

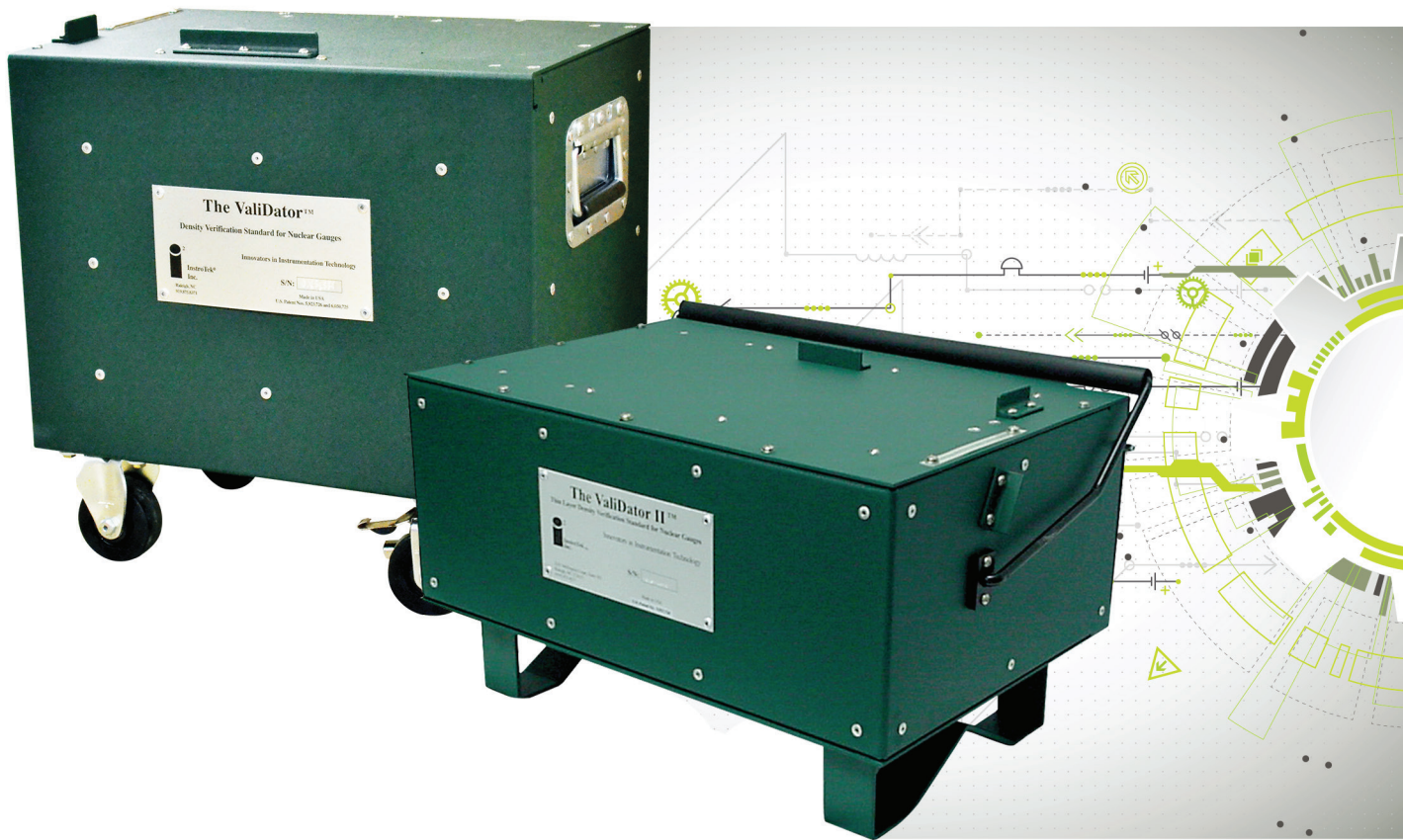


InstronTek[®]
Inc.

innovators in instrumentation technology



Nuclear Gauge Calibration and
Verification System



OPERATING MANUAL

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Validator Nuclear Gauge Moisture/Density Verification and
Calibration System
Manual Revision 6

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1. Introduction

We are happy and proud to share this Nuclear Moisture/Density Gauge verification and calibration technology with you. ValiDator is the first and the only traceable portable verification and calibration system in the industry. InstroTek, Inc. would like to thank you for selecting the ValiDator as your field verification and calibration device. The ValiDator Technology is covered by US Patent numbers 5,923,726 and 6,050,725 including International patents.

We value your input and would like to hear from you with comments and suggestions on how we can better serve you with this or other products.

This guide is designed as a reference for the operation of the Verification and Calibration System. A thorough understanding of the operation and application of Nuclear Moisture/Density gauges is necessary.

Please follow the nuclear gauge manufacturer recommendations with regard to operation and safety concerns of these devices. All ValiDator operations should be done from the end opposite the gauge source, stepping away three feet while the source rod is in the measure position.

Why the ValiDator?

The American Society for Testing and Materials (ASTM) standards and American Association of State Highway and Transportation Officials (AASHTO) specifications require nuclear density gauges to be calibrated or verified every 12 months. In the absence of a field portable validation device, this commonly would require returning a gauge to the manufacturer or other calibration facilities. Strict shipping formalities, weeks without a gauge and expensive calibration fees create a burden on gauge availability for field use.

Gauge owners have never had the option before of performing the verification and re-calibration in the field. The ValiDator from InstroTek, Inc. is designed to optimize the management of your gauge resources and help reduce inconsistencies when multiple gauges are on-site. Multiple gauges calibrated on the same device will reduce conflicts between results.

How to use the validator?

