **ON/YES**

```
PR: #####
UP/DOWN or ENTER
```

Use either the **UP** or **DOWN** buttons to change the value, the **START/ENTER** button will move you one digit to the right. Once you have entered your PR value the gauge ready screen will display.

Marshall

```
MA: #####
Change value?
```

Press the **ON/YES** button

```
MA: #####
UP/DOWN or ENTER
```

Use either the **UP** or **DOWN** buttons to change the value, the **ENTER** button will move you one digit to the right. Once you have entered your MA value the gauge ready screen will display.

Equations used by the gauge

$$\%MA = \frac{WD}{MA} \times 100$$

Where: WD (Wet Density) is measured by the gauge.

$$\%PR = \frac{DD}{PR} \times 100$$

Where: DD (Dry Density) is calculated by the gauge. M (Moisture) content is in PCF.

$$DD = WD - M$$

% PR can also be used to determine % Solids, if the “void-less density” of the material can be determined.

Site Preparation (soil, aggregates, and granular materials)

1. Locate a test site away from other gauges and large objects that could influence the gauge results. These items include your truck, large concrete barriers or walls. If your test site is required to be near or close to walls, then refer to the special functions sections about using an Offset.

2. Using the edge of your scraper plate provided with your gauge level the test surface by removing raised areas and voids. If there are any small voids that weren't filled, use some surrounding local soil or material to bring them up to grade.

3. Place the extraction tool provided with your gauge over one of the guides on the scraper plate.

4. Place the drill rod provided with your gauge into the same guide as the extraction tool.

5. With a hammer of about 4-8 lbs drive the drill rod into the surface of the grade.

   Caution: Wear eye protection as well as hand and shin protection while forming a hole in the surface.

   The drill rod has 6 notches spaced 2" apart, which are numbered for the depth of the reading. These numbers show the depth necessary to drive the rod for a particular gauge depth reading. The rod depth indicators automatically adds 2" extra depth to the hole, which is necessary for accurate readings.

6. Removal of the drill rod should be done in a manner that will not damage the hole. Using a twisting motion as you pull straight up on the drill rod might be the best way to extract the rod from the material. Care must be taken to preserve the integrity of the hole. Collapsed or larger than required holes can negatively influence your readings.

Site Preparation (Asphalt)

1. Locate a test site away from other gauges and large objects that could influence the gauge results. These items would include your work truck, large concrete barriers or walls.

2. For coarse, open graded friction courses you may use fine fill material such as Portland cement or fine sand to fill the voids, but taking care not to completely cover the surface of the asphalt. The gauge base should be resting on the asphalt not the filler.

3. After you have placed the gauge on the test site, rock the gauge back and forth by pressing on opposite gauge corners. Minimizing the amount of rock will ensure the most accurate results achievable in the field.

Taking Measurements

Make sure the depth entered in the gauge is the same as the depth of measurement on the index rod and that the daily standard count is accurate and current. You will get erroneous readings if the gauge depth does not match the depth indicated on the screen. The gauge source rod depth in inches is indicated by the number read just above the handle on the index (notched) rod. Two of the positions do not have numbers: the Safe position, which is all the way up, and the Backscatter position which is the first notch below the safe position notch. To lower the source rod, pull the handle trigger back and push down on the handle. In positions of measurement, always 'lock' in to the position by allowing the trigger to engage the notch and then gently pushing the handle down to 'seat' on the notch.

Caution: Never drive the source rod into the soil by hammering the gauge handle down.

To start measurement, press **START/ENTER**

```
Time = ## sec.
Depth: ## in.
```

After the gauge has completed its count time, it will display:

If you exit out of the results information, you can use the Recall function under Menu to retrieve your results.

To make recording this information easier you can set up the Auto Scroll Feature under Menu.

```
Use UP/DOWN Keys
  To view data
```

```
WD: #.#    PCF
%MA: #.#
```

```
DD: #.#    PCF
%PR: #.#
```

```
Moist: #.#    PCF
%Moist: #.#
```

```
Moist CR: #.###
Dens CR:  #.###
```

```
M Count: ###
D Count: ####
```

Note: If you are only interested in the results from one of the above displays, scroll to that display and start your next reading. The selected screen will be the initial display after each test; however, Auto Scroll should to be deactivated to stay on a single display.

Chapter 3: Menu Functions

This chapter contains functions that may not be used every day. Features under Menu functions are important and will be used periodically for testing under special circumstances and special materials, performing diagnostics test and calibration functions.

Pressing the **MENU** button on the front panel will access menu functions. Some of the menu functions require an access code; contact your RSO or your supervisor to obtain this code.

The following list of functions is available under MENU:

Recall – Allows the user to retrieve the most recent gauge test results.

Offset – This mode provides three different offset functions, Moisture, Density and Trench correction. Use this function to offset factory calibration readings or correct for trench wall influence in the field.

Stat Test – Tests the electronic stability of the gauge.

Drift Test – Tests for electronic drift.

Auto Scroll – Helps users during recording of data in the field. The test screens automatically scroll every 5 seconds.

Set Units – Allows the user to change units between lb/ft^3, kg/m^3, and g/cc.

LCD Backlight – Allows easy viewing of data during night work.

Calibration Constants – Accepts entry and stores calibration constants used for determination of material density and moisture. This function is for authorized users only.

Memory Clear – Clears all data from the gauge. This function is for authorized trained technicians only.

Special Calibration – Allows adjustment of calibration constants for local and special materials.

Thinlayer Mode – Allows the gauge to be used on thin layer asphalt overlays.

Serial Number– Allows for the entry of the gauge serial number.

Bat Volt (Battery Voltage) – indicates battery voltage status

AVG STD Mode – Enable/Disable Average Standard Mode.

Auto-Depth – Enable/Disable the Auto-Depth feature.

Auto-Depth Cal – Calibrate the Auto-Depth feature.

Feaure of the InstroTek Model 3500 Xplorer

Recall

This function allows you to retrieve and review the most recent test data.

1. Press the **MENU** button.
2. Press the **ENTER** button.
3. You can now scroll through the test information.

Offset

There are three offset options in the gauge: Density, Moisture, and Trench.

1. **Density** - allows you to add or subtract a given quantity from the wet density (WD) readings measured by the gauge. This function can be used for correction of the gauge readings to other test methods, such as asphalt cores tested by water displacement method.
2. **Moisture** - corrects the gauge moisture readings to oven or speedy dry moisture.
3. **Trench** - corrects for the effect of trench walls to gauge moisture readings.

To use the offset mode:

1. Press the **MENU** button.
2. Select the Offset function.
3. Scroll **UP** or **DOWN** to the offset you want to enable.

Density Offset - use this function to offset your density up or down by a known quantity. For example, if your gauge's wet density (WD) is 142.0 PCF and the actual field density is 145.0 PCF, you may use a density offset of 3.0 to correct the gauge readings. The offset value can be positive or negative. Follow gauge prompts to enter this value.

```
D Off=00.0 PCF
UP/DOWN or ENTER
```

Note: When density offset is enabled a D will appear on the bottom line of the display.

Moisture Offset - This function provides a means for correction of gauge moisture results to results obtained by oven dry, speedy dry or other laboratory drying methods. Use the following equation to calculate the correction and enter this value when prompted by the software.

$$K = \left(\frac{\%M(True) - \%M(Gauge)}{\%M(Gauge) + 100} \right) \times 1000$$

Where %M (Gauge) is the gauge derived % Moisture (%M) value with K=0 (no moisture offset, factory calibration) and %M (True) is % Moisture determined by oven dry, speedy dry or other laboratory methods.

```
K=00.0
UP/DOWN or ENTER
```

Once the K value is entered in the gauge, all subsequent test results for moisture will be corrected by this offset.

Note: When moisture offset is enabled an M will appear on the bottom line of the display.

Trench Offset - This function provides a means for correction of wall influence on gauge moisture counts. Use this offset functions when taking measurements in a trench with walls 1 meter (3 ft) or less from the gauge.

To use this function, take a standard count on the reference standard block outside the trench and record the moisture standard count, MS. Place the gauge inside the trench on top of the of the reference standard block, set the time to four minutes and press **START**. Record the MC (Moisture Count). Calculate the trench offset by

Trench Offset= MC-MS

Enter the Trench Offset as indicated on the display.

Note: If MC is lower than MS, you do not need to use the trench offset function. If MC count is lower than MS, then there is no influence from the trench walls and trench offset is not necessary.

Note: When trench offset is enabled a T will appear on the bottom line of the display.

Stat Test

A Stat Test may be performed by an operator to validate the normal operation of the gauge electronics. If two out of three stat tests fail the limits set in the gauge, contact your InstroTek representative. Passing limit on stat test results are R=0.18 to R=0.35.

To perform a Stat Test:

1. Press **MENU**.
2. Scroll **DOWN** to Stat Test.
3. Press **ENTER**.
4. Place the gauge on a standard block on a level dense surface, such as soil, asphalt or concrete. Make sure you are 30 feet (10 meters) away from other gauges.
5. Place the source rod in the “SAFE” Position.
6. When the display reads Stat Test, press **START**.
7. After 20 minutes the display will show the results of the test, you can scroll through to see each count.
8. If the test fails, repeat the test. If two out three tests fail, contact your InstroTek representative.

Drift Test

If you notice a consistent drift down or up in your standard counts from count to count or day to day. The electronics may have a drift problem. This test monitors the long-term drift of the gauge. To perform this test requires about 3-4 hours. Make sure the gauge

batteries are charged and do not turn the gauge off during this time. The drift test consists of performing a Stat test and then 3-4 hours later taking five 240-second counts. Passing limit on moisture is less than or equal to 1.0% and density is less than or equal to 0.5%.

