InstroTek® Inc.

innovators in instrumentation technology

MCM-2 HYDROtector™

For the detection of entrapped moisture

OPERATING MANUAL

'This page may be removed from the manual to prevent the unauthorized access to the restricted menu functions of the CPN MCM-2 Hydrotector™.'

Restricted Menu Function

Access Code:

3548

Please note up to 2% of the mechanical components used in the gauge may be recycled material.

This page may be removed from the manual to prevent the unauthorized access to the restricted menu functions of the CPN MCM-2 Hydrotector.

CPN MCM-2 Hydrotector ™
Operation Manual Version 1

1. Table of Contents

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1. General Information

This chapter will allow the user to become more knowledgeable of the MCM-2 Hydrotector's features and capabilities.

Items covered in this chapter:

- Introduction and Functional Description
- Model MCM-2 Hydrotector and Standard Accessories
- MCM-2 Hydrotector Features
- MCM-2 Hydrotector Inspection

Introduction and Functional Description

Thank you for your purchase of the CPN Model MCM-2 Hydrotector. The CPN MCM-2 Hydrotector™ operates by emitting radiation from an encapsulated radioactive source, Americium-241:Beryllium (Am:Be). The sensor is placed against the insulation material and the change in response determines the presence of moisture. To determine the moisture content in insulation surrounding pipes or containers, or to detect hydrogenous fluids in pipes or containers, the Am:Be source emits neutron radiation into the insulation under test. The high-energy neutrons are moderated by colliding with hydrogen in the water (H_2O). Only low-energy, moderated neutrons are detected by the Helium-3 detectors in the sensor. The presence of moisture will give a high count and dry materials will give a low count for a given test time. Increase in water content (or other source of hydrogen) results in a proportional increase in thermal neutron counts detected by the Helium-3 tubes. The moisture data is displayed directly in units of interest on the handheld unit, which communicates with the sensor assembly.

This state-of-the-art instrument offers a simple to operate but superior alternative to other methods of detecting moisture in insulating materials. The operator needs minimal instructions.
The probe is supplied with a handheld control unit that communicates with the sensor using Bluetooth technology. The sensor is attached to a pole and communicates with the handheld to collect data.

The complete assembly is supplied with a shipping and carrying case which contains accessory items, cable, the operating manual, and other materials. In addition, the unit is supplied with a 10 foot pole for easy access to locations not within arm's reach.

Model MCM-2 Hydrotector and Standard Accessories

Each MCM-2 Hydrotector is provided with a durable plastic shipping case and the items shown listed below. There are no special instructions for unpacking the MCM-2 Hydrotector. It comes fully assembled.

Fig 1.1 Standard Equipment

1) **MCM-2 Hydrotector Sensor**
2) **MCM-2 Hydrotector Handheld**
3) **MCM-2 Hydrotector Extension Pole**
4) **Standard Block**
5) **Case Lock with Keys – 2**
6) **Shipping Case**
7) **Pole to Hand-Held Cable**
8) **AC Chargers - 2**
9) **Manual of operation and gauge paperwork**

MCM-2 Hydrotector Features

The **MCM-2 Hydrotector** Provides:

- User friendly alphanumeric keypad and 20 character backlit LCD.
- Rapid, precise repeatable moisture measurements.
- Light weight and portable.
- Storage and recall selection of linear calibrations for 32 tubing/insulation types.
- Operator selected time of test
- Data downloaded to a USB mass storage device (Thumb Drive) or via a PC application available from InstroTek's website.
- Rechargeable NiMh batteries.
- Wireless communications between Handheld and Sensor.
- Templates for easy project creation for different work sites.
- Windows software to organize project data.

MCM-2 Hydrotector Inspection

To familiarize yourself with the **MCM-2 Hydrotector,** perform the following review.

1) Remove the **HYDROTECTOR** from the shipping case and place it on a solid flat surface, such as a concrete floor.

2) Examine the HandHeld, the Sensor, the cable, the keypads, and the display.

Note:
The radioactive source is located at the bottom part of the sensor.
Do not touch this part of the sensor or place yourself in front of it.

3) Pole Extension

The unit is supplied with an extension pole that has the capability of accessing areas up to 10' away. The Sensor connects to the HandHeld using Bluetooth. The keypad on the pole allows ease of testing and collecting data while supporting the pole.

4) Standard Block

A standard block is provided with the MCM2 to allow the user to do a daily check on the operating status of the MCM2 gauge. This makes sure the standard counts are consistent, assuring the user that the gauge is operating correctly and consistently.

2. Operating the Gauge

This chapter explains the basic operation of the MCM-2 Hydrotector. Instructions for taking the daily standard count, baseline count, and test count are included.

Items covered in this chapter:

- The Handheld Keypad
- The Sensor Keypad
- Handheld Connections
- Turning the Gauge On.
- Taking a Standard Count
- Taking a Single Reading
- Taking a Baseline Count

The HANDHELD Keypad

The **MCM-2 Hydrotector** includes an updated keypad interface with menu related function keys. Do not use sharp objects to actuate the keypad. It consists of stainless steel snap domes covered by a polycarbonate overlay and can be damaged by sharp objects.

Functions

BASELINE: Select Baseline Count for a particular section of pipe or insulation.

STANDARD: Select to take the daily standard count.

START/TEST: Starts a test or measurement

ENTER: Function key for software/menu requests

ESC: Escape key used to return to main menu or previous screen

MENU: 14 Items gauge control functions (See Section 3, **Menu Functions** for details)

ON/OFF: Power on/off function, as well as shuts Sensor down

NO/CE: Function key for software/menu requests

YES: Function key for software/menu requests

TIME: Enter count time for the length of a reading. For a given counting rate, the counting time interval determines the precision of the measurement. The longer the time selected, the more precise the measurement. Correspondingly, the longer the counting times the fewer measurements that can be made in a day. Thus, the time interval is normally selected as the minimum time that will meet your specific precision. (See Section 12, **Counting Statistics** for details on precision and statistics).

Arrow Keys: Navigate through the menus

Alpha/Numeric Keys: Expanded keypad aids in project and data entry

The SENSOR Keypad

The Sensor keypad has one key – ON/OFF, four status LEDS, and the charger jack. Note: use the 12V AC-DC charger supplied with the MCM2 for charging.

- Pressing the ON/OFF key with the sensor ON will turn the Sensor off, and the "On" light will stop blinking.
- When ON/OFF is pressed the Sensor will turn on and the "On" LED will flash.
- If the Sensor batteries are low, the Low Battery LED will flash. This indicates remaining battery life is less than two hours.
- When the charger is plugged in, the Charging LED will turn on.
- When the Sensor is connected successfully to the Handheld through the wireless Bluetooth connection, the Connected LED will blink.

Also, the Handheld will order the sensor to turn off when the Handheld shuts down.

Handheld Connections

The Handheld has three connectors at the bottom. These are **USB** thumb drive connector, the **CHARGER** port, and the **POLE** remote keypad connector.

An external USB thumb drive can be used to update the Handheld software to a newer version, or logging or project data can be downloaded to the drive. See Section 10, **USB Data/Transfers**.

The supplied 12V charger is plugged into this charging port to charge the NiMH batteries.

The remote Start button and Alarms on the pole are connected through the supplied cable to the POLE connector. Figure 2.1 shows the connection from the pole to the Handheld.

Turning the Gauge "On"

To start, turn on the Sensor first. Then turn on the Handheld. The Handheld will connect with the Bluetooth in the Sensor and give the display below. If the batteries are low, the "Battery Low" message will be displayed, and the batteries should be charged.

Gauge Ready MM/DD/YY HH:MM PM Press START/TEST B

If Bluetooth connection was not successful, reference the Section 9, **Bluetooth Setup**.

The B after START/TEST means Bluetooth.

Taking a Standard Count

Note: A new standard count should be taken at least once a day.

With the case on the ground, place the standard on the CPN nameplate depression on the top of the case and the gauge on the standard block as shown in the figure below. The test should be done on top of asphalt, soil or concrete to make sure there is no influence from the surface the gauge is sitting on.

Fig 2.1 Taking a Standard Count with the MCM-2 Hydrotector

No other radioactive sources should be within 30 feet of the gauge, and no source of hydrogen should be within 10 feet after starting the reading.

To initiate a new standard count, press **STANDARD**. The display will show the last standard count and asks you "Would you like to take a new STD Count?" Select either **(Yes/No)**.

The standard count is a measurement of the neutrons which have lost significant energy by collision with the hydrogen in the standard block. By taking the standard count in the same

manner each time, it provides a means for checking the validity of the counting function. It does this by comparing the previous standard count to see that it has not changed more than an acceptable amount. It is an indication of acceptable drift of the electronics. Americium-41/Beryllium has a half-life of 432.2 years over one year and will only decay 0.16% per year.

Previous Standard Count

When a new standard count is taken, the average of the last four standard counts is used to evaluate pass or fail on the Standard Count Percent difference. This must be less than 2.0%.

This is calculated using the equation:

(COUNT – AVERAGE) / AVERAGE * 100.

Where
COUNT = the daily or the last Standard Count taken

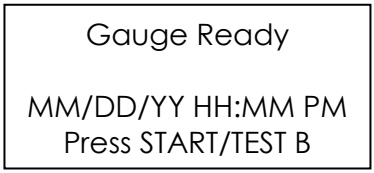
AVERAGE = the average of the previous 4 Standard Counts

The MCM-2 Hydrotector program uses the new standard to calculate moisture count in the field by using (measured count/standard count).

Note: When you first receive the gauge, take 4 standard counts and accept each standard to obtain a good Average.

Taking a Single Reading (Standard Count Required to Calculate Moisture or Ratio)

Turn on the gauge, and wait for the "Gauge Ready" screen to appear.