As easy as taking a field measurement, just place your CPN, Humboldt, InstroTek or Troxler gauge on the ValiDator device and take a reading. Compare the gauge wet density and moisture (M pcf) to the pass/fail range on the ValiDator Calibration Sheet and your verification is complete. Even if the gauge Verification fails, the optional Calibration Software would allow you to eliminate the delays in calibration turn-around-time. Calibrate one or all depths in minutes.

Supported Nuclear Gauges

It is important when you verify or calibrate your gauge that the correct chart and values are selected. If there are gauges in your fleet that are not supported on this list, you may establish guidelines for Verification of these gauges. (Reference Verification Procedures for Gauges Not Supported page 20)

CPN

MC3 New, MC1 DR New: Gauges manufactured with two GM detectors. Standard counts are generally between 30000 & 40000 counts.

MC3, MC1 DR: Gauges manufactured before approximately 1996 with one GM detector. InstroTek currently does not support these gauges. Standard counts are generally between 10000 & 20000. Please contact InstroTek for more information on these gauge models or reference Verification Procedures for Gauges Not Supported page 20.

MC1: InstroTek currently does not support verification of this gauge. Please contact InstroTek for more information on this gauge model or reference Verification Procedures for Gauges Not Supported page 20.

MC2: InstroTek currently does not support verification of this gauge. Please contact InstroTek for more information on this gauge model or refer to manual section Verification Procedures for Gauges Not Supported page 20.

MC3 and MC1 Elite:

These gauges are supported.

Humboldt

5001 B, 5001C, 5001P, 5001 EZ and 5001 SD are supported.

InstroTek

Model 3500 Xplorer and 3500 Xplorer 2 are supported.

Troxler

3401 & 3411: These gauges are only different in electronic functionality. Both these gauges are supported by the ValiDator.

3430 & 3440: These gauges are only different in electronic functionality. Both these gauges are supported by the ValiDator.

3411 New: (Very few gauges were produced, serial numbers greater than 17000)

3450: Please contact InstroTek for instructions on how to calibrate these gauges. These gauges, like 4640, operate with two independent measurement systems. A special optional software application is required for these gauges.

4640: Not supported by the ValiDator I. The ValiDator II available from InstroTek is specifically designed for verification and calibration of 4640B gauges and 3450 in the Thinlayer mode. Please contact InstroTek for information on how these gauges can be verified and calibrated.

3430 and 3440 Plus Gauges: Please contact Instrotek for more information on these gauge models, or reference Verification Procedures on page 18.

Seaman Nuclear

These gauges are not supported.

User Guide Information

ValiDator: Device used to verify and calibrate nuclear gauges.

Validation: Utilizing the ValiDator device to evaluate gauge calibration accuracy at multiple depths, at an assigned density.

Verification: The process of using the Validation System to verify the calibration accuracy of a nuclear density gauging device.

Calibration: The process of re-establishing the calibration parameters for a nuclear density gauging device.

Calibration Constants: Parameters established by the calibration program and used by a density gauge to calculate density and moisture.

ValiDator Density: Factory established densities assigned to a specific Validator device for each measurement depth 0-12.

The ValiDator calibration reports are not exchangeable between different ValiDator units.

Safety

- Always operate in accordance with the nuclear gauge manufacturer recommendations.
- Stand opposite the source rod when operating the ValiDator Device.
- Move three feet (one meter) back when the source rod is extended into the measurement position.
- Use proper lifting techniques when loading and unloading the ValiDator.
- Be aware of heavy machinery operating in the area of testing.

Important: Follow the requirements of your nuclear materials license when operating, maintaining and using nuclear gauges.

Quick Start Instructions

The quick start instructions will benefit the new and the experienced operators using the ValiDation System. The System Operation portion of this manual contains detailed information about all aspects of the ValiDator system. The Validation system is designed for use with various nuclear gauges manufactured by CPN, Humboldt, InstroTek, and Troxler.

Important: Observe manufacturers recommendations regarding safety precautions when operating density gauges. Stand opposite the source rod at a distance of three feet or 1 meter when measurements are being taken. Follow the requirements of your nuclear materials license.

Standard Counts for Daily or Rapid Verification: If you are evaluating your gauges frequently for Quality Assurance, or will not be calibrating on-site, a daily 4 minute standard count may be used for the Standard counts on the Evaluation Form for Verification. Take one 4-minute count at all other depths. Standard count should be taken on a solid surface such as soil, asphalt or concrete base. Do not take standard counts with the standard block on the ValiDator, second floor, or the tailgate of a truck.

Standard Counts for Combination Verification and Calibration: If you will be performing a scheduled Verification or Calibration and would like to optimize the data collection process, perform an Extended Standard Count. (CPN: 20 minute count recording the Wet Count and H₂O Count. Humboldt and Troxler: Perform a Stat Test and record the average Density and Moisture count.) Record the Standard Counts on the Evaluation form. Two 4-minute counts should be averaged for Backscatter (BS) and Depth 12 measurements, due to the relatively lower precision at these positions.

I. Verification Process

- A. Align gauge on the ValiDator. For lowering the Source rod, slide the gauge back until the rod is over the access hole. (See Gauge Placement page 8)
- B. Set count time for four (4) minutes. *Note: All moisture verification is done at the Backscatter position.*
- C. Backscatter measurements should be taken with the gauge aligned with the surface stops; two four-min. counts should be averaged for better precision.
- D. Direct Transmission measurements require that the gauge placement be adjusted to minimize the void between the source rod and the inside of the ValiDator. After lowering the source rod move it towards the control panel end of the gauge and to the left

- side alignment stops. Two 4 min. readings at depth 12 should be averaged for better precision.
- E. Complete a four (4) minute reading and record the gauge results WD, M, DC and MC on the ValiDator Evaluation Form (page 10). Make additional blank copies of this form for future use.
 - F. The Wet Density (WD) and Moisture (M) readings from the gauge should fall between the range indicated on the gauge specific ValiDator Calibration Data Table.
 - G. If the resulting densities indicate the gauge passes, consider the verification process complete. The gauge is now verified for field use.
 - H. If the gauge fails Validation, review precautions and repeat Validation steps A-G.
 - I. A second failure would indicate that a calibration is needed.