1. Perform a Stat Test on the gauge in the morning.
2. Without turning the gauge off, wait 3-4 hours then begin the next steps. You may use the gauge during this time, but if you suspect that the gauge isn't working properly, then it would be best not to use it to obtain density measurements.
3. After 3-4 hours, set the gauge back on the standard block, just as you did for the Stat Test; make sure the source handle is in the "SAFE" position.
4. Press the **MENU** button. Scroll **DOWN** to the Drift Test.
5. Press **ENTER**.
6. Press **START** when the display indicates.
7. After 20 minutes the results will be displayed.
8. If the gauge indicates a failing percentage, then contact your InstroTek technician.

Auto Scroll

The Auto Scroll feature allows for hands-free operation of the gauge after a measurement has been obtained. When this feature is enabled the test results will scroll from screen to screen without the need to push the up or down buttons.

To enable this function:

1. Press **MENU**.
2. Scroll **DOWN** to Auto Scroll.
3. Press **YES** to enable the feature.
4. The gauge ready screen will display.

After a measurement the screen will remind you that Auto Scroll is enabled and after about 5 seconds the screen will change to the results. Every 5 seconds after that the screen will display the next set of results. Press the **ON/YES** button to return to the gauge ready screen to begin a new measurement.

Note: Powering the gauge off will disable Auto Scroll.

Set Units

This menu function allows you to set: pounds per cubic feet (PCF or lb/ft^3), kilograms per cubic meter (kg/m^3) or grams per cubic centimeter (g/cc). Whichever you chose will be the default in all menus. The MA/PR will need to be entered in the same units you select. Depth will be based on the units you select; inches for lb/ft^3 or millimeters for kg/m^3 or g/cc.

To set this option:

1. Press **MENU**.
2. Scroll to Set Units.
3. Press **ENTER**.
4. Select PCF, kg/m^3, or g/cc.
5. Press **ENTER**.

LCD Backlight

This feature allows for use of the gauge during night work. The backlight will stay lit for approximately 20 seconds after a button is pressed.

To enable this feature:

1. Press **MENU**.
2. Scroll to LCD backlight.

3. Press **ENTER**.

4. Press **YES** to enable.

5. To disable the feature repeat steps 1-4. The gauge will prompt to disable the backlight if it is on, pressing **YES** will disable the backlight.

Note: Powering the gauge off will disable the backlight feature.

Calibration constants

This part of the menu will require an access code, if you do not have access to this code; contact your RSO or InstroTek.

Note: This can be done using InstroTek's EZload software available from InstroTek. Only someone familiar with nuclear gauge setup and calibrations should perform these steps. Changing this information will result in erroneous readings.

To enter calibration constants:

1. Press **MENU**.

2. Scroll to Cal Cons.

3. Press **ENTER**.

4. Enter access code using the **UP/DOWN** buttons.

5. The E constant will be displayed. To change it: press **YES**; to skip it: press **NO**.

6. The F constant will be displayed. To change it: press **YES**; to skip it: press **NO**.

7. The depths will be displayed. Scroll to the desired depth and press **ENTER**. A, B, and C constants can be set for each depth. After all depths have been entered and you are back at the select the depth screen, you can press the **ON/YES** button to take you back to the gauge ready screen.

Note: If there are no calibration constants in the gauge, the gauge will indicate "Invalid Cal. Const". Refer to your calibration report to enter these constants in the gauge.

Memory Clear

Only a trained service technician should do this; it will render the gauge useless. This function is used in case the gauge locks up due to an unforeseen problem. Memory clear erases all stored information and in effect resets the gauge to pre-calibration factory defaults.

Special Calibration

Special calibration gives you the functionality to adjust your factory calibration in the field. Special calibration constant, b, can be derived by the gauge or you may enter this constant by using the equation given in this section for calculation of b.

The gauge is calibrated at the factory to "average soil", which is defined as material that is half way between pure granite and pure limestone. For most soil and aggregate materials, average soil approach results in accurate density measurements. However, there are cases when the material composition being tested is much different than the range of materials covered by the factory calibration. Special calibration provides the user the opportunity to calibrate the gauge to local materials and materials not covered by the factory calibration.

In special calibration mode, a new b constant is calculated by using an actual field sample and obtaining the "true density" of the sample by a laboratory method. B value is the only constant in the gauge that is influenced by the material composition. So changing this constant is the most effective way to account for material composition changes in the field.

To perform a special calibration for a local material that may not be covered by the factory calibration, take a minimum of four and a maximum of 10 density counts in the field on the material that the gauge is going to be used on. For granular materials, use direct transmission readings and for asphalt, use BS readings. Average the counts. Obtain samples from the locations where gauge reading are taken. Analyze the

samples in the lab and determine the density of the material ("True Density") in kg/m^3. Use the following equation to recalculate the B value that will be entered in the gauge.

$$B_{Special} = \frac{1000}{True\ Density} \ln \left[\frac{A}{\left(CR + C \right)} \right]$$

Where CR is count ratio (Average count/std. count) determined by the gauge in the field, A and C are calibration constants for the depth of measurement used in the field and True density is density determined by a conventional method in the lab.

Note: The gauge can perform the calculations if counts and true density values are determined and input in the gauge software. Furthermore, the gauge software is written so that the entire special calibration function process, including collection and storage of counts, is performed by the software. Follow gauge instructions to perform Special Calibration.

To use the Special Calibration Function:

Press **MENU** and press **UP** or **DOWN** key until the following displays:

```
 - SPEC CALIB -
UP/DOWN OR ENTER
```

Press **ENTER**

```
Enable Special
Calib?  YES / NO
```

Press **YES** to Enable Special Calibration and **NO** to go back to the gauge ready screen.

```
Gauge Derived?
    Yes / No
```

Note: If special calibration has been used previously, the gauge will ask if the same calibration or previously stored data should be activated. At this point you may activate

the use of the previously used special calibration or select to start a brand new special calibration.

At this point you have the option of using the gauge to derive the Spec Cal constant B or entering the constant that you or the gauge had derived previously. When you select 'Yes', the gauge will prompt you to select the number of counts you would like to take on the material. It is recommended that a minimum of four and maximum of ten readings are selected for this test.

```
# of Counts=1
UP/DOWN OR ENTER
```

(Select 1 to 10 readings)

```
Press Start for
     Count#1
```

Place the gauge on the material at a desired location and press start to accumulate the first count. The gauge will prompt you to take counts until the selected number of counts have completed. Record each individual count taken. Even though these counts are not needed for gauge derived calculations, it will provide you with a record of this data. It is recommended that the gauge be moved to a new test location for each one of the counts. Follow the screen prompts to complete the counts.

After all counts are accumulated, the gauge will average all counts and will ask you for the "True" material density. "True" density is achieved by collecting a representative material sample from the field and analyzing this material in the laboratory by using a conventional density test. You may also consider using other test methods such as sand cone and balloon methods in the field for determination of "True" density.

If you have the "True" material density, you may enter it at this time. Otherwise you may enter this value at a later time. The gauge will save the counts for use at a later time. If you select 'Yes', the gauge will prompt you for density input.

```
Enter Density
Value? Yes/No
```

```
Density=00000
UP/DOWN OR ENTER
```

Once you enter the density, the gauge will calculate a B value and go into the Special Calibration mode. Record the B value. During measurements SC will appear on the screen to indicate that the gauge is in special calibration mode. If the operator turns off the gauge, Special Calibration is automatically disabled and factory "normal" calibration is activated. The gauge will maintain the previous B value until it is over written by a new special calibration test.

Note: If you are operating in g/cc mode, you will be prompted to enter the density in kg/m^3 (g/cc x 1000).

Important: Record and save the B value for future use. Having the B value eliminates the necessity to go through the gauge derived process.

It may be more practical for you to enter the density at a later date. If you have not entered a density value after taking counts on the material, next time you enable Special Calibration, the gauge will ask if you would like to use the stored data. This data contains the counts taken on the most recent use of Special Calibration function.

If you already have the B value, either from gauge derived or from hand calculation, you may enter the B value directly into the gauge special calibration function.

To enter the B value, go to special calibration function under **MENU** and enable Special Calibration. When prompted for gauge derived, press the **NO** key.

```
Gauge Derived?
    Yes / No
```

```
Enter B Value?
    Yes / No
```

To enter B value, select **YES** and on the next screen select the depth of measurement. The previous B value will display on the screen.

```
B=#.####
  Change Value?
```

Press **YES** to change the value and then use the **UP** or **DOWN** keys to enter a new value.

Thinlayer Mode

The Thinlayer function allows for measurements of thin overlay density on asphalt or concrete. This function is only valid if used in backscatter depth. To use this function, you will need to obtain the top material thickness and the density of the material immediately under the thin overlay. The equation used for calculation of the overlay density is:

$$DT = \frac{WD - DB \times K}{1 - K}$$

Where DT is the overlay density, WD is the wet density measured by the gauge and K is the effect of the top layer on the density measurement. K is dependent on top layer material thickness and is defined by

$$K = a_{11} \exp(-a_{12} X) - a_{13}$$

X is the top material thickness and a_{11}, a_{12}, a_{13} are constants derived at the factory.