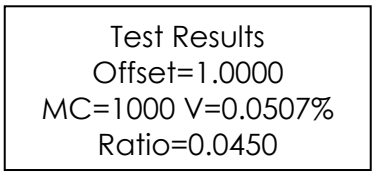


To take a single measurement, press the START/TEST key. The gauge will use the count time and calibration previously selected. The remote START key on the pole will also start a measurement if the coiled cable is connected between the pole and the handheld.

However, before taking a reading, you should select **TIME**, **CALIBRATION**, or **PROJECT**, all of which are covered in more detail in this manual. After this, press the sensor against the surface of the pipe or container you want to measure and press **START/TEST**.

Note: The gauge must have a valid standard count to function correctly.

After the count time, the gauge will display the results.



Test Results

MC	Moisture Count: Raw gauge counts/unit time
Ratio	Ratio: MC/Standard Count
V	Volume %: volumetric moisture content

Offset %Volume offset

To see what calibration was used to calculate V, percent volume. Press the down arrow.

Current Calibration ALPHA A: 1.345600 B: -0.009800

The moisture in percent volume is calculated with the following formula:

$$V\% = A\ x\ Ratio + B$$

Where A and B are from the selected calibration that is stored in the gauge.

(See Section 6, **Calibration** for more details on how to create a new calibration and enter it into the gauge)

Taking a Baseline Count

To obtain a BASELINE measurement simply place the sensor on the area to obtain the measurement, press the BASELINE key, then you will be prompted to press START/ENTER to start the count.

The importance of the BASELINE key on the handheld is that it is the measurement on which subsequent measurements will be compared. Hence it is important that the operator obtain a good BASELINE measurement.

If the operator is investigating a section of pipe (or other insulated object) for moisture penetration or content, the measurements should be compared to a measurement of a dry section of pipe that has the same characteristics as the rest of the pipe. This measurement is referred to as a BASELINE.

Measurements of the remaining portions of the pipe at regular or specified intervals may now be accumulated. These measurements will be compared to the BASELINE to determine if there is a likelihood of moisture penetration or content.

The comparison of measurements is based on a percentage away from the BASELINE measurement. These percentages can be set by the user and an alarm will sound when a subsequent measurement exceeds the BASELINE by that percentage indicating the likelihood of moisture. And a second alarm will sound when a subsequent measurement exceeds BASELINE by a user input percentage indicating an extreme likelihood of moisture. The alarm levels can be changed in the ALARM section of the setup menus. If the alarms are set to low percentage, the sensitivity will increase. However, the chance of a false alarm will increase.

Note: A Baseline count may be taken at any time. If in the middle of a simple project or full project press **ESC** and then press BASELINE and a new Baseline count will be taken. After that press start to resume project.

3. Menu Functions

1) **New Simple Proj** – Start a new simple project. Only name and Readings/Tube are required. A simple project allows you to enter a note or ID before the first count, which is then saved before the gauge takes the count. If you press no, the gauge will immediately take a count. (See page 21 for complete instructions on how to create a simple project).
2) **Recall Last Test** – Displays the last test results.
3) **LCD Backlight** – Turns on/off the LCD Backlight.
4) **Moisture Offset** – Enter the required Moisture Offset. This corrects the gauge moisture reading to oven or speedy dry moisture.
5) **Projects** - User defined measurement/site information. It contains calibration, section/count time, and information depths. Projects are required to log readings outside of the daily log.
6) **Diagnostics** – Various tests to aid in determining problems and prove the device is operating correctly
   a) Keypad Diag – Displays the key depressed
   b) Stat Test – Statistical Test
      A Stat Test may be performed to validate the normal operation of the gauge electronics. A Stat Test consists of taking 20, one minute readings, and calculating the standard deviation between each reading and the average. If two out of the last three stat tests fail the limits set by the gauge, contact your CPN/InstroTek representative. Note: *Control the movement of other gauges during this test. Always keep other gauges a minimum of 10 meter (30 feet) away, while taking a Stat test.*
      i. New Stat Test - Performs a Stat Test consisting of 20 one minute readings.
      ii. Review Last Test – Displays the Results of the last Stat Test taken.
      iii. Save on USB – Saves the results of the last Stat Test to the USB thumb drive.

c) Drift Test
If there is a consistent drift in the 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. The drift test consists of performing five 240-second counts. To obtain a meaningful drift result, first take a Stat Test (please refer to the Stat Test section) and wait 3-4 hours before starting a drift test. The average of the five drift counts is compared against the average of the 20 one minute Stat test averages. Passing limit on moisture is equal to 1.0% or less. Note: *Control the movement of other gauges during the test. Always keep other gauges a minimum of 10 meter (30 feet) away, while taking a Drift test.*
   i. New Drift Test - Performs a Drift Test consisting of 5 four minute readings.
   ii. Review Last Test – Displays the Results of the last Stat Test taken.
   iii. Save on USB – Saves the results of the last Stat Test to the USB thumb drive.

d) Standard Test
   i. New Count – Takes a new STD of 256 seconds. Functions the same as the Front panel key "STD"
   ii. Review STD Counts – Shows the last 32 STDs taken. Only the last 4 are averaged for the STD used.
   iii. Save on USB – Saves all 32 STDs to the USB thumb drive.

e) Extended Chi-2 – Performs 10 Chi tests consisting of 32 256 second readings. (this is a 23 hour test)
f) HE3 Probe Diag – Starts the tube and pulse counter – displaying the counts received.
g) Battery Diag – Displays the battery voltage.
h) Backlight Diag – Turns the backlight on and off.
i) SD Card Diag – Writes a string to the SD card and reads that string back.
j) USB Drive Diag – Writes a test file to the USB drive.
k) Defaults – Puts all the gauge control data into their default states.

l) Bluetooth Diag – This configures your device for Bluetooth connectivity.

7) **Select Language**
   a) English
   b) Spanish
   c) German
   d) French
8) **Alarm Settings** – Allows you to select the sensitivity levels for the alarm as percentage away from the baseline count. The first alarm level is set to be more sensitive than the second alarm level.
9) **Serial Number** – Displays and changes the serial number.
10) **Set Date/Time** – Sets the date and time
11) **Buzzer** – Turns the buzzer on and off
12) **Logging**
   a) Start Logging
   b) Change Log Time – Set the count time for the log (0 – 999 seconds).
   c) Change Number of Logs – Set the number of counts to take (0 – 999).
   d) View Log – Displays the results of the last log.
   e) Save on USB – Saves the results of the Logs to the USB thumb drive
13) **Calibration**
   a) Sel. Calibration – If using SIMPLE or DAILY projects, choose the necessary calibration.
   b) Enter/Edit Cal – Change the values of a particular calibration
   c) View Calibration – View the values of all 32 calibrations.
   d) Save on USB – Saves the results of the last Stat Test to the USB thumb drive.
   e) Load From USB – Loads the values for all 32 calibrations from a file on the thumb drive.
14) **Search for Sensor** – Configures and searches Bluetooth for a MCM-2 device to connect to.
15) **Connect to PC** – Configures Bluetooth to allow your MCM-2 gauge to connect to a PC.

4. Storing Project Data

Readings can be stored by the gauge as they are taken in the field or pre-set with count time and number of readings/logs per location. Each pipe site represents a record of information. Prior to storing any readings, you must define the format of the pipe site record. After readings have been logged, they may be recalled for display or downloaded to an external device.

There are 3 ways to log data with the MCM-2 Hydrotector:

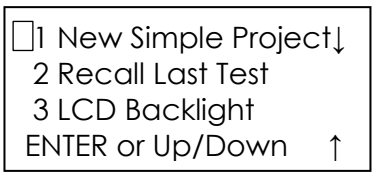
1) **Simple Project**
2) **Daily Project**
3) **Continuous Logging** (This method will be explained in the following chapter.)

Each will be described in detail below.

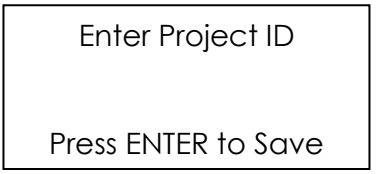
Simple Project:

To start a simple project from the Gauge ready screen:

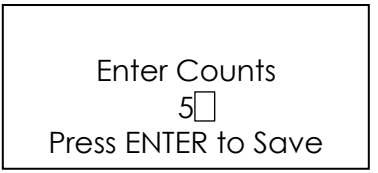
- Press **MENU**
- Press "**1**" on the key pad or – Use Arrow keys to select '**1. New Project**'.
- Press **ENTER** – Use Arrow keys to select '**New Simple Proj.**'.



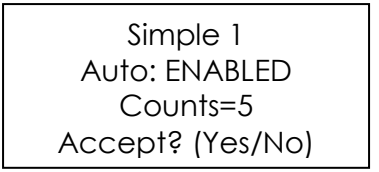
- Enter your project ID using the keypad on the bottom of the gauge. To select a certain letter, hit the designated number key several times until you reach it.

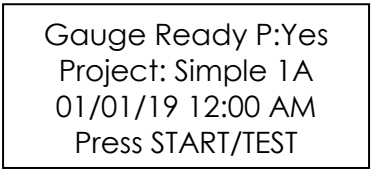


- After you press **ENTER**, you will be directed to enter the number of counts you wish you take at the site.

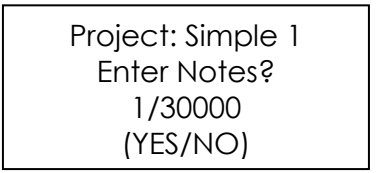


- Press **YES** at the Accept Screen if the data is correct. Notice the A on the Gauge Ready screen; it signifies that Auto Store is enabled. To disable Auto Store you must go through the "**5 New Project Menu**".





- Press **START** from this screen to take a test. You will be prompted to enter notes at the beginning of each section. Press **YES** to enter any notes. Press **NO** and the test will begin.