II. Calibration Process

Note: Gauge Calibration is a sophisticated process and should only be attempted by advanced and trained users. Please refer to the Calibration Section of the Manual for calibrating gauges.

Precautions before You Begin

Nuclear gauge: Note: Do not take a Standard Count on the ValiDator.

- Clean Base
- Record the Current passing standard count in the field location where Validation is to be performed.
- Count time set to four (4) minute counts
- Stable Gauge Electronics (Run the manufacturer recommended diagnostics if field results are questionable.)
- No other gauges should be within 30ft (10 meters) of the testing area.
- When taking measurements stand opposite the source side of the unit a distance of three feet (1 meter) away.
- Gauge positioned correctly on the ValiDator. (Refer to Gauge Placement page 8)
- Gauges meet the requirements for supported gauges. (Refer to User Guide page 4)

ValiDator Device:

- Top surface free of debris
- Placed on solid level surface, three feet from any vertical structure.
- * Tailgates, Carpeted floors, upper floors of buildings, trailers, and uneven surfaces are not acceptable.

Equipment

Items required for Verification and Calibration include: ValiDator Device, ValiDator Density Data (In shipping case), ValiDator Evaluation Form (page 10 of user guide), stable nuclear gauge, and current gauge calibration data (for calibration option).

Gauge Placement

Nuclear gauges differ between manufacturers. It is important to align each gauge using the positioning stops on the top and left of the ValiDator.

Backscatter & Moisture Readings

All Backscatter (Depth 0) and Moisture readings should be taken with the gauge flush with the stop at the top and on the left as shown below.



Direct Transmission (Depths 2-12) Readings

Direct Transmission (Depths 2-12) readings require the gauge to be positioned such that the void between the source rod and the inside of the ValiDator block is minimized. Slide the gauge back until you can drop the source rod in the hole on top of the ValiDator. Once the source rod drops in the hole, make sure to keep the gauge flush with the left stop and slide the gauge back away from the top stop until it can't be moved any further.



Validator Evaluation Form

Validator S/N		Verification/Calibration Date:	
Gauge S/N		Operator:	
Gauge Model			
Daily Standard Counts Calibration Standard Counts	DS _____	MS _____	
	DS _____	MS _____	

Establish these counts using the average counts from the results of a Stat Test, 20-minute count or (5) 4 min. Counts. This data is used for the Calibration process.

Count Time 15 sec 1min 4 (Recommended) 16 20 Circle one

<u>Depth</u>	Gauge at Backscatter Stop			<u>DC</u>	Gauge at Backscatter Stop			<u>MC</u>
	Pass	<u>WD</u>	Fail		Pass	<u>M</u>	Fail	
BS	P _____	F _____		_____	P _____	F _____		_____
BS	P _____	F _____		_____	P _____	F _____		_____
BS Avg.	P _____	F _____		_____	P _____	F _____		_____
2	P _____	F _____		_____				
3	P _____	F _____		_____				
4	P _____	F _____		_____				
5	P _____	F _____		_____				
6	P _____	F _____		_____				
7	P _____	F _____		_____				
8	P _____	F _____		_____				
9	P _____	F _____		_____				
10	P _____	F _____		_____				
11	P _____	F _____		_____				
12	P _____	F _____		_____				
12	P _____	F _____		_____				
12 Avg.	P _____	F _____		_____				

Notes/Re-counts: _____

Example of Gauge Calibration Report

Gauge Calibration Report

CPN Gauge Model: MC1Elite
Serial Number: 30648
Calibration Density Standard Count: 4647
Calibration Moisture Standard Count: 1066
Calibration Date: 03/27/2018

Validator Serial Number: 04021227

Print Date: 08/09/2018

Depth	Validator Count	Validator Density	A	B	C
0.0	2751	139.3	3.35803	62.03814	0.23624
2.0	11365	131.0	10.61460	90.20660	-0.03976
4.0	11145	117.4	11.73345	76.79411	-0.14748
6.0	6552	127.3	13.93170	54.67042	0.05018
8.0	2210	155.5	14.10710	44.20234	0.05617
10.0	1504	143.3	15.98260	34.40520	0.07487
12.0	1147	129.2	12.31049	31.09511	0.05284

Moisture Parameters:

A	B	Moist. Content	Moist. Count
58.30788	3.07740	34.5	687

Operator Signature

Date

Supervisor Signature

Date

Example Gauge Calibration Report Key

- 1) Make (CPN, Humboldt, InstroTek or Troxler)
- 2) Model
- 3) Serial Number
- 4) Calibration Standard Counts
- 5) Calibration Date
- 6) Factory Density Constants (A, B, C Parameters)
- 7) Calibration Block Densities lb. /ft³ or kg/m³
- 8) Calibration Block Counts
- 9) Factory Moisture Constants
(E & F or A & B for CPN gauges)

2. ValiDator Accessories and Application

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

List of Equipment & Accessories

User Guide
ValiDator (Calibration Box)
ValiDator Density Data (Laminated Sheets)
Quick Start Instructions
NIST Certificate

List of Optional Accessories

Optional VeriFier Software (USB Flash Drive)
3430 and 3440 Constant Download Cable
InstroTek 3500 Gauge Constant Download Cable

Note: Small scratches should be expected on the ValiDator working surface due to extensive quality control process utilizing measurements with multiple gauges.