The gauge software automatically performs Thinlayer calculations. To use this function, select the menu item and go to “Thinlayer” mode.

```
- Thin Layer -
UP/DOWN or ENTER
```

Select **ENTER** to get into the Thin Layer function. Follow the screen prompts to enable the Thinlayer mode.

Enter thin layer material thickness in inches or mm, depending on the unit already selected in the gauge. The range of thicknesses that can be used with this function is 1 to 3.5 inches (25 to 90 mm). Do not use this function for thickness outside this range, as the results will not be accurate.

```
Mat Thick=000
UP/DOWN or ENTER
```

Enter the density of the material immediately under the top material. To obtain this density, use the gauge to measure the material density prior to construction of the overlay.

```
Bot Dens=00000
UP/DOWN or ENTER
```

Once bottom material density is entered, the gauge Thinlayer mode can be activated. During measurements TL is displayed on the display to indicate Thinlayer mode is active. If the gauge is turned off, the Thinlayer mode is disabled. Enable this function again through the menu by following gauge prompts and activating the most recent saved data.

The most recent Thinlayer function inputs will remain in the gauge until a new set of thickness and bottom density data is entered for a new job.

Serial Number

This allows the user to enter the serial number of the gauge into the scaler. This is set at the factory. Authorized technicians should only use this function.

Bat Volt (Battery Voltage)

This function measures and displays the total voltage on the two set of three D Size NiCad batteries (6 batteries total). The maximum measurable voltage on the battery packs is approximately 8.3 volts. The low voltage indicator comes on at 7.0 volts and the gauge will shut off at 6.8 volts. Based on the condition of the batteries and the usage, you may expect a full day of use from the time of low battery indication to shut off. Use the cigarette lighter adaptor (DC charger) for charging the batteries in the field.

Average Standard Mode

If this mode is enabled, the percent change between the current standard count and the average of the last four standard counts taken by the gauge is displayed. The current standard count is used to calculate the results of the Density and Moisture content.

When this feature is disabled, the gauge does not perform any checks, however, it still uses the current standard count to calculate the Density and Moisture content of each measurement.

Auto-Depth

If the gauge is equipped with the Auto-Depth system, the technician can enable the gauge to automatically determine the depth setting. When this feature is disabled the technician will need to manually select the correct depth using the DEPTH key on the front panel. This feature, if equipped, is enabled as a default from the factory.

Auto-Depth Calibration

If the gauge is equipped with the optional feature of Auto-Depth, the technician can calibrate the depth strip if an error in depth determination is found. The user simply follows the prompts on the screen and the gauge will self-calibrate. The gauge is shipped from the factory with the Auto-Depth calibrated.

Other Features of the Model 3500 Xplorer

Note: Only trained technicians should perform these functions.

The Reset Button - This button allows you to reset the operating program, if the program freezes or stops responding then pressing this once will reboot the system, you will not lose any calibration constants, standard counts, or last measurement. But if you have LCD back light or Auto Scroll set on you will need to re-enable those functions. The scaler will need to be removed from the gauge to use the reset button. Simply unscrew the four screws on the front of the panel, lift out of the housing and turn over the scaler. The reset button is on the top of the scaler circuit board. *See Fig 3.1*

RS-232 - This connection allows you to download the constants into the gauge with the aid of the computer software. Please contact InstroTek, for more information.

J-45 - This connection is only used at the factory to "burn-in" the system software used on the Model 3500 Xplorer. You **should not** plug any wires to this, as it could damage the scaler and result in the need to purchase a replacement scaler.

Switches - The switches are set at the factory and **should not** be changed doing this will result in damage and the need to purchase a replacement scaler. Changing these will also void any warranty in effect.

CAUTION: Under no circumstances should the gauge specific switches be changed from the factory settings either on the scalar or baseboard.

Display Contrast - This dial sets the contrast of the LCD; this can be changed to the liking of the user. Using a small screwdriver adjust the contrast level.

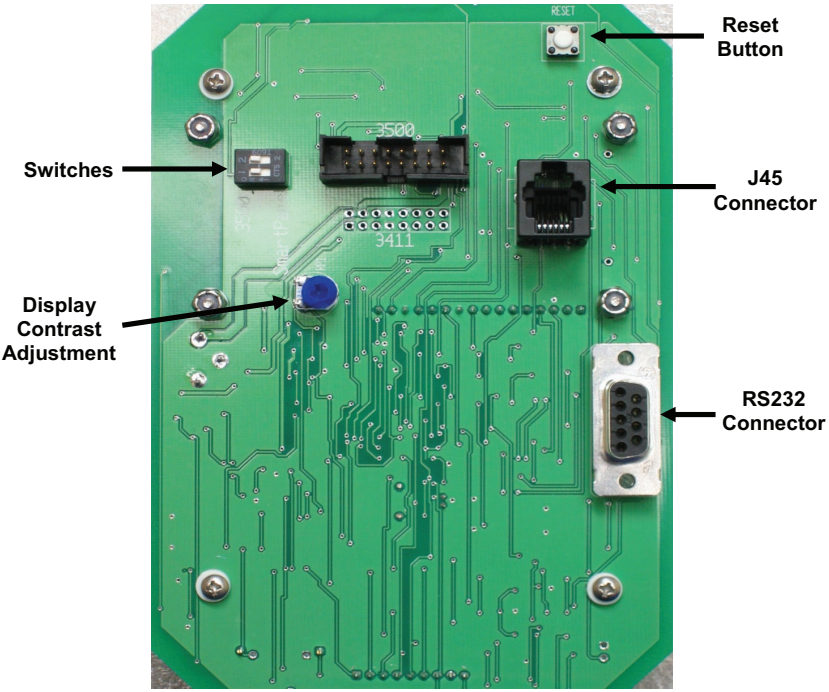


Fig 3.1 Backside of the Front Panel circuit board

Chapter 4: Radiation Theory

This chapter covers information on basic atomic physics. It is important that the users have an understanding of this section in order to have a handle on applications and safety related issues.

Elements/Atoms

Elements are combinations of the three sub-atomic particles: Proton, Electron and Neutron. Each element has a unique property. Typical elements are Silicon, Oxygen, Gold, Copper, and Iron. Currently 103 primary elements have been identified, 90 natural, the rest man made. A few other elements have been created in the laboratory, but they decay very quickly.

Atom is a Greek word for indivisible. The simplest element/atom is hydrogen. It has one proton, no neutron, and one electron. A more complex element is oxygen that has 8 protons and 8 neutrons in the nucleus, and 8 electrons in orbit.

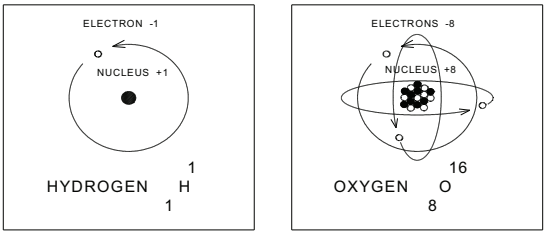


Fig 4.1 Examples of Atoms

The atom is not solid, it is mostly space. If the nucleus of hydrogen was the size of a marble and placed on the 50 yard line of a football stadium the electron would be the size a pinhead in the stands.

Each element/atom has been assigned a one or two letter symbol that is an abbreviation of its name (generally Latin).

Symbol	Latin	English
Au	Aurum	Gold
Cu	Cuprum	Copper
Fe	Ferrum	Iron

The atomic number (Z) is the number of protons in the nucleus
The mass number (A) is the sum of the protons and the neutrons in the nucleus.

Isotopes

Elements that have the same number of protons (same atomic Number), but different numbers of neutrons (different atomic mass numbers) are called Isotopes. Hydrogen has three isotopes. The most abundant hydrogen isotope has one proton and no neutrons. The isotope of hydrogen with two neutrons is called Tritium and is unstable. Tritium is produced in the atmosphere by neutron bombardment of nitrogen.

Earth's Crust

Our task is to measure the density of soils. The elements in the periodic table we are concerned with are those in the earth's crust.

---------- ATOMIC ----------					% EARTH'S
ELEMENT	SYMBOL	NO. (Z)	MASS (A)	Z/A	CRUST
Oxygen	O	8	16.00	0.5000	49.9%
Silicon	Si	14	28.09	0.4984	26.0
Aluminum	Al	13	26.98	0.4818	7.3
Iron	Fe	26	55.85	0.4655	4.1
Calcium	Ca	20	40.08	0.4990	3.2
Sodium	Na	11	22.99	0.4785	2.3
Potassium	K	19	39.10	0.4895	2.3
Magnesium	Mg	12	24.31	0.4936	2.1
Other					2.8
Hydrogen	H	1	1.008	0.9921	
Water	H_2O	10	18.016	0.5551	

The density of a material is dependent upon its atomic mass (A). But the count rate in the nuclear density gauge is dependent on the number of electrons (atomic number (Z)). For the most materials in the earth's crust this presents no problem since the ratio of the atomic number to the atomic mass (Z/A) is approximately 0.5.

Radioactivity

Not all Isotopes are stable. Isotopes with atomic numbers greater than 92 are unstable. Americium used for moisture measurement in the nuclear gauge has an atomic number of 95. It is a by-product from neutron bombardment of Plutonium to produce weapons materials. All 13 isotopes of Americium that have been identified are radioactive.

Some isotopes of lower atomic number are also unstable; Cesium-137 used in the nuclear gauge for density measurement has an atomic number of 55. Of 22 isotopes identified, Cesium-133 found in nature is stable, while Cesium-137, a by-product of making atomic weapons materials is not. By nuclear reactions, man has produced a large number of unstable isotopes not found in nature.