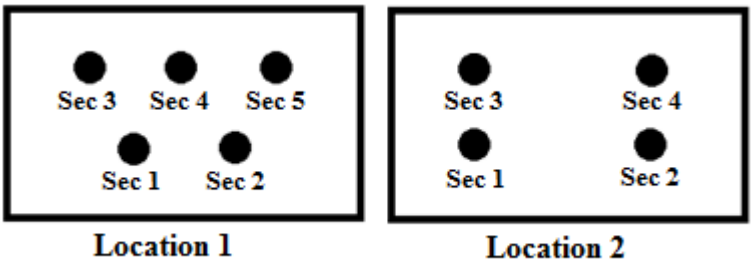
Project: Simple 1 A
1 of 5 15 sec
3 sec

- After the test finishes the result screen is shown. Press **START** from here will run another test. If Auto Store is disabled, pressing **ENTER** will save the results.

Project: Simple 1
1 of 5 15
MC=0 V=0.0000%

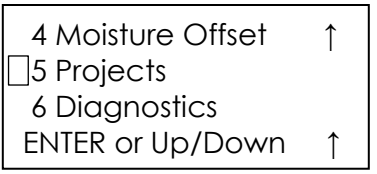
Full Project Template:

The Full project is used in a situation where you have a static setup with 2 or more Locations and a known number of Sections. This example contains 2 locations with different number of sections, readings and calibration constants.

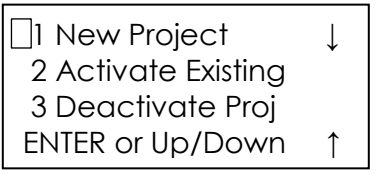


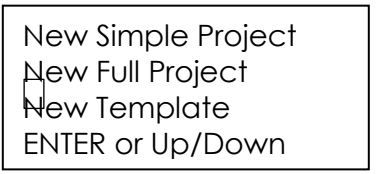
To setup a full Project you must first setup a template.
From the Gauge Ready screen:

- Press **MENU** – Use the Arrow keys to select '**5. Projects**'.
- Press **ENTER** – Use Arrow keys to select '**1. Act/Deact Project**'.

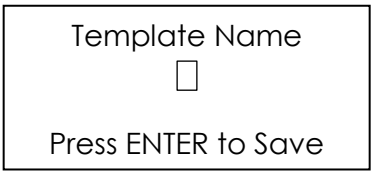


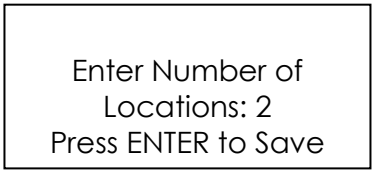
- Press **ENTER** – Use Arrow keys to select '**1. New Project**'.
- Press **ENTER** – Use Arrow keys to select '**New Template**'. Press **ENTER**.



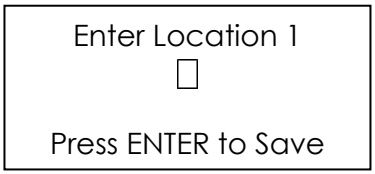


- Use Arrow and ENTER keys to enter Template ID. Press **STORE**.
- Use Left and Right Arrow to enter the number of locations, 2 in this example.

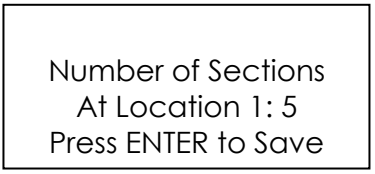




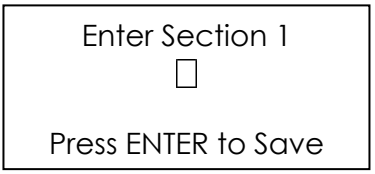
- Enter Location 1 ID.



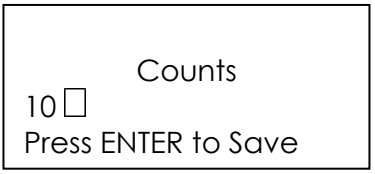
- Enter number of sections at this location, 5 in this example.



- Use Arrow and ENTER keys to enter section 1 ID. Press **STORE**.



- Use keypad to enter the number of readings for this section, 10 in this example.



- Use **UP/DOWN** keys to select the calibration constant for this section of pipe. Each section can have a different calibration constant.

```
Sel. Calibration
01: YY
02: Beta
03: Gamma
```

- Repeat for the remaining Sections and Locations.

When you are finished you will be presented with the accept screen. Press **YES** if all the data is correct.

```
      Template: XYZ
Locations: 2
Stations: 9
   Accept? (YES/NO)
```

Full Project:

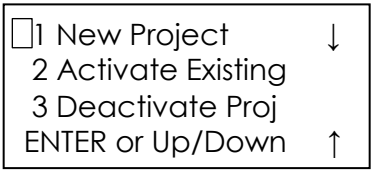
Once the template has been created, you can select it for a new Full Project.

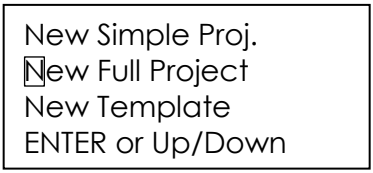
- Press **MENU** – Use Arrow keys to select '**5. Projects**'
- Press **ENTER** – Use Arrow keys to select '**1. Act/Deact Project**'

```
 4 Moisture Offset   ↑
□5 Projects
 6 Diagnostics
ENTER or Up/Down     ↓
```

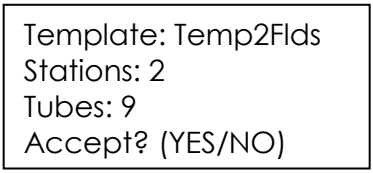
```
□1 Act/Deact Projec ↑
 2 Auto Store
 3 View Stored Proj.
ENTER or Up/Down    ↓
```

- Press **ENTER** – Use Arrow keys to select '**1. New Project**'
- Press **ENTER** – Use Arrow keys to select '**New Full Project.**'

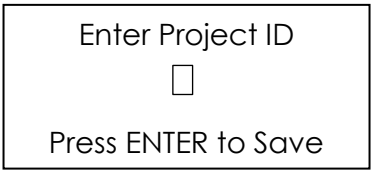


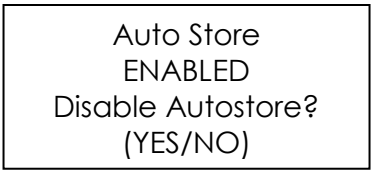


- Use **UP/DOWN** keys to select the Template for this project.
- A summary of the Template will be displayed. Press **YES** to accept it.

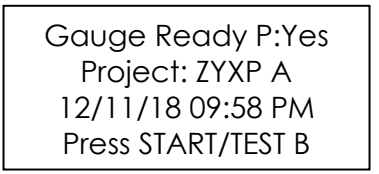


- Use the keypad to enter Project ID. Press **ENTER to save**.
- Press **NO** to leave Auto Store Enabled (The Results will be stored automatically in the project, no need to press STORE at the result page.) Press **YES** to Disable Auto Store (to save the results in the project you will have to press STORE at the result page). Pressing **STORE** at the results screen with Auto Store on will cause the result to be stored a second time.

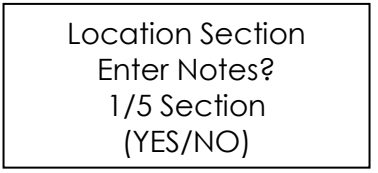


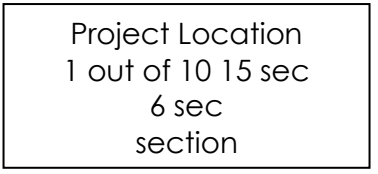


- Once accepted, the gauge will show the Gauge Ready Screen.



- Press **START** from this screen to take a test. You will be prompted to enter notes at the beginning of each section. Press **YES** to enter any notes. Press **NO** and the test will begin.





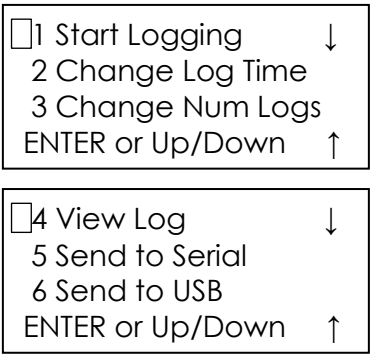
- After the test finishes the result screen is shown. Pressing START/TEST from here will run another test. Previous results will be stored automatically

Project – Location Section 4/10 A MC=3912 V=-3.0621% Press ENTER to Save

5. Logging

How to Format Continuous Logging:

Use the **MENU** key item **(12) Logging** to format the data storage area to agree with the section conditions. For each section at which one record of data is stored, the format will allow 1 to 999 moisture readings per section. The gauge always provides for an identifier: example: L001 for each record, stores the selected ID number, the date and the time of the logging.



How to START and LOG Your Measurements

Ensure there is an updated Standard count. Select time, calibration and format. Then to log a record of information, place the gauge on the measurement location and press **START**. If no project is selected, the results may be saved in the Daily Log by pressing **ENTER** on the keypad.

How to RECALL Last Test (MENU item 2)

Normally the stored data will be downloaded to a printer or computer. It may also be recalled to the display by pressing **MENU and Selecting 2-Recall Last Test**. When first entered, it will point to the last record store. Use the **Arrow Up/Down** key to step up the record list (it steps back through the list and circles around at the beginning).

6. Calibration

Calibration Process

A calibration is specific to a particular geometry. For the MCM2 Hydrotector three geometrical and physical parameters enter into the measurement: the amount of moisture present in the insulation and in the pipe, the concentration of the moisture, and the geometry of the object where moisture is to be measured.

A site calibration requires the gauge, a sample of pipe, dry insulation samples and wet insulation samples of known moisture content. Place the dry insulation over the empty pipe and take a measurement with the MCM2 recording the counts and the ratio. Remove the dry insulation and replace it with the wet insulation. Then take a measurement with the MCM2 recording the counts and the ratio.