Application Overview

Verification & Calibration Process

There are several steps necessary to accomplish a gauge verification and calibration. Gauge calibration verification is the most fundamental use of the ValiDator device. Position a density gauge on top of the ValiDator device, take a four (4) minute density reading and evaluate the resulting density using the laminated gauge specific ValiDator Density Data Table provided.

The steps below describe a procedure within the Verification and Calibration process. Density and Moisture gauge data is required by the VeriFier Software and should reflect the most recent calibration. If not available, this data may be obtained from the organization that completed this calibration.

Calibration constants are used by the gauges to perform the calculations necessary to process raw count data into a density. Density and moisture tables may be used for any gauge, but are more common with units that do not have internal memory or an internal processor. Gauge manufacturers use NVRAM (Non-Volatile Random Access Memory) or EPROM's (Erasable Programmable Read-only Memory) in their gauges.

Calibration constants may be entered into a gauge (CPN MC3, MC3 Elite, MC1 Elite, Humboldt EZ and SD, InstroTek 3500 and Troxler 3430, 3440, 3430 Plus and 3440 Plus) using the operating keypad. Units that employ EPROM's (Troxler 3411 and Humboldt 5001 series) may operate using density tables while an EPROM is programmed and mailed for installation. InstroTek can program EPROM's for your gauges. Simply fax or mail the Calibration Constants Report and InstroTek will program and ship your EPROM by Priority Mail for a nominal charge. You can also purchase a Prom Programmer Package to burn proms at your facility. VeriFier allows creation of hexfiles for Troxler 3411B and Humboldt 5001C gauges. There is an option available on 3401 and 3411 gauges that you can use to allow direct entry of constants through the keypad. SmartPanel from InstroTek is a "drop in" replacement for the existing 3401 and 3411 scalars. SmartPanel upgrades the 3401 and 3411 gauges with many features, including direct entry of calibration constants through the keypad. For more information on the InstroTek SmartPanel, please visit our website at www.InstroTek.com.

3. Software Installation

Computer Requirements: Windows operating system

Installing VeriFier Software on a PC

Object: Allow the operator to access the software and re-calibrate a nuclear gauge.

Support: Before loading any software, consult with your organization PC Manager or operating system manuals.

Locate your flash drive included with your *ValiDator* system. Please read license agreement before opening software package. This software should only be loaded on one computer. Access codes will be needed to complete installation.

NOTE: **ValiDator and its' associated software is licensed to a single user. Use of the ValiDator and its' associated software is not allowed for calibration of gauges from other organizations.**

Windows

1. Download VeriFier software from USB flash drive provided by InstroTek.
2. Follow prompts, click finish when complete.
3. Call InstroTek for registration codes:
 - Enter Main Registration Code
 - Click on Calibrate and enter Calibration Registration Code
 - Enter Password "calibratenow" or "calnow"
 - Provide Product Key to InstroTek service Representative
 - Enter Product Code

Upgrading Software Version

You may load the new software version directly over the existing version and not lose your existing data.

- Close all Windows programs.

- Follow the Install instructions.
- Follow prompts.

Moving Software

- VeriFier software may only be installed on one computer.
- Moving to another computer is possible. Please contact InstroTek for procedures and access codes.

4. System Operation

Calibration Accuracy Verification & Calibration Process

Verification Process

Verification of the gauge is necessary to determine the status of the gauge calibration. Gauges are calibrated when they are shipped from the manufacturer. Without performing periodic verification, it is not possible to assess the accuracy of your gauge calibration. ASTM and AASHTO standards require gauges to be verified for calibration accuracy at least once every 12 months and also the calibration is checked on newly acquired or repaired nuclear gauges. With the ValiDator, gauges may be verified to meet this requirement.

Verification

Definition: Use the reference densities assigned to a ValiDator device for evaluating the calibration accuracy of a density gauge.

Resources: ValiDator Device, Gauge Field Evaluation Form, ValiDator Calibration Tables, *Density Gauge, **Stable surface.

Important: Follow the requirements of your nuclear materials license when operating, maintaining and using your gauge.

Calibration

Calibration is a process of calculating new parameters for the nuclear gauge. Only advanced users with a high degree of experience and understanding of gauge measurement and operations should perform this process. It is recommended that one individual in an organization be responsible for the calibration process. The Verifier Software with counts taken on the ValiDator can be used to generate new moisture and density calibration constants for the gauge.

Resources: InstroTek VeriFier Software, PC, Completed Evaluation Form, *Density Gauge, Gauge Calibration Constants, **Stable surface

Note: The VeriFier Software used for calibrating your gauge assumes that the current gauge calibration information is obtained and entered accurately.

Moisture Calibration

The ValiDator is engineered to provide moisture verification and calibration in pcf or kg/m³. The nuclear gauge moisture calibration process differs from density in that the moisture calibration is a straight line and rarely will need to be re-calibrated. However, the VeriFier software provides the capability for the moisture calibration of the gauge.

*Density Gauge: A gauge qualified for evaluation should meet the requirements below:

- Gauge base should be free of asphalt or debris that would cause the unit to rock,
- Pass the manufacturers recommended statistical stability and drift tests, and
- Pass a standard count at the evaluation site.
- No other nuclear gauges should be within thirty (30) feet.
- Make sure proper recommended maintenance steps are taken prior to calibrating gauges.

**Stable Surface:

- Be at least three (3) feet (1M) from any vertical structure.
- Dry and level,
- Have a density of greater than 100pcf (1602 Kg/m³).
- Parking lots and construction sites are ideal surfaces for testing.