Any unstable isotope that gives off energy—while decaying to a stable isotope—is defined radioactive. Like other forms of energy, radiation can be useful or harmful depending upon its use.

Alpha, Beta, Neutron, and Gamma Radiation

Sources used in the nuclear gauge are composed of four types of radiation: Alpha particle, Beta particle, Photons (gamma rays), and Neutrons.

ALPHA particles travel only about an inch in air and are stopped by a sheet of paper or the skin tissue. In the nuclear gauge, alpha particles are used to produce neutrons.

Beta particles travel a few feet in air and are stopped by an inch of wood or a thin sheet of aluminum or plastic. In the nuclear gauge beta particles are stopped by the source containment.

Gamma rays travel hundreds of feet in air and can be shielded by thick lead or concrete.

Neutron particles travel hundreds of feet in air and can be shielded by water, plastic, or special concrete.

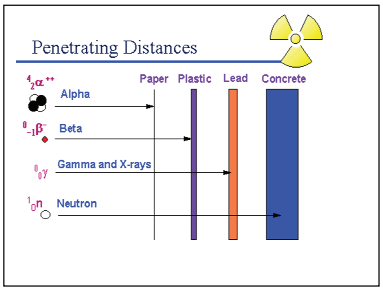


Fig 4.2 Penetrating Distances

Cesium-137 and Americium-241/Be are used in the 3500 portable moisture/density gauge and they produce all four types of ionizing radiation. The alpha and beta radiation will be stopped by the stainless steel source containment. Only neutron and gamma radiation contribute to occupational radiation exposure.

Neutron radiation

Neutron radiation in the 3500 gauge is produced by alpha particles from the Americium 241 bombarding the Beryllium. Neutron radiation has no charge and is very penetrating. To shield against neutron, the first step is to slow down the neutron, which is called

thermalization. Thermalization is achieved by interaction of neutron with particles of same mass as neutron, like hydrogen in water or polyethylene. As neutrons collide with these particles, neutron energy is reduced allowing for effective absorption by the shielding material.

Gamma radiation

Gamma radiation is electromagnetic radiation that is released from nuclear reactions. X-rays, radio waves and light are some other examples of electromagnetic radiation. Gamma rays and visible light have no electrical charge or mass and travel at speed of light. Unlike visible light, gamma rays are very energetic and can penetrate several inches of solid material. The gamma source in the 3500 gauge in the process of decaying to Ba-137 releases beta particles which will be stopped by the capsule wall. The Cs-137 releases gamma ray energy of 0.662 Mev. This gamma energy is used to determine the density of the material.

Half-Life

An important characteristic of radioactive material is that its activity decays with time. The half-life ($T_{1/2}$) of a radioactive material is the time it takes for half the atoms in any given mass of the material to decay. Half-lives vary from fractions of a second to millions of years. After ten half-lives only 1/1,000th of the radioactivity remains.

The two sources in the 3500 model are Cesium-137 for density measurements and Americium-241/Be for moisture measurements. Cs-137 has a half-life of 30 years, while Am-241/Be has a half-life of 458 years.

To correct for decay, a standard count is taken each day of use and the ratio between the measured count and the standard count, Count Ratio, is obtained. Count ratio automatically corrects for any decay in the source.

Chapter 5: Radiation Safety and Health Physics

This chapter covers information on health physics and radiation safety concepts.

Terms

Roentgen

The Roentgen is equivalent to 1 electrostatic unit of charge from interaction of gamma radiation in 0.001293 gram of air at 1 atmosphere pressure.

RAD

The Roentgen has limited use since it does not consider the dose effects of the radiation. Initially, it was replaced by Radiation Absorbed Dose.

Rem

The RAD only applied to air so it was soon replaced by Rem (Roentgen dose equivalent man). The Rem includes the biological effectiveness of the dose. It is related to the Roentgen by its Relative Biological Effectiveness (RBE) or Quality Factor.

Quality Factor (QF)

Quality factor takes into account the differences in biological effect of different radiation. For example, QF for X-ray and gamma rays is 1, 20 for alpha particles and 10 for high energy neutrons.

Natural Radiation

The best way for us to appreciate the Rem is to know it relates to our everyday life. Man is exposed every year of his life to 100 to 300 mRem (milliRem) per year. This comes from several natural sources.

Source	Description	Annual Dose
Cosmic	From the sun and other space sources and their reaction with the earth's atmosphere. It increases 1 mrem for every 100 ft of elevation above sea level.	
	San Francisco (Sea Level)	44 mRem
	Denver (5,280 ft)	97 mRem
Earth	From the natural radioactive materials in the ground	15 mRem
Housing	From the materials we use to build our homes and work places.	
	-Stone house	50 mRem
	-Brick or concrete house	45 mRem
	-Wood house	35 mRem
Living	Eating/Drinking/Breathing	25 mRem
	Body	15-20 mRem
	Television (2 hours per day)	0.3 mRem
	Jet plane trip (3000 mile flight)	2 mRem
Man	Weapons testing fallout	4 mRem
	Medical X-rays	9-210 mRem per test
	Nuclear Moisture/ Density Gauge	25 mRem/yr

Fig 5.1 Natural Radiation and Annual Dose

Typical yearly totals are 123 mRem for someone living alone in a wood house in San Francisco, and whom does not; fly, get sick, or watch television, and 272 mRem for someone living in a stone house in Denver, flying coast to coast 10 times per year, watching television 4 hours per day, and getting one dental X-ray (20 mRem).

There is no evidence to suggest that people living in regions of higher natural radiation have poorer health as a result. Some of the longest living people in the world live in high mountain regions. (In areas of Brazil and India the natural radiation is ten times greater than the average in other parts of the world).

The exposure limit set by the United States Radiation Protection Authorities is 5000 mRem per year for radiation workers.

ALARA

As **L**ow **A**s is **R**easonably **A**chievable considering social and economic matters.

No matter what the allowable legal limits are, the operator and his company should review their procedures to determine if with reasonable steps the dose could be reduced. This should be taken considering all aspects, e.g. one could design a density/moisture gauge with sufficient shielding that little or no radiation escaped, but it would be so heavy that it would not be a practical portable gauge.

The three ways the operator has to reduce the dose:

Time	Minimize the time of exposure
Distance	Do not get closer than necessary
Shielding	Place a shield between the source and the operator. The gauge has such shielding built in.

ALARA is another way of saying: Use common sense.

Time

When the operator is using a radioactive source, he is in a radiation field from that source. Reducing the time spent with the gauge significantly reduces the radiation dose received by the operator. The strength or dose rate of that field is measured in mRem per hour. For a given dose rate and time in the field the operator will receive a dose.

Dose = Dose Rate x Time

LESS TIME = LESS DOSE

Distance

Distance is one of the most effective ways to reduce radiation exposure. Radiation starts from a point source and as the distance increases spreads out on a spherical surface. Its intensity at any distance from the source depends upon the square of the distance from the source.

$$I_1 \times (D_1)^2 = I_2 \times (D_2)^2$$

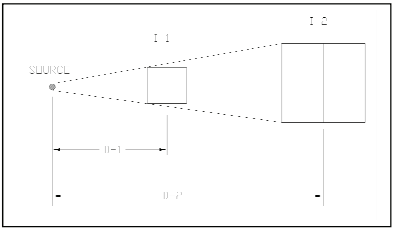


Fig 5.2 Distance

Doubling the distance will reduce the dose rate to one/fourth. Cutting the distance in half will increase the dose rate by four times.

Shielding

Shielding is an effective way to reduce radiation exposure. Alpha particles can be stopped by a single sheet of paper; however, gamma and neutron radiation cannot be completely stopped by shielding, but can only be reduced. Polyethylene—which contains a very high concentration of hydrogen—is usually used for shielding neutrons. Lead or tungsten is used for shielding gamma rays.

MORE SHIELDING = LESS DOSE

Regulations

Since radioactive material can be hazardous to the public if not used properly, its possession and use is controlled by regulatory agencies.

License

To possess and use radioactive material, the organization, corporation, partnership, or individual user must obtain a specific radioactive material license. When the organization applies for a license, it must specify the type, form, amount, and use of the radioactive material.

Radioactive Material	Form	Amount
Cesium-137	Sealed Source	Not to exceed 11 mCi per source
Americium-241/Be	Sealed Source	Not to exceed 44 mCi per source

Use For use in InstroTek 3500 Xplorer Moisture/Density Gauge

The quantity specified under amount is the MAXIMUM activity which shall not be exceeded for a single source. Furthermore, you should ensure that the storage is adequate for the number of gauges you requested in your license.

The requested use should be as general as possible, since the actual use will be limited to the specific applications stated in the license. Unless so stated the gauge cannot be used to do things like helping your child do a science projects.

Leak Testing

Portable moisture density gauges use radioactive material that is double encapsulated in stainless steel. The probability of such a sealed source leaking is very remote. To verify that the sealed source is not leaking the gauge must be tested periodically.

A gauge should be checked upon its receipt to see that its leak test is current and should not be used unless it is current. A new test must be taken within twelve (12) month period. A leak test kit has a swab or patch which is moistened, wiped around the source area, placed in a plastic bag and then mailed to a lab for analysis. A source is considered leaking if more than 0.005 microcurie of removable contamination is found. A copy of the leak test certificate should be kept with the gauge and a second copy in the RSO's files available for inspection by the regulatory agency. If the user has several gauges it is more convenient if they are all tested at the same time, e.g. the first working day of January and July.