The dry percent volume $V\%_{dry}$ will be zero. To calculate the average percent volume of the saturated sample of insulation, you will need to weigh the sample dry and weigh the sample saturated. Then calculate the mass of water with

$$m_{water} = m_{wet} - m_{dry}.$$

Measure the volume of the insulation material

V_{ins} = Volume of section of insulation.

The volume that water occupies is

$$V_{water} = m_{water}/\rho_{water}.$$

$$V\%_{water} = 100 \times \left({m_{water,ins}/\rho_{water}}\Big/{V_{ins}} \right)$$

The coefficients are given by the following calculations:

$$A = \frac{V\%_{wet} - 0\%}{Ratio_{wet} - Ratio_{dry}}$$

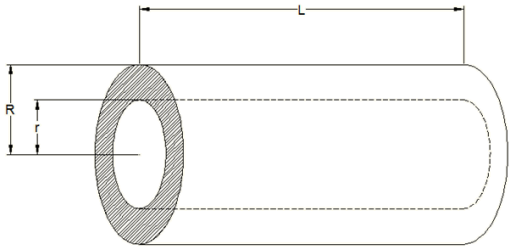
$$B = -A * Ratio_{dry}$$

Where,

$$V\%_{wet} = V\%_{water}$$

It is important to note that the calibration applies to that particular pipe or container geometry and also to that type of particular insulation.

Example: 36 inch section of a 6 inch schedule 40 pipe with 2 inches of insulation.



$$V_{ins} = (\pi R^2 - \pi r^2)L$$

Now suppose you have made measurements on the example above and obtained the following wet ratio and dry ratio from the gauge.

$$Ratio_{wet} = 0.92$$
$$Ratio_{dry} = 0.13$$

You cut and measure the volume of section of insulation from that 36 inch pipe (Note: It could be the entire insulation that you are measuring and not a cut out piece). The insulation piece must be uniformly saturated with water. Find the insulation volume.

$$V_{ins} = \pi r^2 * l$$
$$V_{ins} = 3.14 * (5^2 - 3^2) * 36"$$
$$V_{ins} = 1809.6\ in^3 (29{,}653\ cm^3)$$

The weight of that section is measured and gives the value below.

$$m_{water,ins} = 7413\ g$$

The volume occupied by water is given by calculating the volume of water from the mass and dividing it by the volume of the insulation, as shown below.

$$V\%_{water} = 100 \times \left({m_{water,ins}/\rho_{water}}\Big/{V_{ins}} \right)$$
$$= 100 \times \left({7413\ g / 1\frac{g}{cm^3}}\Big/{29{,}653\ cm^3} \right)$$
$$V\%_{water} = 25\%$$

Now calculate A and B.

$$A = \frac{25\% - 0\%}{0.92 - 0.13} = 31.646$$

$$B = -31.646 * 0.13 = -4.114$$

This calibration could be carried out in a laboratory environment or in the field.

It is imperative that the operator realize that any measurement made using the calibration above only applies to that particular pipe and insulation geometry and insulation material. It will be a relative measurement when using it on any other pipe or container having different geometry and insulation material.

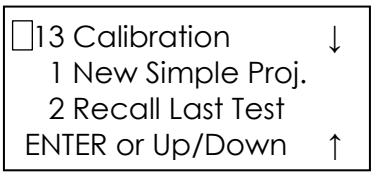
Range

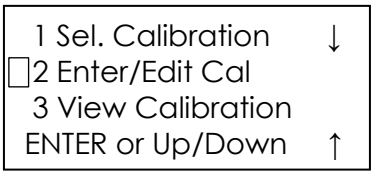
The linear calibration supplied with the MCM-2 Hydrotector is useful over the most commonly used moisture range, 0 to 40%. For use in moisture contents higher than this, it is necessary to have a special calibration that covers the intended range of use.

Entering Calibrations

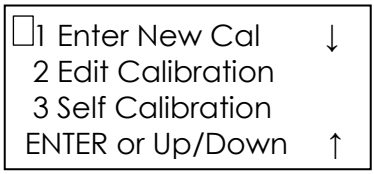
Calibrations can be entered manually or by self-calibration. 32 different calibrations can be stored in the gauge.
Changing Existing Calibration:

- Press **MENU** – Use Arrow keys to select '**13. Calibration**'
- Press **ENTER**.
- Use Arrow keys to select '**2. Enter/Edit Cal**'. Press **Enter**.

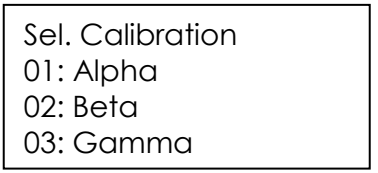


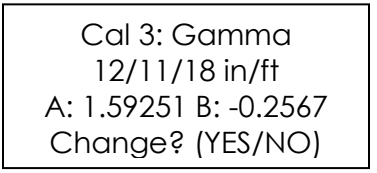


- You will be prompted to enter the access code. Enter it and the next menu list is displayed.
- Use the Arrow keys to select '**1. Enter New Cal**'. Press **ENTER**.

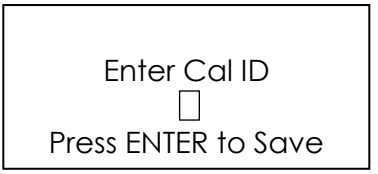


- Use the Arrow keys to select the calibration you wish to change. You will be asked if you really wish to change the calibration.
- Press **YES**.

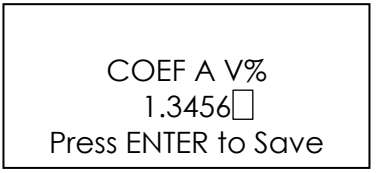


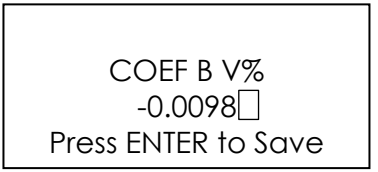


- The unit will display the following screen.



- Enter the Calibration ID.





- Once the B coefficient is entered the unit will display the message below.

Cal 1: XX MM/DD/YY V% A=1.3456 B=-0.0098 Save? (YES/NO)

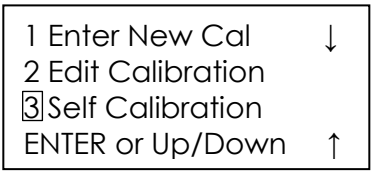
- Press **YES** to save and **NO** to discard.

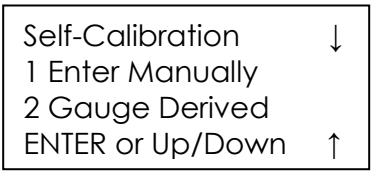
An alternative method of updating the calibrations manually

- From the Gauge Ready Screen, press **MENU** – Use the Arrow keys to select '**13. Calibrations**'.
- Press **Enter**. Use the Arrow keys to select '**4. Send to USB**'. Insert a Thumb Drive, and press **ENTER**.
- After the data has been downloaded to the Thumb Drive, remove the Drive and insert it into your PC.
- The calibrations will have been saved in the folder \InstroTek\MCM-2 Hydrotector\ CAL 01-01-80_12_00_AM.XML
- Open the file with EXCEL, make any changes you want and save it back to the thumb drive as \InstroTek\MCM-2 Hydrotector\LoadCal.XML
- Insert the Thumb Drive back into the gauge. Use the Arrow keys to select '**6. Load From USB**'.
- Press **Enter**.

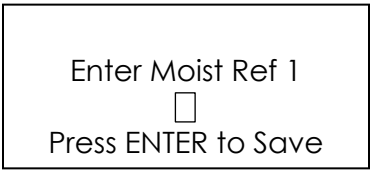
Self-Calibration

- From the Gauge Ready Screen, press **MENU** – Use the Arrow keys to select '**13. Calibrations'**.
- Press **Enter**. Use the Arrow keys to select '**2. Enter/Edit Cal**'. Press **Enter**. Enter the **Password** (**3548**).
- Use the Arrow keys to select '**3. Self-Calibration**'. Use the Arrow keys to select '**2. Gauge Derived**'.
- Press **Enter**.



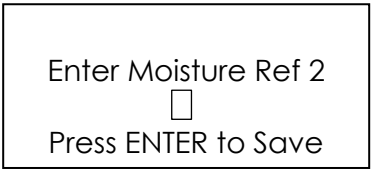


- The display asks for the first Reference.
- Enter the first Moisture Reference value in percent volume.



- Place the Sensor on the first moisture reference. Press **ENTER**.

- Enter the second Moisture Reference value in percent volume.



- Display asks for the second reference.

Place Probe in
Moisture
Standard 1
Press START/TEST

- Place the Sensor on the second moisture reference and press ENTER

Self-Calibration 2
240 sec

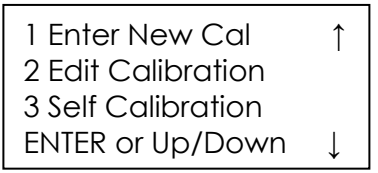
- The gauge will run a 240 second test on the first moisture reference. After the test has completed, you will be prompted to repeat the steps for the second moisture reference. After the second test is completed the results are shown.
- Press **YES** to accept the calibration. Use the Arrow keys to select the calibration slot where you wish to store the new calibration. Press **ENTER**.