Unacceptable surfaces would be as follows: trailer floors, truck tailgates, second-story floors, wet surfaces with standing water or carpeted floors.

Verification Procedures

Gauge Evaluation

- The gauge base should be free of dirt and debris, no other nuclear gauges near-by, 3 ft. (1 m) from any vertical structure, and on a stable surface.
- Pass the manufacturers statistical stability test or ASTM and AASHTO recommendations in D6938, D7759 and/or AASHTO T310.
- Complete and pass a four (4) minute standard count in the area where verification tests are being conducted.

Refer to the gauge operator's manual for gauge cleaning, routine maintenance and evaluation procedures.

Site Preparation and Gauge Placement

- Select a flat, level and dry surface with a density greater than 100 lb/ft³ (1602 Kg/m³) three (3) feet from any vertical structure. Note: Soil, asphalt or concrete are good examples of the surface to place the ValiDator for testing. Parking lots or open fields are recommended locations for testing.
- Remove ValiDator from shipping case, place unit on selected area, and position handle at bottom stop.
- Take a Daily or Calibration Standard Count and record on ValiDator Evaluation Form. Do not take the Standard Count on the ValiDator.
- Align the density gauge on the top of the ValiDator using the specific guides on top of the ValiDator device. (See Gauge Placement page 8) Backscatter readings should be measured in contact with alignment stop. After lowering the source rod for direct transmission, position the gauge to the rear of the ValiDator device against side stops to reduce the air void between the source and material being read.
- Select the specific ValiDator Density data table for the model nuclear gauge under test.

NOTE: Do not take standard counts on top of the ValiDator.

Verification Procedure for Gauges Not Supported by the Validator

For gauges not supported you can establish a history and determine when each individual gauge falls outside a $\pm 1\%$ limit. Observe the following procedure to establish a verification process for gauges not supported.

Example:

Depth	A	B	C	D	E	F
Date	12/7/2017	6/7/2018		12/7/2017	6/7/2018	
	S/N 7022	S/N 7022	Difference PCF $B - A$			Dif. $E - D$
BS	150.2	150.6	0.4	5.6	5.7	0.1
2	118.5	117.6	-0.9			
4	136.2	135.2	-1.0			
6	132.1	132.0	-0.1			
8	125.0	125.5	0.5			

1. Send your gauge to a calibration facility for a calibration.
2. When you receive the gauge, take a four-minute Standard Count. Use the following form or generate your own spread-sheet program.
3. Take four minute WD and M readings on the ValiDator at each depth and enter in column **A** and **D** for density and moisture, as baseline readings.
4. At a later date, for example, every six months take readings and store in **B** and **E**.
5. Compare **A** to **B** and **D** to **E**, and determine differences between **C** and **F**.
6. If any of the WD numbers are outside of ± 1.5 lb/ft³ (± 24 Kg/m³) difference or M outside ± 1.0 lb/ft³ (± 16 Kg/m³), take readings again. If it fails again, the gauge needs to be calibrated.

Note: This procedure assumes that the Calibration received is accurate. For re-calibrating these gauges contact InstroTek.

Gauges Not Supported Verification History Profile

Gauge Model _____
Gauge S/N: _____
Validator S/N: _____

Date: _____
Operator: _____

Date	Depth	(A) Baseline Density	(B) Test Density	(C) % Diff. <i>B - A</i>	(D) Baseline Moisture	(E) Test Moisture	(F) Diff. <i>E - D</i>

Verification Measurements and Data Evaluation

Reports may be generated using the optional VeriFier Software.

- Complete a single four (4) minute reading at the desired depth(s) under evaluation, and record the Wet Density (WD) Density Count (DC) Moisture (M) Moisture Count (MC) on the ValiDator Evaluation Form (Introduction page 10). **Note: For better precision at Depth 0 (BS) and 12, it is recommended that you take (2)-four minute counts and record the average on the form.**
- Use the ValiDator Density Table to evaluate the Wet Density and Moisture of the depth being tested for the pass/fail range. If the Wet Density and Moisture fall within this range the gauge passes the verification process. *Note: All gauge moisture measurements are performed from the backscatter position. The ValiDator moisture value is determined using the BS measurement stop.*
- If a failure is indicated, repeat the testing process reviewing the precautions listed on page 7.
- Failing a second time would indicate an inaccuracy in the gauge calibration and the need for calibration.
- Before moving on to Calibration, complete a statistical analysis using manufacturer recommendations or ASTM Standard Test Methods detailed in 6938 and D2950 sections on standardization and reference checks. Record this information on the ValiDator Evaluation Form page 10. (The Analysis is commonly referred to as a Statistical Stability Test or Stat Test. If this test passes you may use the Density and Moisture Average for your Calibration Standard Count.) Before calibration, make certain the gauge meets gauge manufacturers requirement for routine maintenance and care.
- Utilize VeriFier Software (if available), to perform a new calibration.

Verification Using VeriFier Software

To utilize the features of the VeriFier Software, you must enter the current gauge calibration and ValiDator density data into the software. Follow Step I: Entering Gauge Calibration Data on page 25 and Step II entering ValiDator Densities on page 26.

Step I: Verification Data Entry

1. Enter the current gauge calibration data into VeriFier software. (Follow procedure Step I page 25)
2. Enter the ValiDator densities from laminated sheet. (Step II, page 26)
3. Enter counts from ValiDator Evaluation Form taken by the gauge on the ValiDator.
 - 3.1. Daily Density and Moisture Standard Counts
 - 3.2. Verification Date
 - 3.3. Failure Cutoff, default value is 2pcf (32 Kg/m³)
4. Enter Gauge Counts from Evaluation Form
 - 4.1. Enter Moisture Count at Backscatter
 - 4.2. Enter Density Count at all depths
5. Click on Calculate to display the Calculated Density and Error. This density should be similar to the WD from the ValiDator Evaluation form.
6. To change measurement units, click on Options and select desired units.
7. To print a Verification report, click on Report.
8. To customize your report click on Options, then Customize.