Personal Monitoring

Dosimetry (measurement of the dose to an individual) is required if the expected dose is 10% or more of the allowed dose of 5,000 mRem in a year. Most licensing agencies require personal monitoring for their operators. Proper use of a moisture/density gauge will result in a dose less than 1% of the allowed dose, but most regulatory agencies take the position that it may be exceeded if improperly used and thus require dosimetry. Dosimetry is also used for long-term legal protection to the licensee.

Training

Persons using devices containing radioactive materials must be trained in the safe use of the gauge by completing an approved course offered by an organization licensed to provide training. In some large organizations the Radiation Safety Officer is trained and licensed to conduct the course.

When in the field the user should have available for inspection:

- Copy of the Radioactive Material License,
- Copy of individual's authorization from the RSO,
- Copy of Gauge Operator's Manual,
- Copy of Radiation Safety Plan, and
- Copy of the current Leak Test.

Notify the regulatory agency of any incident or condition that might be hazardous to the user or the public. For gauge users this includes:

Immediate: Accident involving possible dispersement of radioactive material, or theft, or loss. Total Effective Dose Equivalent >5 Rem, loss of equal or greater than one week of operations, damage to property of greater than $200,000

24 Hour: Exposure of an individual to 5 Rem or more,
Accident resulting in the loss of one or more days operation, or
Damage to property in excess of $2,000.

30 Day: Exposure of an individual in excess of the allowable dose: Occupational exposure of 5 Rem, dose to embryo/fetus during entire pregnancy to declared pregnant women 0.5 Rem, dose to individual member of the public 0.1 Rem per year.

Safety Plan

Each organization must have a Radiation Safety Plan that describes procedures to be followed and what to do in case of; fire, theft, and/or accident.

Radiation Safety Officer (RSO)

The licensee must designate some person in the organization as the Radiation Safety Officer (RSO). The RSO is the contact point for the regulatory agency to see that the regulations are followed. The RSO is the person in the organization responsible to see that safe practices are followed and that the proper records are maintained. Designating an RSO does not relieve the owner/officers of the ultimate responsibility.

Notice to Employees

A "Notice to Employees" is a document issued by the regulatory agency. Normally safety problems would be reported to the organization's Radiation Safety Officer or a manager. This document contains addresses and/or telephone numbers for employees to contact if they are not satisfied with the organization's response.

Transfer

The gauge should not be transferred to another party for service, disposal, sale, or use *unless* the other party is authorized to receive the appropriate radioactive material. Always remember that the "transferor" (the licensee) has the responsibility to obtain a copy of the "transferee's" license or obtain an official attestation that they are able to receive that particular type, form, and quantity of radioactive materials. The best way to establish authorization is to have a copy of the other parties' radioactive material license. Look at paragraphs 6, 7, 8, and 9, for type, form, amount, and use, and verify that the license has not expired. The regulations provide that if the user applies for renewal within 30 days of the renewal date, the license is considered in "Timely Renewal" until the regulatory agency issues a new license. If this is the case, along with the copy of the license get a copy of the Timely Renewal Letter from the regulatory agency or a statement from the other party.

Temporary Storage

Use of the gauge will involve removing it from its storage location described in the license and bringing it to job sites and other locations to test materials. The end user is responsible to verify requirements with the appropriate US NRC or Agreement State regulatory agency prior to establishing a Temporary Storage location. Normally the gauge will be returned to its permanent storage location listed on the license each evening. Sometimes it will be stored in temporary locations, for example, in a trailer on a job site. This storage location should follow the same rules for security, posting, safety, and charging as the permanent location. If the gauge will be in the temporary

location for longer than 30 days, the regulatory agency should be notified by letter/FAX. If it will be longer than 180 days the license should be amended. The gauge should not be left in an improper storage location at the job site or in your home.

Reciprocity

Radioactive material may be used in another licensing jurisdiction on a temporary basis. The other licensing jurisdiction must be notified in writing at least 3 days in advance. It can be a letter describing the device, the amount and type of radioactive material it contains, the location the gauge will be used, and the duration of the intrusion. Attach a copy of your license.

If it will be for more than 180 days in any calendar year then it is necessary to get a license in the other jurisdiction.

Service/Maintenance

Prior to each use, the integrity of the shutter should be checked.

The gauge will require cleaning of the shutter block area, depending on the type of soil and number of tests. To minimize exposure, face the base of the gauge away from you, allowing the body of the gauge to act as a shield when you remove the shutter. Use compressed air or a long handled brush to clean out the shutter area. Although the probability is very low of there being removable contamination, there is no justification to wipe the rod with the bare hand.

Note: The exposure at ¼ inch from the source rod is approximately 800 mRem/hr.

Disposal

Radioactive material is defined as a hazardous substance. It should not be disposed of without considering others. When the gauge is no longer needed or useful to the organization, it is best to transfer the ownership out of the organization. A disposal broker such as a manufacturer may take the gauge back for a fee. In all cases, the recipient must be properly licensed.

Chapter 6: Transportation

This chapter covers the necessary requirements for transporting the gauge to job sites and from one facility to another.

General Awareness

The transportation of hazardous materials is regulated by the U.S. Department of Transportation. This includes the carrying of the radioactive material as contained in portable moisture/density gauges in private vehicles on public highways. The regulations are published in the Code of Federal Regulations, 49CFR100-177. Copies of this publication are available from the US Government Printing Office. They are updated in October.

Note: The regulations define any employee that is involved with the transportation of hazardous materials, as a HAZMAT employee, and requires that they receive appropriate training by the HAZMAT employer. This training must take place within 90 days of hire or transfer, and must be current within two years. The employer is responsible to maintain records of training and testing.

Specific Functions

Shipping Name

Table 172.101 of 49CFR100-177 contains a list of hazardous materials. The gauge contains radioactive material double encapsulated in stainless steel capsules. The proper shipping name selected from this list is:

[RQ] Radioactive Material, Type A Package, Special Form, 7, UN 3332

Special Form describes a sealed source with minimum possibility to disburse contamination in an accident. This must be certified by a document which is maintained on file for at least one year after the latest shipment (e.g. the last time the gauge was transported in the company vehicle on a public highway). Normally it will be supplied by the gauge manufacturer. If you have gauges from more than one manufacturer you must have a certificate from each. A copy of an IAEA Certificate of Competent Authority as described under International Air Shipments can be used to satisfy this requirement. Class 7 applies to Radioactive Material. UN3332 is an assigned number which allows quick selection in reference manuals.

Reportable Quantity

49CFR requires that shipments of quantities of hazardous materials above certain levels be reported to the EPA in the event of an accident. For the radioactive materials in the gauge per 172.101 App Table 2, the reportable levels are:

- Cs-137 1,000 mCi
- Am-241 10 mCi

8 to 10 mCi of Cs-137 is not a reportable quantity, but 40 to 50 of Am-241/Be is a reportable quantity. For a reportable quantity, RQ must be included either before or after the description. The shipping name label on the package must include the RQ.

Packaging

The package the gauge is shipped in, must meet certain requirements. For radioactive material in Special Form, a Type A package is appropriate. The package or a prototype must be tested and a copy of the tests and certification maintained on file for at least one year after the latest shipment. This document will normally be supplied by the gauge manufacturer. The tests include; water spray, free drop, corner drop, compression, and penetration test.

Labeling

A radioactive label must be selected from the following:

RADIOACTIVE	Dose rate at package surface	Transport Index
WHITE-I	= or < 0.5 mRem/hr	NA
YELLOW-II	>0.5 mRem/hr to = or < 50.0 mRem/hr	= or < 1.0
YELLOW-III	> 50.0 mRem/hr	= or < 10.0

Fig 6.1 Various Label Dose Rates and Transport Indexes

The gauge instruction manual will include a radiation profile drawing showing dose rate measurements on the surface and at one meter. The Model 3500 Xplorer fits the RADIOACTIVE YELLOW-II category.

RADIOACTIVE YELLOW-II labels must be placed on two opposite surfaces. The source type, source activity, and Transport Index entered should agree with the manufacturer's published data.

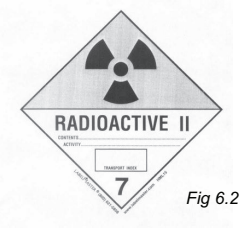


Fig 6.2 Yellow II Label

The Transport Index is an indicator to the vehicle operator the degree of control required. It is actually the dose rate in mrem/hr at one meter from the package. Since it is intended to be used by non-technical personnel, it is expressed as a dimensionless number rounded up to the nearest 1/10th. For multiple package shipments the driver limits the vehicle total TI to 50. Package(s) with a TI of 1.0 or less should not be closer to passengers than one foot. The TI for Xplorer is 0.5.

Marking

The package must be marked with the following:

Shipping Name	RQ, Radioactive material, special form Type A Package UN3332
Package Type	7A TYPE A (in ½" characters)
Country of Origin (International shipments)	**USA**

InstroTek combines the above information on one label.

Shipping Papers

The shipment must be accompanied by shipping papers which include:

Name of Shipper

Description, RQ

Contents and activity (in parentheses)

Label Category

Transport Index

Package Type

Certification/Signature: This is not required for a private carrier if the shipment is not to be transferred to another party. It is easiest to include it, just in case.

Emergency Contact: A telephone number which must be monitored at all times the shipment is in transit and answerable by a person knowledgeable of the hazardous material being shipped and has comprehensive emergency response information, or has immediate access to a person with such knowledge. For normal daytime work, this can be the organization's phone number with instructions to notify the RSO. When shipping the gauge for service, service centers will normally supply a 24 hour number.