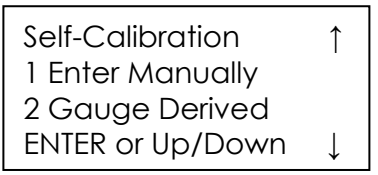
R1=0.0000 C1=0
R2=0.0000 C2=0
A=0.0000 B=0.0000
Accept? (YES/NO)

Save Results in:
01: Alpha
02: Beta
03: Gamma

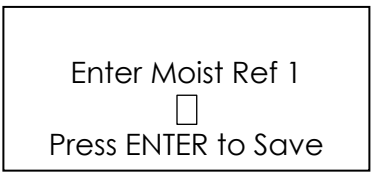
Manual Entry Calibration

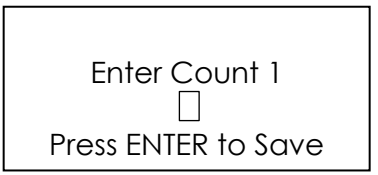
- From the Gauge Ready Screen, press **MENU** – Use the Arrow keys to select '**13. Calibrations**'.
- Press **Enter**. Use the Arrow keys to select '**2. Enter/Edit Cal**'. Press **Enter**. Enter the **Password (3548)**.
- Use the Arrow keys to select '**3. Self-Calibration**'. Use the Arrow keys to select '**1. Enter Manually**'.
- Press **Enter**.





- Enter the first Moisture Reference value. Press **ENTER**. Enter the first count value.





- Repeat for the second reference. At results page, press **YES** to accept.

7. Maintenance

General

This section supplies basic information to perform maintenance on a field level basic.

The model **MCM-2 Hydrotector** consists of four major assemblies:

1) Sensor
2) HandHeld
3) Standard Block
4) Pole with HandHeld cable

Using the following maintenance guide, isolate the problem to one of the major assemblies. If a second gauge is available, the parts can be interchanged to easily isolate the defective assembly.

If the cable is defective, it should be replaced. *It is recommended that a spare cable be kept on hand to minimize down time*.

If the HandHeld or the Sensor Assembly is found to be defective, they should be returned to the factory for repair. The Sensor top shell can be easily separated from the source located in the bottom, making it easy to ship the Sensor top shell by UPS or other convenient means, and leave the source in a secure facility.

Leak Testing

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

1) Use a Leak Test Kit to perform this required test for leakage of the source material from its capsule.

2) Tip the shielding box on its side, away from the operator. Leave the probe latched in the shielded position.

3) Use the cotton swab in the kit and swab the circular radioactive material label on the end of the probe for any removable traces of the Am-241:Be source material.

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

Fig 7.1 Leak Test Procedure

8. Operation Precautions

Error Messages

If an error occurs in the **MCM-2 Hydrotector,** then the function that was being performed is aborted, and an error description or number is displayed (the gauge is actually in the **READY** mode). Errors that may occur in the normal operation of the gauge, will display a descriptive message. You should take corrective action as appropriate.

Operating Errors

NO STD!:	No moisture standard count. Take a new standard.
SD ERROR:	Internal memory full, delete projects and directories, SD card failed, or is missing.
LOG EMPTY!:	Record log empty when PRINT or RCL pressed.
CNT ZERO:	There were no counts, probably due to bad or missing detectors.
MOIST=0:	Gauge cannot calculate moisture, check the standard count value.
Batt Low:	The batteries have been depleted. Charge the battery pack.
Sensor Battery Low:	Battery in the Sensor is low and needs to be recharged.

9. Bluetooth Setup

The Handheld and Sensor communicate through their on-board Bluetooth radios. The Sensor and Handheld should be kept within of 15 feet of each other to ensure a reliable connection. The Handheld and Sensor should be paired at the factory, but if a new unit is used, the Sensor and Handheld must be paired.

This setup is done through Menu Item 14 – Search for Sensor. Make certain there is only one Sensor turned on within 50 feet of the Handheld. Turn the selected Sensor on, and select Menu Item 14. The Handheld will display "Configuring Bluetooth", and then display "Bluetooth Searching". After a few minutes, the display should read "1 MCM2 Found". The serial number of MCM2 sensor will be displayed as item 1 on the menu. Write this number down. Press **ENTER** to select this item. The Handheld will connect with the Sensor, and the blue "Connected" LED will blink on the Sensor.

Now, if the Sensor is ON, when the Handheld powers on, it will search for the paired Sensor. If it connected successfully, the Handheld will display that it connected, and display the serial number of the MC2 Sensor. Also, the Sensor "Connected" LED will blink. When the Handheld is shut off, it will command the Sensor to shut off, and the Bluetooth connect is stopped.

10. USB Data/Transfers

Using the logging feature, the gauge can record many records of site readings for recall later. It is extremely convenient if the data can be used in a program that can manipulate the data for the user needs.

To download project data and get it from probe to computer:

Press **MENU** – Use Arrow keys to select **5. Projects**.
Press **ENTER** – Use Arrow keys to select **4. Save Projects**
Press **ENTER** – Select:

1) **Send Project to USB** – Project will be saved on Thumb drive in .XLS format.
2) **Send All to USB** – All projects will be saved on Thumb drive in .XLS format.

InstroTek/CPN	MCM2	MC_PRESCALED_TO__SECONDS												
SN	2018	12/11/18_09:54_PM	Prescale	60	Seconds									
Project_Name	ZYXP													
Locations	2													
Station	1	ZYX1												
Tube#	Tube_ID	Reading	Cal_#	Cal_ID	A	B	Cal_Units	STD	MC	Ratio	%V	Tube_1	Tube_2	Date/Time
1	ZYX11	1	32	Jacque_2	5.1727	-3.8369	lb/cf	26115	3660	0.1401	-3.112	0	0	12/11/18_10:01_PM
		2	32	Jacque_2	5.1727	-3.8369	lb/cf	26115	3868	0.1481	-3.0708	0	0	12/11/18_10:02_PM
		3	32	Jacque_2	5.1727	-3.8369	lb/cf	26115	3600	0.1379	-3.1239	0	0	12/11/18_10:02_PM
		4	32	Jacque_2	5.1727	-3.8369	lb/cf	26115	3912	0.1498	-3.0621	0	0	12/11/18_10:03_PM
		5	32	Jacque_2	5.1727	-3.8369	lb/cf	26115	3636	0.1392	-3.1167	0	0	12/11/18_10:17_PM

Example of project in .XLS file

11. Updating Handheld Software

To update the Handheld software, get the latest revision of software from InstroTek. It is called MCM2Scaler.cyacd. Place this file on a thumb drive. Turn the MCM2 off. Install the thumb drive into the USB connector. Turn the MCM2 on. The screen will show that the software is loading. When it is finished, the MCM2 will reboot and run normally. **Do not unplug the drive or turn off the MCM2 or the MCM2 will not work.** When the MCM2 is turned on the software version is shown at startup. Remove the drive. Turn the gauge off then on, and check that the version is correct.

12. Counting Statistics

General

Radioactive decay is a random process. For Cesium-137, which has a half-life of 30 years, it can be expected that in 30 years one-half of the material will have decayed, but in the next minute exactly which atoms will decay and exactly how many will decay is only by chance. Repeated measurements with the gauge will thus most likely result in a different count for each measurement. A typical set of 32 such measurements is shown in Figure D.1.

Figure D.2 shows the distribution of these counts. The two characteristics of interest are: 1) the average value (also called measure of central tendency or mean), and 2) how wide the counts spread around this average.

Mathematically the average value is defined as:

$$\bar{x} = \frac{\sum x}{n}$$

The width of the spread is defined by a term called standard deviation.

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n-1}}$$

Or an alternate form useful on calculations:

$$s = \sqrt{\frac{n\left(\sum x^2\right) - \left(\sum x^2\right)}{n(n-1)}}$$

Where:

s = standard deviation of the sample
x = count (value of each sample)
$\bar{x}$ **=** average of the sample
n = number of measurements in the sample.

The above describes the average value and the standard deviation of a sample from a population. They are in approximation to the true average value and true standard deviation of the population.

μ **=** *true average of the population*
σ **=** *true standard deviation of the population*

The distribution from measurement samples of any process can be classified into expected shapes that have been previously observed. Three are applicable to radioactive decay; Binomial, Poisson and Normal (also called Gaussian).
The Binomial distribution applies when the measured event can take one of two states. Tossing a coin is an obvious case. It can also be applied to a given atom, either decaying or not, in a time period. It is difficult to deal with computationally.

SAMPLE	COUNT
32	4370
31	4370
30	3742
29	4370
28	4370
27	3812
26	4370
25	4370
24	4402
23	4370
22	4370
21	4370
20	3636
19	4370
18	4370
17	3566
16	4370
15	4370
14	4370
13	4368
12	4370
11	4368
10	4370
9	3730
8	4368
7	4370
6	4370
5	4370
4	4370
3	4370
2	4370
1	4370

Fig D.1

Since the number of atoms is very large and the expected probability of a decay occurring is very low (source life in years and measurement time in minutes), we can use the Poisson distribution which is a special case of the binomial distribution for these conditions. A special property of the Poisson distribution is that the expected standard deviation is equal to the square-root of the average value.

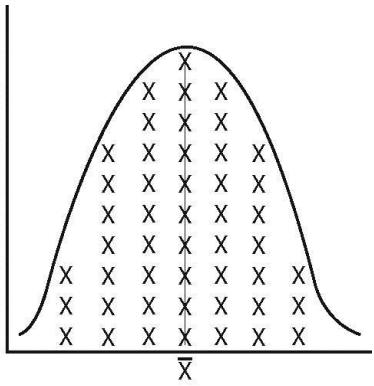


Fig D.2

$$\sigma = \sqrt{\bar{x}}$$

If the sample is large enough, we can approximate for the standard deviation of the sample.

$$\delta = \sqrt{\mu}$$

This is an important relationship. It means that if repeated measurements are taken without moving the gauge and the detector electronics are working properly, then the spread of the counts will only be dependent upon the average count rate. This is in contrast to most measurements where the spread will depend upon the process. Figure D.3 shows the diameter of a part turned on a new lathe while Figure D.4 shows the same part turned on an old lathe. Both lathes produce a part with the same average diameter, but a loose bearing caused the wider spread for parts manufactured on the older lathe.