VeriFier (Gauge: Troxler 3430,27578 - ValiDator: 98121050)

Gauge ValiDator Options CaliBration About Units: English

Daily Std Count: Moisture Std Count:

Validation Date: Failure Cutoff:

Depth	Gauge Count	ValiDator Density	Calculated Density	Error (pcf)
Moisture	119	9.0	9.3	0.25
0.0	685	142.2	142.7	0.55
2.0	2572	142.7	142.5	-0.21
3.0	3300	129.2	129.4	0.23
4.0	2045	152.1	151.7	-0.40
5.0	1975	147.3	146.5	-0.76

Selected Density is the Validator Density. Factory Calibration
This is the density that your gauge will read.

Calibration Procedures

The calibration process utilizes the optional VeriFier Software. Contact InstroTek to obtain your specific password for operating this program. *Note: Only trained, qualified and experienced users should perform the Calibration and you should follow the requirements of your nuclear materials license for operating, maintaining and using your gauge.*

The nuclear gauge's current calibration data is necessary to complete the calibration process. If not available at your organization, contact the gauge calibration facility that performed this calibration for a copy.

For loading the Verifier Software see Chapter 3: Software Installation.

Note: If the gauge is not maintained nor has service problems, Calibration is not going to resolve any service or maintenance problems. Contact your service center to address any service issues with the gauge.

Step I: Entering Gauge Calibration Data

(An example of the Gauge Calibration Sheet may be found on page 11)

1. From the **Gauge** pull down menu, select **New** if this is the first time this gauge data is being entered.
2. Enter Password. (This was obtained from InstroTek on installation. Please contact InstroTek if lost.)
3. Enter Gauge General Information; Make, Model (Select the model defined on page 3), Serial Number, Factory Calibration Standard Count (This is the Calibration Standard Count on the Gauge Calibration Sheet of the Gauge under test.)
4. Enter Gauge Calibration Data.

Caution: If this data is entered incorrectly, the gauge calibration may be inaccurate.

Caution: Do not use the AC depth in the Verifier program for CPN Gauges.

- a) Calibration Constants: The A, B, and C values used by the gauge to calculate Wet Density and E and F or A and B for CPN gauges to calculate Moisture (M pcf).
- b) Calibration Block Densities: **Note: Calibrations completed at facilities other than the specific gauge manufacturer may require correcting the densities before re-calibrating using the Validator.**
If the densities for your Mg block indicated on your calibration sheet is less than 110 pcf (1762 kg/m³ or 1.762 g/cm³), then the densities need to be normalized. To normalize the densities, divide the Mg block density by 0.988, divide the Mag/Al block density by 0.974, and divide the Alum block density by 0.964. If the units on the calibration report are in kg/m³, then divide the density values by 16.018 and follow the above normalization procedures, dividing mag density value by 0.988, Mag/alum density value by 0.974 and Alum density value by 0.964. If the units are in g/cm³, then multiply by 62.4 and follow the above normalization procedures, dividing mag density value by 0.988, Mag/alum density value by 0.974 and Alum density value by 0.964.
- c) Calibration Block Counts: These are the Density counts from the gauge calibration sheet.
- d) Moisture Constants: Depending on the gauge manufacturer, these are the E and F, or A and B for CPN gauges used by the gauge to calculate Moisture in pcf or Kg³/m³.

5. Change data or Select a Different Gauge:
 - a) From the Gauge pull down menu, select **Modify** if the gauge data requires updating or correction.
 - b) From the Gauge pull down menu, select **Pick** to review and select a specific gauge.