Emergency Response

In addition to emergency response notification to the local Public Health Agency for an accident involving radioactive material, the National Response Number must be notified within 24 hours in the event of a transportation accident involving the release of radioactive material, the death or hospitalization of personnel, or property damage in excess of $50,000.

National Emergency Number: 800-424-8802

InstroTek Accident Emergency Number: 800-535-5053

Preparation for Transport

1. **Inspection** - The gauge and package should be checked prior to each shipment. This should include:
   - The gauge handle is in the shielded position and the trigger is securely locked,
   - Confirmation that the shutter block is fully closed by either a visual inspection or radiation survey,
   - The gauge is placed properly in the package and that the package contains only those items which are required to be present,
   - The integrity of the package, case, hinge and hasps are in accordance with the package certificate,
   - All required labels and hazard markings are installed, legible and confirmed as correct,
   - That the package is locked or sealed in such a way that, while intact, will provide evidence that the package has not been opened.

2. **Bracing** - The package should be braced in the vehicle to prevent movement during transportation or a reasonable accident. This can be accomplished by brackets, chain, wire rope, or cord.

3. **Safety** - The package should not be in the passenger compartment. The preferred locations are the rear of a pickup, rear of a van, or trunk of a sedan.

4. **Secured** - The package should be chained—or wire roped—and locked to the bed of a pickup, locked in the freight area of a van, or locked in the trunk of a sedan to prevent theft. Two separate levels of security must be used to secure the gauge during transport.

5. **Driving** - The technician should drive in a friendly, low-profile manner; for example, minimum lane changes. And park in the outer area of a public parking lot.

6. **Shipping Papers** - The driver should have within view and within reach (normally on the seat adjacent to the driver) the shipping paper, and the emergency response information sheet. To satisfy HAZMAT and other regulatory requirements it is recommended that each gauge have a documentation package as follows:
   - Bill of Lading
   - Emergency Response Sheet
   - Leak Test Certificate
   - Manual of operations

7. **Miscellaneous** - YELLOW-II **does not** require placarding the vehicle. Transporting the Xplorer model 3500 does not require placarding the vehicle.

Commercial Shipments

The previously defined requirements for private carriage transportation apply with the following changes/additions:

1. Label
   Consignor/consignee: an address label must be on the package.

2. Lock or Seal
   The package must incorporate a seal that if broken will show improper entry

Additional requirements depend upon the mode of commercial transportation; truck, air-domestic, and air-international.

Truck Freight

Shipping Paper:

The shipping paper will be a Bill of Lading supplied by the carrier and properly filled out by the shipper and emergency response form. If more than the gauge will be shipped, the hazardous material must be listed first. The pre-printed Bill of Lading includes the certification. A sample Bill of Lading and emergency response is in the *Appendix*.

Driver:

The driver may keep the shipping papers in a pocket on the driver's door

Air Transport, Domestic

In the USA, shipment of the radioactive material in the gauge is not allowed on passenger carrying aircraft. This is not a problem since Federal Express, a cargo only airline, can transport the gauge anywhere in the USA overnight, if requested. While it is a domestic shipment, Federal Express has opted to follow the requirements of the International Air Transport Association (IATA) rather than 49CFR. This requires some changes and additional information.

Shipping Paper:

Federal Express has a special combination document that is both an Air Bill and a Declaration of Dangerous Goods Document. The DG document has specific places for the shipping information. It includes certification.

The words "Cargo Aircraft Only" must appear on the Air Bill.

The source activity must be stated in units of Bq, instead of, or in addition to the units of mCi on the DG document.

10 mCi 370 MBq
40 mCi 1.48 GBq

The size of the package in mm or meters must be stated on the DG document

Label:

The source activity must be stated in units of Bq, instead of, or in addition to the units of mCi on the RADIOACTIVE YELLOW-II labels.

A CARGO AIRCRAFT ONLY Label must be installed within 6" of each of the two RADIOACTIVE YELLOW-II labels.

Note: Pay attention to details of completing the form. Any minor error, like leaving the title off of the signer will be cause for rejection of the shipment. The carrier is not allowed to make corrections.

Air Transport, International

International air shipment of radioactive material is under IATA requirements. Most countries outside the USA will allow portable moisture/density gauges to be carried on passenger planes. However any international air shipments into or out of the USA must enter or exit the USA on a cargo only aircraft.

Shipping Paper:

The shipping paper will be an Air Bill supplied by the carrier and properly filled out by the shipper. The pre-printed Air Bill includes the certification. A normal practice is for the shipper to supply a Letter of Instruction, which includes the required export declaration, to a Forwarder, who in turn completes the Air Bill.

The words "Cargo Aircraft Only" must appear on the Air Bill.

Besides the Air Bill, a Shipper's Deceleration of Dangerous Goods must accompany the shipment. This form is obtainable from the Air Carrier. It has a red "candy stripped border". Two copies are required. It is best to supply additional copies if more than one carrier is involved in the routing. A sample is in the Appendix.

The source activity must be stated in units of Bq on the DG document.

The size of the package in mm or meters must be stated on the DG document. The DG document must cite the number of and Certificate of Competent Authority that was obtained from the appropriate government agency prior to the first export shipment of the type of sources in the gauge. In the USA it is obtained from the DOT. This document will generally be supplied by the gauge manufacturer, which obtained them from the source manufacture. These documents expire. Current copies should be obtained as appropriate. Some carriers require that copies of the cited Certificated be attached to the DG document. Certificates of Competent Authority on file may be used to satisfy the Special Form certification required to be on file for at least one year after the latest shipment.

Label:

The source activity must be stated in units of Bq on the RADIOACTIVE YELLOW-II labels.

A CARGO AIRCRAFT ONLY Label must be installed within 6" of each of the two RADIOACTIVE YELLOW-II labels.

Chapter 7: Gauge Theory

This chapter covers the theory of operation for nuclear moisture density gauges.

Gamma and neutron radiation and their interaction with matter is a complex topic and difficult to cover in sufficient details in this manual. The discussion below will be limited to the engineering application of these radioisotope sources and their operations in the field.

Density Measurement

Density measurement in the gauge is accomplished by using a Cesium-137 (Cs-137) radioactive isotope and two Geiger Mueller (GM) detectors. Density measurements are usually accomplished in two different modes, backscatter (BS) and direct transmission. In the backscatter mode the source and the detector are in the same plane. In direct transmission, a hole is formed in the material and the source rod is inserted at a desired depth, between 2 and 12 inches (50 to 300 mm).

Cs-137 has a maximum energy of 0.662 Mev. Photons from the source penetrate the test material and are scattered back to the GM detector or absorbed by the material by Compton scattering and photoelectric absorption. In the density range of interest, the number of photons detected by the GM tubes is inversely proportional to the material density. For example, a given gauge at a density of 110 PCF (1760 kg/m^3) will show 1500 counts; whereas, the same gauge will show a count of 700 at a density of 160 PCF (2560 kg/m^3); therefore, the higher the counts, the lower the density.

The final stage of the gauge manufacturing process is the calibration. The density calibration method used by most manufacturers utilizes an exponential equation that models the relationship between the known densities and the counts. InstroTek uses the following equation.

$$CR = A\exp\left(-B \times WD\right) - C$$

Where A, B and C are gauge parameters, CR is the count ratio and D is the material density. The A, B and C values are commonly known as calibration constants. In the field when a count is collected on the test material, the resulting wet density (WD) displayed on the screen is calculated by:

$$WD = \frac{1}{B}\ln\left(\frac{A}{CR + C}\right)$$

Count ratio (CR) in the above equation is calculated by the ratio of counts to reference standard counts. Test Count (TC) is divided by Standard Count (SC).

$$CR = \frac{TC}{SC}$$

Cs-137 has a half-life of 30 years, 2.2 % reduction in intensity per year. The count ratio is used in this case to correct for natural decay of the source. For this reason it is very critical that users obtain an accurate reference standard count on a daily basis. This will ensure that any decay in the counts is canceled by the decay in the reference standard count. For example, six months after calibration, the Cs-137 source will decay 1.1% (1.1% reduction in counts). The 1.1% change will be reflected in the test counts and the reference standard count. Ratio of these two counts will cancel the 1.1% effect on the counts and will in effect normalize the counts, regardless of the date of testing after calibration. Not using a count ratio will result in erroneous readings, if source decay is not accounted for.

Gauge software uses the gamma count taken at the test site and the standard count to automatically calculate and display wet density (WD) for the material.

Moisture Measurement

Moisture measurement in the gauge is accomplished by using an Americium-241: Beryllium (Am-241:Be) source, which emits fast neutrons, and a single Helium 3 (He-3) tube. Neutron measurements are always accomplished in the backscatter mode. Both the Am-241:Be and the He-3 tube are fixed inside the gauge base.

The average energy released by the Am-241:Be source is 4.5 Mev, with a spectrum energy ranging from 0 to 10 Mev. In the moisture measurement process, fast neutrons from the source interact with the hydrogen nucleus present in water and thermalize (slow down). The thermal or slow neutrons are then counted by the He-3 tube. Increase in water content results in a proportional increase in thermal neutron counts detected by the He-3 tube.

There are two assumptions made in the measurement of moisture by neutron method. First is that any interaction between the source and material is due to interaction with hydrogen in the form of water. Reviewing the composition of normal soils in the literature, the probability is very strong that any thermalization in soils is due to interaction with hydrogen in water. Second, that there are no elements that absorb neutrons. However, in construction type soils, boron in some soils, chlorine in coastal soils, and iron oxide in deposits can be encountered in sufficient concentration to affect the readings.