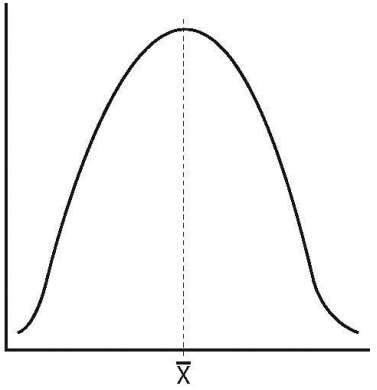


Fig D.3

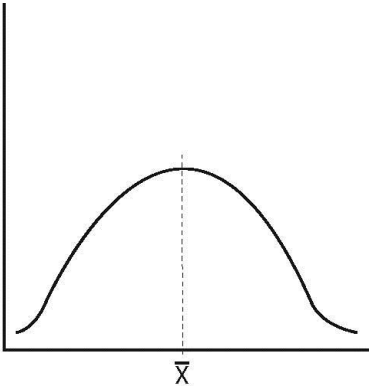


Fig D.4

The Poisson distribution to discrete measurements, e.g. count or not count. Provided the average value is large enough (20 or greater), the Poisson distributions can be approximated by the Normal distribution.

Using the Normal distribution simplifies things even further. It is a continuous distribution. It is symmetrical about the average, and most important, it can be completely described by its average and standard deviation.

As shown in Figure D.5, for a normal distribution, 68.3% of all counts will be within one standard deviation, 95.5% of all counts will be within two standard deviations, and 99.7% of all counts will be within three standard deviations.

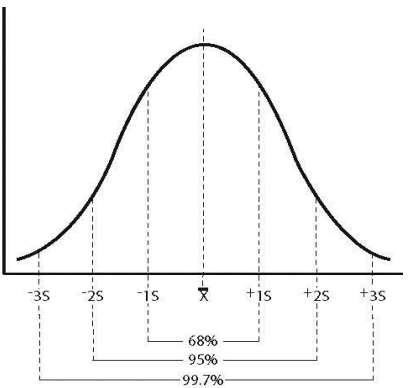


Fig D.5

Thus, these three distribution models become identical for the case with a small individual success probability, but with a large number of trials, so that the expected average number of successes is large. This allows

the use of the best features of each distribution for three statistical situations concerning the gauge:

1) Single measurement precision.

2) Expected spread of measurements.

3) Expected difference between two measurements.

Single Measurement Precision

The expected variation for one standard deviation (68.3%) of a single count can be expressed as a percent error as follow:

$$\%ERROR = 100 \bullet \frac{\sqrt{x}}{x} = 100 \bullet \frac{1}{\sqrt{x}}$$

This expression reveals that the only way to improve the count precision (e.g. reduce the percent error) is to increase the size of x (e.g. the gauge manufacturer selects components for a higher count rate while gauge user counts for a longer period of time).

The following table demonstrates that a minimum of 10,000 counts of readings is required to achieve a count precision of 1.0 percent or better, 68.3% of the time.

Counts	Square Root	Count Precision (68.35)	Count Precision (95.5%)
1	1.00	100.00	
10	3.16	31.60	63.2
100	10.00	10.00	20.0
1,000	31.62	3.16	6.32
10,000	100.00	1.00	2.00
100,000	316.22	0.32	0.63

The count precision improves with the square of the count. Thus taking four times the counts improves the count precision by a factor of two.

To provide a consistent frame of reference to the operator, the count displayed in the MCM-2 Hydrotector is always an equivalent to 60-seconds count or CPM (counts per minute), regardless of the time base selected. It is necessary to correct a precision determination for other time base selections as follow:

$$\%ERROR = 100 \bullet \frac{1}{\sqrt{\frac{x \bullet t}{60}}}$$

In this equation, ***t*** is the selected time in seconds.

Example:

A 60-second direct count is taken and displays 3000.

The precision of the count is:

$$Precision = \frac{100}{\sqrt{\frac{3000 \bullet 60}{60}}} = 1.82\%$$

The direct reading is 2.0 gm/cm³. To determine the end measurement precision, it is a necessary to multiply the count precision by the slope of the calibration curve. Assuming a slope of 0.0416 gm/cm³ per percent, the 2.0 gm/cm³ reading varies by +/- 0.076 gm/cm³ (68% of the time representing one standard deviation).

If you take repeat measurements but move the gauge between readings, then the standard deviation of that set of readings will include both the source random variation and the variation due to re-positioning the gauge, and thus be larger.

13. Windows Application

Requirements:

1) Windows Operating System XP and above.
2) Your PC must have Bluetooth capability.

Description

The 503 Hydroprobe_MCM2 Application is designed to make programming and downloading data from your 503 or MCM2 easier.

You have the ability to store templates on your hard drive and upload them to your device, making it easier to restore any lost data.

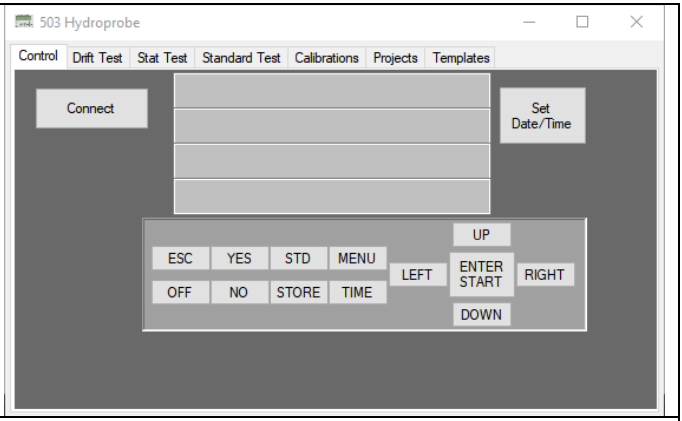
The application is used for both the 503 and MCM2. This manual will only discuss the use with the MCM2 Hand Held Unit.

Installing the Software:

1) Download the 503 Hydroprobe-MCM2 Setup.msi file from www.InstroTek.com .
2) Double Click the 503 Hydroprobe-MCM2 Setup.msi file.
3) Follow the Instructions in the Install Wizard.
4) Double Click the Shortcut that was placed on your desk top to start the application.

Using the Application

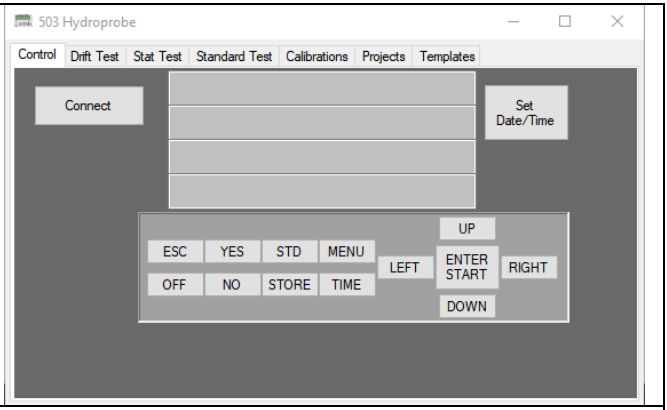
When the application is first started you will be shown this screen:



There are 7 tabs across the top. Each of these will be discussed below.

Control Tab

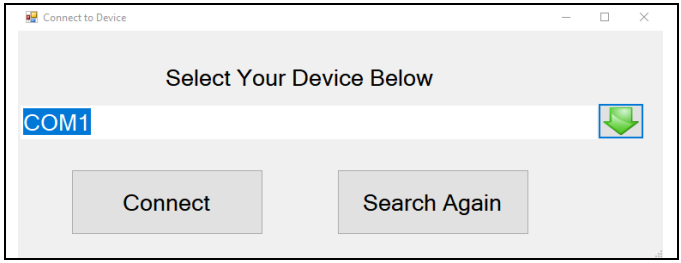
This is where you connect to your MCM2 Hand Held. You must have previously paired with the MCM2 Hand Held using Your Windows Bluetooth Wizard. Your MCM2 Hand Held must also be on and must be set up to connect to your PC. This is done by pressing "Menu" and selecting "15 Connect to PC".



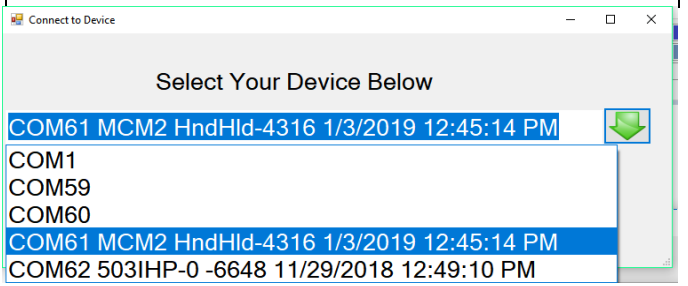
The "Connect" button us used to Connect to the MCM2 Hand Held.

Pressing it will bring up a connect dialog.

Select Device



Clicking the large Green Down Arrow will show you a list of devices you may attach to.

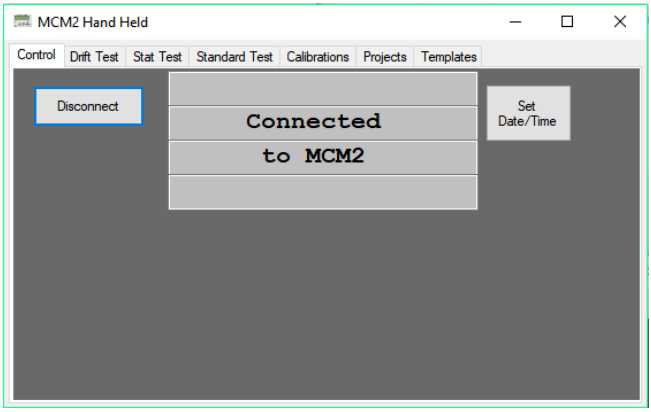


All MCM2 Handhelds will be shown as "MCM2 HndHld".