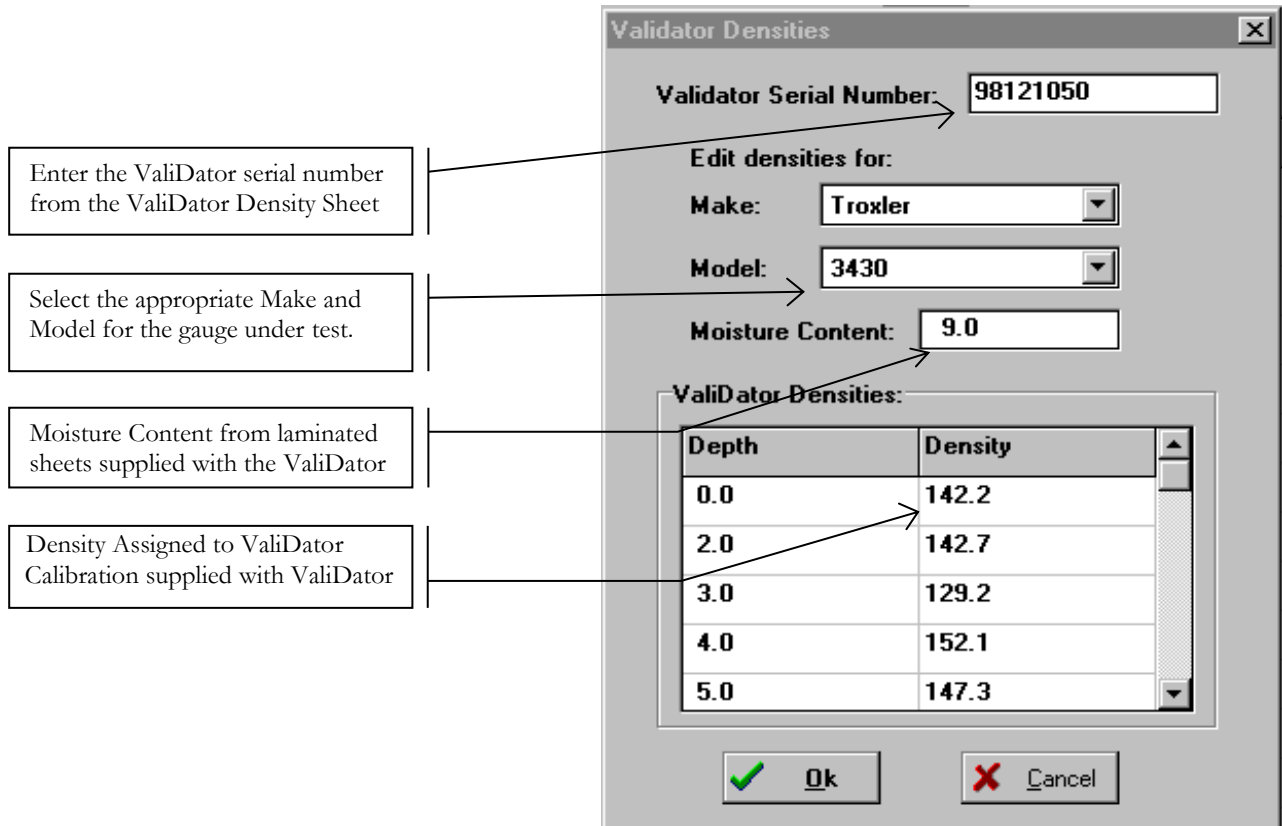
CPN MC3, MC1, MC3 Elite and MC1 Elite

If density value for magnesium (low block) provided on the calibration report is less than 110 pcf (1762 kg/m³), enter the values indicated for all three blocks on the report for calibration density values. If the values are 110 pcf (1762 kg/m³) or higher, multiply the magnesium (low block) density by 0.976, magnesium/aluminum (mid block) by 0.954 and aluminum (high block) density by 0.974 and multiply granite density by 1.

Step II: Entering ValiDator Calibration Densities

(Use the laminated ValiDator Density Data supplied with your ValiDator. These sheets are manufacturer, model, and ValiDator specific. For large organizations, a multiple ValiDator function is available. Insure that before a calibration is attempted that the correct ValiDator is selected.)

1. Select **ValiDator** from the pull down menu, and Select **New**. Enter the ValiDator Serial number, and From the Model pull down, select the appropriate model from the laminated ValiDator Calibration Table.
2. Enter the Moisture content from the laminated sheet and all the depths and densities found on your sheet. You may enter Pcf or Kg³/m, but not both. The options menu allows you to change units.
3. To change ValiDator Densities, choose **Modify**.
4. For selecting another ValiDator, select **Pick**.



Step III: Entering Calibration Counts

(This procedure will calculate new Calibration constants from the counts taken on the ValiDator. It is extremely important to accurately input this data.)

1. From the Calibration pull down menu, select **Calibrate** and enter the Password at the prompt. Contact InstroTek for a misplaced password.
2. Enter the Calibration Standard Count that you established while collecting Verification data.
3. Enter the Calibration date. This is the date you collected the data on the ValiDator for calibration.
4. Enter the Gauge count for the appropriate depth in the first column. This is the Density Count (DC) from the ValiDator Evaluation form.
5. Enter the Moisture count taken at Backscatter. This is the (MC) from the evaluation form.
6. After the Gauge count data is entered, click on the 3 or 5 block calibrate button depending on the number of blocks used in the previous calibration. Generally, CPN, InstroTek and Troxler gauges use a three (3) block calibration, while Humboldt gauges are five (5) block calibrated.

- Print the Calibration report by Selecting Calibration from the Verifier screen and click on Report.

*Note: Performing a different calibration method (3 block instead of a 5 block) other than the one used for the current calibration will produce faulty constants. If an error in the final calibration is noted you may revert back to the original by pressing **CTRL+E**.*

Daily Standard Count
This is an extended density and moisture Standard Count from the average of (5) four-minute standard counts

Calibration Date
This is the date that the calibration was done.

Gauge Count
Density Counts from each depth taken on the ValiDator. Depths 0 and 12 are the average of (2) four-minute readings.

Calib. Moisture Count
Moisture count taken at backscatter

The screenshot shows the 'InstroTek Calibrator (Troxler 3430,27578)' window. It contains several input fields and buttons:

- Calib Density Std Count:** 2864
- Calib Moisture Std Count:** 679
- Calibration Date:** 01/08/1999
- Buttons:** Calibrate (3 Block) and Calibrate (5 Block)

A table displays calibration data for different depths:

Depth	Gauge Count	A	B x 1000	C
0.0	797	4.99572	1.48617	-0.105924
2.0	2698	15.3774	1.31361	-0.185168
3.0	3481	17.6393	1.35673	-0.162872
4.0	2197	20.1084	1.42057	-0.138181
5.0	2004	20.7065	1.50533	-0.110405
6.0	1886	21.3802	1.60806	-0.0874333

At the bottom of the window, there are additional fields and buttons:

- Calib Moisture Count:** 119
- Constants:** E=0.02209 F=1.06246
- Buttons:** Ok and Cancel

Calibration and Verification Uncertainties

ASTM DD7759 requires the reporting of verification and calibration uncertainties. The software calculates and reports uncertainty budgets for each gauge verified and calibrated.