Gauge software contains offset features so that gauge readings can be corrected for these influences in the field.

Depth of Measurement

In density backscatter mode, the depth of measurement is independent of the density of the material. In backscatter mode 85% of the density reading is from the top 2.5 inches (64 mm) of the material and the remaining 15% is from the top 2.5 to 4 inches (64 to 100 mm) of the material.

Moisture measurement depth depends on the gauge geometry and moisture content of the material. The measurement of moisture is heavily weighted by the material closest to the gauge. In general a gauge with a range in moisture measurement of 0-40 PCF (0 to 640 kg/m^3); the measurement depth is approximately 9 inches (230 mm) for soils containing 10 PCF (160 kg/m^3) of moisture.

Calibration

Density Calibration - Calibration of density in the gauge is achieved by using block of known density. The objective of the calibration is to calculate the constants, A, B and C that are used in the density equation. Once these constants are determined, the gauge can be used in the field to calculate wet density.

$$CR = A\exp\left(-B \times WD\right) - C$$

Since the above density equation used in the gauge contains three constants, it is necessary to use three known density blocks at the factory to provide an original calibration. There are many different methods of calibrating the gauge by assuming certain criteria or by using historical data. However, the bases of all these methods depend on having a minimum of three different counts for three different known density blocks.

Moisture Calibration - Gauge moisture calibration is performed by utilizing at least two blocks of known hydrogen density covering a range of moisture in the construction materials. The two blocks routinely used for moisture calibration are magnesium (0 lb/ft³, 0 kg/m^3) and a combination block of magnesium and polyethylene (~ 35 lb/ft³, ~560 kg/m³). The gauge standard count and the counts on these blocks are used in a linear equation such as the one below to calculate the parameters E (intercept) and F (slope).

$$MCR = E + F\,M$$

MCR is the moisture count ratio, which is the ratio of the measured moisture count and the daily moisture reference standard count. The daily reference standard count is performed on a high-density polyethylene block provided with each gauge. M is the moisture content of the material in PCF or kg/m^3. The E and F parameters are placed in the gauge memory and are used in the field with the count ratio obtained on the test material to calculate the moisture content from the equation.

Gauge Errors

Density - There are three error parameters inherent in all gauges manufactured: Nuclear Precision (P), Surface Roughness (SR), and Composition Error (CE).

Precision or repeatability of the gauge is defined as the variation in repetitive density reading on the same test spot for a given counting time. Precision is calculated based on the equation (P= √Count/ Slope) which depends on the number of counts collected during a given period and the volume of the test material measured by a specific gauge at a given depth. Precision for a typical gauge for a one minute reading at the time of manufacture is approximately ±0.5 PCF (8 kg/m^3) at backscatter and ±0.25 PCF (4 kg/m^3) at 6" direct transmission depth. The reduction in precision over the life of the gauge (approximately 30 years) is insignificant.

Surface Roughness error is caused by streaming of photons from the source to the detectors in the air space immediately under the gauge. Surface roughness error at BS depth is much higher than direct transmission. Surface error is usually calculated by taking a reading with the gauge directly on limestone block and repeating the reading on the same block with 0.05" (1.3 mm) gap under the gauge (100% air voids). The difference between the flush and raised reading is a measure of the error expected from the gauge on rough surfaces, such as open graded or base coarse asphalt. Filling the surface with Portland cement or fine cement powder helps reduce this error, when measurements are taken on rough materials.

Composition Error is caused by the effect of material characteristics on the gauge measured density. Since attenuation of photons is effected by chemical composition of the material, density measurements can be effected significantly by soils with compositions significantly different then the references with which the gauge is calibrated. This error indicates the amount of error you will have in your measurements when going from one soil composition extreme to another. Composition error is determined by measuring limestone and granite standards with known densities. Standards of limestone and granite that are homogenous are available which have compositions that bracket the composition of most soils. Composition error for nuclear gauges is calculated by the following equation.

$$CE = \frac{[(Lime\ (Gauge) - Lime\ (Actual)) - (Granite\ (Actual) - Grnaite\ (gauge))]}{2}$$

Lime (Gauge) and Granite (Gauge) are density of limestone and granite standards measured by the gauge after calibration. Lime (Actual) and Granite (Actual) are actual density values of limestone and granite. This error indicates the amount of error you will have in your measurement when going from soil extreme to the other.

Composition error in most gauges can be minimized by appropriate filtering of the detection system and /or adjustment of the source to detector distance. Even though this error can be minimized, any adjustment to reduce this error can cause an increase in surface error and reduction in gauge repeatability. During design, it is extremely critical that the gauge geometry is optimized to reduce all the above errors to an acceptable limit.

Moisture – The moisture source has a half-life of 430 years and the reduction in moisture precision is insignificant over the life of the gauge.

As mentioned in the previous sections of this manual, there are two assumptions made in the measurement of moisture by neutron method. First is that any interaction between the source and material is due to interaction with hydrogen in the form of water. Second, that there are no elements that absorb neutrons. However, in construction type soils, boron in some soils, chlorine in coastal soils, and iron oxide in deposits can be encountered in sufficient concentration to affect the readings. Also, variation in bound hydrogen in clay soils can cause significant errors in gauge moisture readings and have to be corrected for under the offset functions in the MENU.

Gauge software contains offset features to account for some of these errors in the reading. Refer to the Menu functions for more details on how to correct your gauge readings using offset functions.

Chapter 8: Routine Maintenance and Troubleshooting

This chapter covers routine maintenance items such as leak test procedure, routine maintenance of gauge components, and troubleshooting hints.

Leak Test Procedure

Leak test is required by your license and shall be performed once every twelve months (1 year), unless indicated differently by your license. To conduct a leak test on Xplorer, follow the below procedure:

1. Place the gauge in safe position.
2. Remove the four screws from the front panel and lift the panel.
3. Locate the radiation label in the bottom of the gauge.
4. Using InstroTek Leak Test Kit, part number I100100, moisten one swab
5. Wipe the radiation label with the swab.
6. Replace the front panel and tilt the gauge on its side.
7. Use the swab and wipe around the source rod opening under the gauge.
8. Pack the swab in the plastic bag provided with your kit.
9. Record the gauge and source information on the form provided with your kit.
10. Package the swab and the information form and mail to InstroTek for analysis.
11. Tighten the four screws on the front panel and store the gauge.

Routine Maintenance

Radiation sources

The 3500 Xplorer contains two radioactive sources. The sources require no maintenance. The small Americium-241:Beryllium source is in the center of the gauge base, in a cavity surrounded by lead shielding. **Do not attempt to remove this source.** The Cesium-137 is inside the end of the source rod which is attached to the handle. The source is fixed inside the tip of the source rod. In the safe position (source rod handle at the top of the index rod) the Cs-137 source is surrounded by tungsten shielding. **Do not attempt to remove this source from the source rod.**

Bottom Plate

Maintenance in the bottom plate area of the gauge may be required if the following problems are encountered while using the gauge. Difficulty in lowering or raising the source rod when pulling the handle up or down, and/or unusual density counts. These are generally an indication that soil or other material has migrated into the bottom of the gauge and it needs to be cleaned and fresh grease added.

Important: InstroTek uses and recommends only MagnaLube G as a grease in this gauge. MagnaLube has Teflon filler which provides superior and longer lasting performance in the environment these gauges are typically used.

MagnaLube G is a trademark of SaundersEnterprises, Inc.
Teflon is a trademark of DuPont Company.

Procedure

1. With the source rod in the "SAFE" position, place the gauge on its side with the bottom plate to your right or left. (This positioning will prevent unnecessary radiation exposure to the operator.)

2. Examine the bottom plate. Clean the screw heads if necessary to make removal easier and to prevent the screw heads from stripping.

3. Use a Phillips screwdriver to remove the bottom plate. It is normal to see evidence of wear, however if deep grooves are present where the sliding block slides, it may indicate that the plate needs replacement. There should be a scraper ring in the bottom plate hole where the source rod extends, if the ring is worn or missing call InstroTek for a replacement.

4. If a large amount of dirt has accumulated in the cavity above the bottom plate, the scraper ring has become worn and should the replaced. Replace the scraper ring by removing the retaining ring with a small screwdriver. It is recommended that the scraper ring be changed at least once a year or more often depending on the use. The scraper ring can be pushed out from the bottom. Clean the entire plate of any debris and install a new scraper ring and retaining ring. Add a layer of grease where the sliding block slides.

5. To remove the sliding tungsten shield, use a screwdriver to pull the shield out by the spring. Remember to stand to the side with the source rod in the safe position. Use a screwdriver and rag to remove debris form the sliding block cavity.

Caution: Do not use your hand to clean this area.

Clean the sliding block and spring, add grease to the sides, top, bottom, and angle of the block; reinstall. Make sure the spring is centered in the cavity so the sliding block moves straight in and out.

Source Rod Bearings

1. The source rod bearings will need periodic lubrication with MagnaLube. Indications of this are difficulty in moving the rod up and down or binding of the rod.

2. To add bearing grease, remove the top shell by removing the four screws under the top shell lip. Pull the cover up towards the handle. You will not be able to remove the cover. If needed tie it to the handle to keep it out of the way.

3. Notice the grease fitting on the back of the tower. Add MagnaLube grease here with a hand operated grease gun. Two to three pumps from the grease gun will be sufficient. Do not force grease into the fitting if you feel resistance.