Select the one you wish to connect to.

Press the "Connect" button to connect to it.

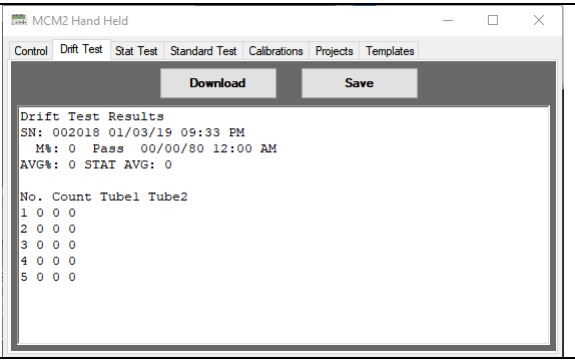
Connect Message



You will see this screen when you have successfully connected to the device. You can press the "Set Date/Time" button to set the date and time of MCM2 Hand Held to the same Date/Time of your PC.

Drift Test Tab

This tab downloads the previous Drift test taken by the MCM2 Hand Held. You can save the results for future reference.

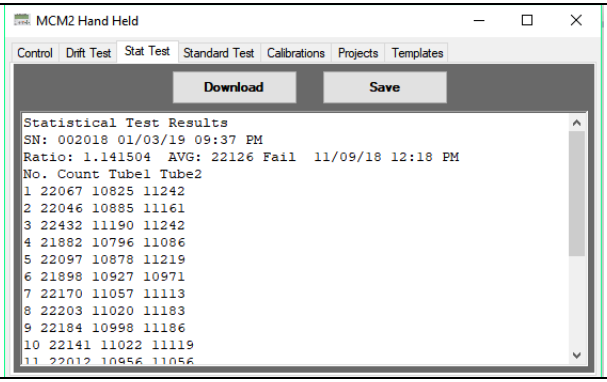


Pressing the "Download" button will retrieve the last Drift test.

Pressing the "Save" button will save the results to your PC.

Stat Test Tab

This tab downloads the previous Stat test taken by the MCM2 Hand Held. You can save the results for future reference.

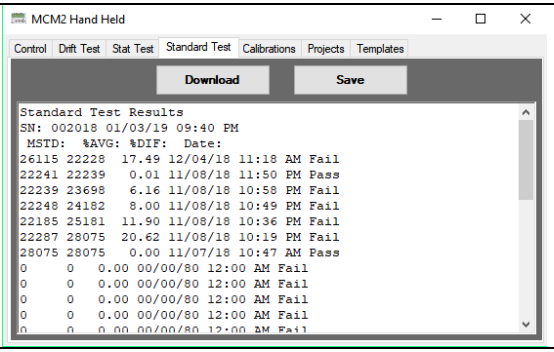


Pressing the "Download" button will retrieve the last Stat test.

Pressing the "Save" button will save the results to your PC.

Standard Test Tab:

This tab downloads the previous 32 Standard tests taken by the MCM2 Hand Held. You can save the results for future reference.

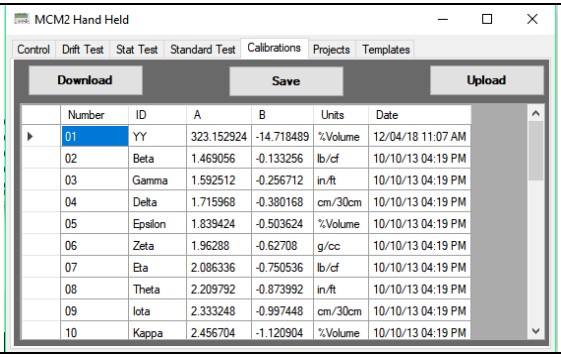


Pressing the "Download" button will retrieve the last 32 Standard tests.

Pressing the "Save" button will save the results to your PC.

Calibrations Tab

This tab downloads the 32 Calibration Constants Saved on the MCM2 Hand Held. You can save the results for future reference.



Number	ID	A	B	Units	Date
01	YY	323.152924	-14.718489	%Volume	12/04/18 11:07 AM
02	Beta	1.469056	-0.133256	lb/cf	10/10/13 04:19 PM
03	Gamma	1.592512	-0.256712	in/ft	10/10/13 04:19 PM
04	Delta	1.715968	-0.380168	cm/30cm	10/10/13 04:19 PM
05	Epsilon	1.839424	-0.503624	%Volume	10/10/13 04:19 PM
06	Zeta	1.96288	-0.62708	g/cc	10/10/13 04:19 PM
07	Eta	2.086336	-0.750536	lb/cf	10/10/13 04:19 PM
08	Theta	2.209792	-0.873992	in/ft	10/10/13 04:19 PM
09	Iota	2.333248	-0.997448	cm/30cm	10/10/13 04:19 PM
10	Kappa	2.456704	-1.120904	%Volume	10/10/13 04:19 PM

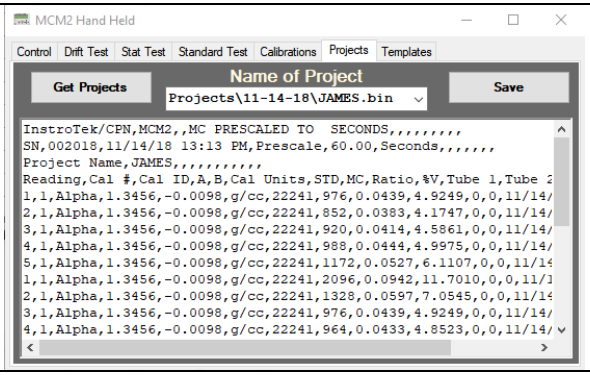
Pressing the "Download" button will retrieve the Calibration Constants.

Pressing the "Save" button will save the Calibrations to your PC.

You can edit the values on this screen and upload them to the MCM2 Hand Held by pressing the "Upload" button.

Projects Tab

This tab downloads all the Projects that are stored on the MCM2 Hand Held. You can save the results for future reference.



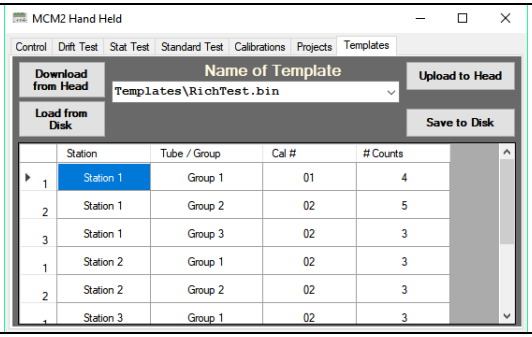
Pressing the "Get Projects" button will repopulate the Drop-Down Box containing the name of the Projects.

Select the Project you wish to view from the Drop-Down Box.

Pressing the "Save" button will save the Project to your PC.

Templates Tab

This tab downloads all the Templates that are stored on the MCM2 Hand Held. You can save each template to your PC as well as load previously saved Templates from the PC and upload them the MCM2 Hand Held.



Pressing the "Download from Device" button will repopulate the Drop-Down Box containing the name of the Templates.

Select the Template you wish to view from the Drop-Down Box.

You can edit the Template from this Tab.

Pressing the "Save to Disk" button will save the Template to your PC.

Pressing the "Load from Disk" will permit you to load a previously saved Template to the application. You can then upload the Template to the MCM2 Hand Held.

Pressing the "Upload to Head" button will upload the currently displayed Template to the MCM2.

14. Radiation Theory and Safety

The neutron probe is a source of fast or high energy neutrons and a detector of slow or thermal neutrons.

The fast neutrons are slowed down by collision with the nucleus of matter in the soil, and then absorbed by the material or escape because of the finite geometry. Since the mass of the nucleus of hydrogen is the same as that of a free neutron, the presence of hydrogen will result in a high field of thermal neutrons. Heavier elements will also slow down the neutrons, but not nearly so effectively. While it takes, on the average, only 18 collisions with hydrogen, it takes 200 with the next element normally found in pipe insulation.

The thermal neutrons are continually being absorbed or escaping due to the insulation or the geometry of the measurement surface. The element Boron, for example, has a high affinity for absorbing thermal neutrons. The resulting detected thermal neutron flux will depend on the creation, escape, and absorption of thermal neutrons produced through their interaction with hydrogen. The neutron probe may thus be used as a measuring device for moisture, but if accurate volume percentages are desired, a calibration may be required for a particular geometry and insulation material.

The sensor uses He3 tubes to detect thermalized neutrons, which are slow low energy neutrons. The neutrons emitted from the source are high energy, fast neutrons which cannot be detected by the He3 tubes. Every time a neutron makes a collision with another element it loses some of its energy and slows down. The number of collisions necessary to slow a neutron so that it can be detected depends on the element as shown in the table below.

How Neutron Backscatter Works

	Element	Mass	Collisions to Thermalize
Steel	Iron	56	514
	Carbon	12	112
Insulation	Silicon	28	262
	Calcium	40	371
	Aluminum	27	251
	Oxygen	16	152
Water	Hydrogen	1	18

Fig 14.1 MCM-2 Cross Sections

From the table above only 18 collisions are required for a high energy fast neutron to become a low energy slow neutron and detectable. The more hydrogen the more slow neutrons and the more slow neutrons detected. Everything else is in the hundreds of collisions.