4. Remove any grease that was forced out. Replace the top cover. Do not over tighten the screws.

Cleaning

Most of the gauge cleaning should be done with a mild cleaner such as 409 or a citrus based cleaner like GooGone. We do not recommend using fuels (gasoline or diesel) or oils to clean the gauge as these chemicals can damage plastic, rubber, and synthetic materials. If the aluminum gauge bottom becomes coated with asphalt, WD-40 or GooGone will remove the asphalt. Keep the liquefied asphalt away from the plastic surfaces and gaskets. Be sure to wipe off residue before putting the gauge back in use.

Troubleshooting

Symptom	Probable Cause
Gauge does not power on	1. Dead batteries, recharge or change batteries 2. Gauge inside is wet, dry the interior of the gauge 3. Ribbon cable inside the gauge is defective or not connected 4. Keypad is defective
Density readings are incorrect	1. Check calibration constants 2. Check standard count
Counts are erratic	1. Circuit problem, contact InstroTek

Chapter 9: Specifications and Appendices

Specifications:

National and International Standards	*ASTM D2922, D2950, D3017; AASHTO T310*
Density Measurement Range	*1120 to 2720 Kg/m^3 (70 to 170 lbs/ft^3)*
Moisture Measurement Range	*0 to 640 Kg/m^3 (0 to 40 lbs/ft^3)*
Density Source	*Cesium 137*
Moisture Source	*Americium 241: Beryllium*
Density Source activity	*370 MBq, 10 mCi*
Moisture source activity	*1.48 GBq, 40 mCi*
Transport Index (TI)	*0.5 mRem*
BS Precision at 2000 Kg/m^3	*7.8 kg/m^3 (0.49 lbs/ft^3)*
Direct Transmission Precision at 2000 Kg/m^3	*3.5 kg/m^3 (0.22 lbs/ft^3)*
Moisture Precision at 240 Kg/m^3	*4.42 kg/m^3 (0.28 lbs/ft^3)*
Composition Error BS	*16 kg/m^3 (1.0 lbs/ft^3)*
Composition Error Direct Transmission	*13 kg/m^3 (0.8 lbs/ft^3)*
Surface Error BS	*48 kg/m^3 3.0 lbs/ft^3)*
Surface Error 150 mm (6") depth	*16 kg/m^3 (1 lbs/ft^3)*
Backlight Display	*Yes*
Internal Temperature Monitoring	*Yes*
Shielding Materials	*Lead, Tungsten, and Cadmium*
Top Shell	*UV stabilized plastic*
Batteries	*Two set of 3 cell D size Nickel Cadmium*
Base and tower	*Aluminum*
Source Rod and Handle	*Stainless Steel*
Index Rod	*Stainless Steel*
Operating Temperature (ambient)	*-10° to 70° C (14° to 158° F)*
Maximum Surface Temperature	*170° C (338° F)*
Gauge Size	*58.4cm x 36.8cm x 22.2cm (23"x14.5" x 8.75")*
Weight	*14Kg (31 lbs)*
Shipping Weight	*42 Kg (94 lbs)*

Appendix 1: Sample Bill of Lading

Bill of Lading Error! Bookmark not defined.

Shipper:
ABC Company, Inc.
1234 John Smith Rd
Raleigh, NC 27617

UN 3332, RQ, Radioactive Material, Special Form, NON FISSILE OR FISSILE EXCEPTED, 7
Type "A" Package, Containing:

Cs-137, 370 MBq (10 mCi)
Am-241:Be, 1.48 GBq (40 mCi)

Radioactive Yellow II Label, TI=0.5

********EMERGENCY CONTACT********

1-800-535-5053

Shipper _____
(Signature)

Appendix 2: Emergency Response Information

Nuclear Gauge Emergency Response Information for Transportation
Reference DOT p5800.5 ERG93, and 49CFR

Potential Hazard

1) Proper Shipping Name

- UN3332 Radioactive Material Type A Package, special Form, Non-Fissile or Fissile-Excepted, 7, RQ

2) Health Hazards

- Radiation presents minimal risk to lives of persons during transportation accidents.
- Undamaged packages are safe; damaged packages or materials released from packages can cause external radiation hazards. Contamination is not suspected.
- Packages (cartons, boxes, drums, articles, etc.) identified as "Type A" by marking on packages or by shipping papers contain non-Life endangering amounts. Radioactive sources may be released if packages are damaged in moderately sever accidents.
- Packages (large and small, usually metal) identified as "Type B" by marking on packages or by shipping papers contain potentially life endangering amounts. Because of design, evaluation, and testing of packages, life endangering releases are not expected in accidents except those of utmost severity.
- Commonly available instruments can detect most of these materials.
- Water from cargo fire control is not expected to cause pollution.

3) Fire or Explosion

- Packaging can be consumed without content loss from sealed source capsule.
- Radioactive source capsules and Type B packages are designed to withstand temperatures of 1475°F (800°C)

Emergency Action

4) Immediate Precautions

- Priority response actions can be performed before taking radiation measurements.
- Priorities are lifesaving, control of fire and other hazards, and first aid.
- Isolate hazard area and deny entry. Notify Radiation Authority of accident conditions.
- Delay final cleanup until instruction or advice of Radiation Authority.
- Positive pressure self-contained breathing apparatus (SCBA) and structural firefighter's protective clothing will provide adequate protection against internal radiation exposure, but not external radiation exposure.
- Call the following numbers depending on the gauge model:
    - ***InstroTek, Inc. 1-800-535-5053***

5) Fire

- Do not move damaged packages; move undamaged packages out of fire zone.
- Small Fires: Dry chemical, CO_2 water spray or regular foam.
- Large Fires: Water spray, fog (flooding amounts)

6) Spill or Leak

- Do not touch damaged packages or spilled material.
- Slightly damaged or damp outer surfaces seldom indicate failure of inner container.
- If source is identified as being out of package, stay away and await advice from Radiation Authority.

7) First Aid

- Use First aid treatment according to the nature of the injury.
- Persons expose to special form sources are not likely to be contaminated with radiation material.

Appendix 3: Model 3500 Xplorer Radiation Profile

Fig A3.1 Closed Case Radiation Profile

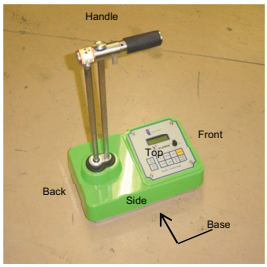


Fig A3.2 Gauge Radiation Profile

Fig A3.3 Open Case Radiation Profile

		Gauge						Transport Case					
		Front	Back	Sides	Top	Bottom	Handle	Handle End	Base End	Top	Bottom	Hinge Side	Latch Side
Surface	Gamma	*7.0*	*12.0*	*12.0*	*6.0*	*12.0*	*0.1*	*0.1*	*8.0*	*7.0*	*8.0*	*5.0*	*6.0*
	Neutron	*0.5*	*0.5*	*0.6*	*2.0*	*7.0*	*0.1*	*0.1*	*3.0*	*1.0*	*0.6*	*0.8*	*1.0*
	Total	*7.5*	*12.5*	*12.6*	*8.0*	*19.0*	*0.2*	*0.2*	*11.0*	*8.0*	*8.6*	*5.8*	*7.0*
10 cm	Gamma	*5.0*	*4.0*	*6.0*	*2.5*	*2.5*	*0.1*	*0.05*	*6.0*	*4.0*	*5.0*	*3.0*	*4.0*
	Neutron	*0.3*	*0.2*	*1.0*	*1.0*	*3.0*	*0.1*	*0.05*	*2.0*	*0.5*	*0.5*	*0.3*	*0.8*
	Total	*5.3*	*4.2*	*7.0*	*3.5*	*5.5*	*0.15*	*0.1*	*8.0*	*4.5*	*5.5*	*3.3*	*4.8*
30 cm	Gamma	*3.0*	*1.5*	*2.0*	*0.8*	*1.2*	*0.1*	*0.05*	*0.6*	*1.6*	*3.0*	*1.6*	*2.0*
	Neutron	*0.1*	*0.1*	*0.4*	*0.8*	*1.0*	*0.1*	*0.05*	*0.8*	*0.2*	*0.3*	*0.1*	*0.4*
	Total	*3.1*	*1.6*	*2.4*	*1.6*	*2.2*	*0.15*	*0.1*	*1.4*	*1.8*	*3.3*	*1.7*	*2.4*
100 cm	Gamma	*0.3*	*0.2*	*0.2*	*0.1*	*0.2*	*0.05*	*0.05*	*0.3*	*0.2*	*0.4*	*0.4*	*0.05*
	Neutron	*0.05*	*0.05*	*0.2*	*0.1*	*.01*	*0.1*	*0.0*	*0.1*	*0.05*	*0.0*	*0.1*	*0.1*
	Total	*0.35*	*0.25*	*0.4*	*0.2*	*0.3*	*0.15*	*0.05*	*0.4*	*0.25*	*0.4*	*0.5*	*0.15*

Notes:

1- Gamma Measurements made with a Victoreen Model 492 Ionization chamber, S/N 3695, calibrated 22 JAN 2010.
2- Neutron Measurements made with a Ludlum Model 12-4 neutron meter, S/N 237866, calibrated 7 APR 2012.
3- Dose rates are for 10 (+/- 10%) mCi Cs-137 gamma source and 40 (+/- 10%) mCi Am241:Be neutron source.
4- Tests conducted by Adam C. O'Neill and Ali Regimand on 14 JUL 2010.

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