15. Appendices

Appendix 1: Sample Bill of Lading

Bill of Lading

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

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

Am-241:Be, 1.85 GBq (50 mCi)

Radioactive Yellow II Label, TI=0.2

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

1-800-535-5053

Shipper

_____

(Signature)

Appendix 2: Specifications

Dimensions/Shipping Weights:

Performance:

Model	Weight	Length	Width	Height
Gauge & Carry Case	21.4lbs (9.71kg)	28" (711mm)	12" (305mm)	11" (280mm)
Sensor	3.8lbs (1.72kg)	22" (559mm)	7" (178mm)	5" (127mm)
Handheld	1.4lbs (0.64kg)	9" (229mm)	4.5" (114mm)	2" (51mm)

Performance:

Function – Moisture measurements in insulating materials

Range - Linear calibration: 0 to 40% per volume

Precision - 0.24% at 24% per volume at one minute

Count Time - User selectable from 1 to 999 seconds

Count Pre scale - All counts are prescaled to 60 seconds

Display - 4 lines x 20 character Liquid Crystal Display

Data

- **Storage -** 2 GB of storage
- **Format -** Operator programmable
- **Notes -** 0-99 notes of 19 characters each
- **Counts -** 0-99 counts per record

Calibration - 32 user programmed (linear)

Units - Volume % (V), Ratio, Counts

Sensor Construction

- **Body -** Aluminum with epoxy paint & hard-anodize finish

Electrical:

Power

- **Handheld: NiMH 6 Cell 2500 mAh Battery Pack**
- **Sensor: NiMH 4 Cell 800 mAh Battery Pack**
- **Charger: 12V, minimum 1A charger for Sensor and Handheld.**

Battery Life - The Sensor will last 24 hours on a full charge, and the Handheld will last 48 hours on a full charge. There are two hours of battery life left after the "Battery Low" indicators turn on. Battery life decreases as the batteries age and are recharged repeatedly.

Environmental:

Operating Temperature

- **Ambient -** 32° to 150° F (0° to 66° C)
- **Storage -** -4° to 140° F (-20° to 60° C)

Humidity (Non-Condensing) - 95%

Radiological:

Neutron Source - Maximum 1.85 GBq (50 mCi) Americium-241:Beryllium

Encapsulation - Double-encapsulated sealed source

Shielding - None

Shipping Requirements:

RQ, UN 3332, RADIOACTIVE MATERIAL, TYPE A PACKAGE, SPECIAL FORM, 7

Special Form Approval - CZ/1009/S
An NRC or agreement state license is required for domestic use. Contact CPN for assistance in obtaining training for a license.

CPN is an InstroTek company and reserves the right to change equipment specifications and/or design to meet industry requirements or improve product performance without notice. All Radiological changes to the gauge are subject to state and national approvals and regulations.

Appendix 3: Emergency Response Information

Nuclear Gauge Emergency Response Information for Transportation

Reference DOT ERG 2016 pg 266-267 Guide 164, and 49CFR

Potential Hazard

1) Proper Shipping Name

- UN3332 Radioactive Material Type A Package, special Form, 7, RQ

2) Health Hazards

- Radiation presents minimal risk to transport workers, emergency response personnel and the public during transportation accidents. Packaging durability increases as the potential hazard of radioactive content increases.
- Undamaged packages are safe; contents of damaged packages may cause external radiation exposure and much higher external exposure if contents (source capsules) are released.
- Contamination and internal radiation hazards are not expected, but not impossible.
- 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 Type A packages are damaged in moderately severe accidents.
- Type B packages, and the rarely occurring Type C packages, (large and small, usually metal) contain the most hazardous amounts. They can be identified by package markings or by shipping papers. Life-threatening conditions may exist only if contents are released or package shielding fails. Because of design, evaluation, and testing of packages, life endangering

releases are not expected in accidents except those of utmost severity.

- Radioactive White-I labels indicate radiation levels outside single, isolated, undamaged packages are very low (less than 0.005 mSv/h (0.5 mRem/hr)).
- Radioactive Yellow-II and Yellow-III labeled packages have higher radiation levels. The transport index (TI) on the label identifies the maximum radiation level in mRem/h one meter from a single, isolated, undamaged package.
- Radiation from the package contents, usually in durable metal capsules, can be detected by most radiation instruments.
- Water from cargo fire control is not expected to cause pollution.

3) Fire or Explosion

- Packaging can burn completely without risk of content loss from sealed source capsule.
- Radioactivity does not change flammability or other properties of materials.
- Radioactive source capsules and Type B packages are designed and evaluated to withstand total engulfment in flames at temperatures of 800°C (1475°F) for a period of 30 minutes.

Public Safety

- **CALL EMERGENCY REPSONSE Telephone number on Shipping Paper first. If Shipping Paper is not available or there is no answer, refer to the appropriate telephone number listed on the inside back cover of the DOT Emergency Response Guidebook.**

EMERGENCY RESPONSE PHONE #:1-800-535-5053 (US & Canada)
1-352-323-3500

- **Priorities for rescue, life-saving, first aid, fire control and other hazards are higher than the priority for measuring radiation levels.**
- Radiation Authority must be notified of accident conditions. Radiation Authority is usually responsible for decisions about radiological consequences and closure of emergencies.
- As an immediate precautionary measure, isolate spill or leak area for at least 25 meters (75 feet) in all directions.
- Stay upwind, uphill and/or upstream.
- Keep unauthorized personnel away.
- Delay final cleanup until instructions or advice is received from Radiation Authority.

4) Protective Clothing

- Positive pressure self-contained breathing apparatus (SCBA) and structural firefighters' protective clothing will provide adequate protection against internal radiation exposure, but not external radiation exposure.

5) Evacuation

Large Spill

- Consider initial downwind evacuation for at least 100 meters (330 feet)

Fire

- When a large quantity of this material is involved in a major fire, consider an initial evacuation distance of 300 meters (1000 feet) in all directions.

6) Fire

- Presence of radioactive material will not influence the fire control processes and should not influence selection of technique.
- Move containers from fire area if you can do it without risk.

- 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)

7) Spill or Leak

- Do not touch damaged packages or spilled material.
- Damp surfaces on undamaged or slightly damaged packages are seldom an indication of packaging failure. Contents are seldom liquid. Content is usually a metal capsule, easily seen if released from package.
- If source is identified as being out of package, **DO NOT TOUCH.** Stay away and await advice from Radiation Authority.

8) First Aid

- Ensure that medical personnel are aware of the material(s) involved, take precautions to protect themselves.
- Call 911 or emergency medical service.
- Medical problems take priority over radiological concerns.
- Use first aid treatment according to the nature of the injury.
- Do not delay care and transport of a seriously injured person.
- Persons exposed to special form sources are not likely to be contaminated with radioactive material.
- Give artificial respiration if victim is not breathing.
- Administer oxygen if breathing is difficult.
- Injured persons contaminated by contact with released material are not a serious hazard to health care personnel, equipment or facilities.

Appendix 4: Closure Instructions for MCM-2 Hydrotector

Note: These closure instructions are for both orange and white cases. This case is certified for all versions of the MCM-2 series gauges.

1) The contents of the MCM-2 package are shown below.

The gauge is part of the Type A Package. The Am241:Be is permanently affixed inside the source probe which is housed inside the gauge during non-use and transportation.

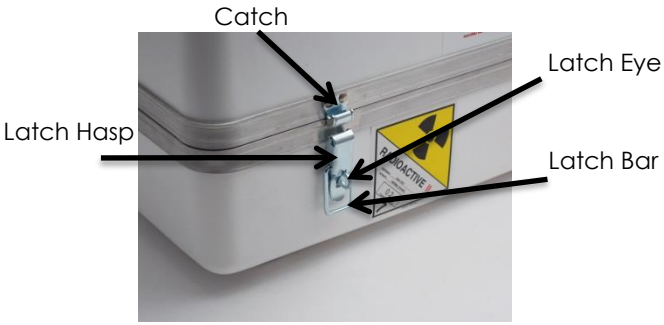
2) Placing the contents

The interior of the box has pre-formed sections for the placement of the gauge, standard accessories, and manual. The manual and other gauge related documents should be packed with the gauge by laying it over the neutron gauge arm.

3) Close the lid.

4) Fastening of the latches

A picture of the latch mechanism is shown below; note the three parts: the catch, the latch bar, the latch eye, and the latch hasp.



5) Place the latch bar into the catch as shown below. Make sure the latch bar is securely in the catch.

6) Push firmly down on the latch hasp until the latch eye is completely through the latch hasp.

7) In order to secure the latch, insert a wire tie or lock through the eye as shown below.

8) Secure the wire tie or lock as shown above. **You must make sure that the wire tie is of sufficient size that it will not slip through the slot in the latch hasp allowing the case to be opened.**

16. Index

17. Warranty

InstroTek, Inc. extends a 2-year limited warranty on the Model MCM-2 Hydrotector™ to the original purchaser of this equipment. This warranty covers defects in material, workmanship, and operation under the conditions of normal use and proper maintenance. This warranty includes all components except for the normal wear components including all accessories, shipping case, seals, batteries, scraper ring, and reference standard block.

InstroTek will replace, free of charge, any part found to be defective within the warranty period.

This warranty is void if inspection shows evidence of abuse, misuse, or unauthorized repair.

This warranty covers replacement of defective materials and workmanship only. It does not cover shipping charges, duties, or taxes in the transport to and from the factory or authorized service center.

InstroTek's liability is in all cases limited to the replacement price of its products. InstroTek shall not be liable for any other damages, whether consequential, indirect, or incidental arising from use of its product.

If return of the product is necessary, please include return shipping directions, contact name, phone & fax number and a description of the action needed.

Call InstroTek, Inc. for shipping details at (919) 875-8371.

Contact Information

Contact us for top quality, best value and superior service!

email: **sales@instrotek.com** ✦ visit: **InstroTek.com**

CALL A LOCATION NEAR YOU:

Headquarters: **Research Triangle Park, NC** phone: **919.875.8371**

Bensalem, PA phone: **215.645.1064** ✦ **Grand Rapids, MI** phone: **616.726.5850**

Denver, CO phone: **303.955.5740** ✦ **Austin, TX** phone: **512.452.8848**

Las Vegas, NV phone: **702.270.3885** ✦ **Concord, CA** phone: **925.363.9770**