Calibration Uncertainty

CPN Gauge Model: MC1Elite
 Serial Number: 30648
 Calibration Density Standard Count: 4647
 Calibration Moisture Standard Count: 1066
 Calibration Date: 03/27/2018

ValiDator Serial Number: 04021227

Print Date: 08/09/2018

Gauge Density Estimated Measurement Uncertainty:

Depth	Density		
	Low	Med	High
0.0	1.10	1.15	1.28
2.0	0.77	0.75	0.74
4.0	0.73	0.72	0.72
6.0	0.71	0.72	0.74
8.0	0.72	0.74	0.79
10.0	0.73	0.80	0.95
12.0	0.80	0.91	1.22

Gauge Moisture Estimated Measurement Uncertainty: 4.02

Note: Expanded uncertainties calculated above are for coverage factor K=2, which defines a measurement confidence level of approximately 95%. These values meet the requirement of ASTM D7759 and D6938. The calculations of uncertainty are based on the calibration facility being compliant to ASTM D7013, with potential influences controlled, such as wall effect, background and operator experience.

Gauge density measurement uncertainties are calculated at density values of Low: 1762 Kg/m3 (110 lb/ft3), Med: 2162 Kg/m3 (135 lb/ft3), and High: 2627 Kg/m3 (164 lb/ft3). The values reported are in percent (%).

Gauge moisture measurement uncertainty is calculated at moisture density value of 560 kg/m3 (35 lb/ft3). The uncertainty value reported is in percent (%).

Verification Uncertainty

CPN Gauge Model: MC1Elite
 Serial Number: 30648
 Validator Serial Number: 04021227
 Validation Date: 03/27/2018

Errors listed on the Verification Report indicate the difference between the values read by the gauge and the actual values assigned to the ValiDator block at each depth. These values are a measure of the accuracy of the gauge with the calibration constants listed in the Verification Report and meet the requirements for verification of ASTM D7759, ASTM D6938 and AASHTO T310.

Maximum expanded uncertainty using the ValiDator for verification at k=2 are presented below for all depths according to the requirements of ASTM D6938, D2950 and D7759. The values below are in percent (%) and indicate the maximum expanded uncertainty for the range of densities normally encountered in construction material testing, low [109.4 lb/ft3 (1752 kg/m3)], medium [135.6 lb/ft3 2172 kg/m3)], high [162.1 lb/f3 (2597 kg/m3)] and moisture (34 lb/ft3 (545 kg/m3)).

Max Uncertainty	Density	Moisture
BS	1.434	2.880
2	0.940	
3	0.876	
4	0.704	
5	0.662	
6	0.623	
7	0.643	
8	0.671	
9	0.746	
10	0.752	
11	0.866	
12	0.984	

Note: Expanded uncertainty calculated using NIST Technical Note 1297 in percent for density and moisture verification by the ValiDator block at k=2

Verification Report

CPN Gauge Model: MC1Elite
 Serial Number: 30648
 Daily Density Standard Count: 4647
 Daily Moisture Standard Count: 1066
 Validator Serial Number: 04021227
 Validation Date: 03/27/2018
 Failure Cutoff: 2.0. Failure cutoff for Moisture is always ± 1 pcf (± 16 kg/m³)

Page 1/2

Print Date: 08/09/2018

Depth	Gauge Count	Validator Density	Calculated Density	Error
Moisture	587	34.5	35.2	Pass
0.0	2751	139.3	139.3	Pass
2.0	11365	131.0	131.0	Pass
4.0	11145	117.4	117.3	Pass
6.0	6552	127.3	127.2	Pass
8.0	2210	155.5	155.4	Pass
10.0	1504	143.3	143.2	Pass
12.0	1147	129.2	129.1	Pass

Calibration Standard Count: 4647
 Calibration Date: 03/27/2018

Depth	A	B	C
0.0	3.35803	62.03814	0.23624
2.0	10.61460	90.20660	-0.03976
4.0	11.73345	76.79411	-0.14748
6.0	13.93170	54.67042	0.05018
8.0	14.10710	44.20234	0.05617
10.0	15.98260	34.40520	0.07487
12.0	12.31049	31.09511	0.05284

Moisture Parameters:

A	B
58.30788	3.07740

Step IV: Programming New Constants in the Gauge

MC3: Press the Step and Calib. key on the front panel. Select Wet Coefficients, using the select key to change the depth. The A, B, C and A, B coefficients may be entered by pressing the Enter key.

3430: Press the special key and use the arrow keys to select Calib. Constants. Enter the code 4678 using the arrow keys. Enter the E and F constants (moisture constants), select depth and enter the A, B and C constants. Use the arrow keys to choose the depth.

3440: Press Shift-Special 1, then 9 and enter the code 4688. Some gauges require a secondary code, which is 5936. Select Calibration Constants from menu and follow the screen prompts and enter the E & F moisture constants and select the depths for entering the A, B and C constants.

3430 and 3440 Plus: Contact Troxler to purchase codes in order to enter constants into these gauges. Troxler charges their customers an additional fee for performing this step.

3500, 3500 Xplorer 2 and SmartPanel: Press menu, use up and down keys, select *calibration constants*, Enter code (4659) and press enter. Then enter constants for moisture (E and F) and A, B and C constants for all depths.

3411B and Humboldt 5001: These units utilize an EPROM (Eraseable Programmable Read Only Memory) Chip. Fax or email the new constants report to InstroTek and we will program a chip for you. On receipt of the programmed chip remove the old chip noting the position of the reference notch on the top. Use a small screwdriver to leverage the chip from the socket. You may also purchase a Prom Programmer Package for burning proms at your facility. If you choose to purchase a PROM programmer package, you may use Verifier to create new hexfiles for Troxler 3411B and Humboldt 5001C gauges.

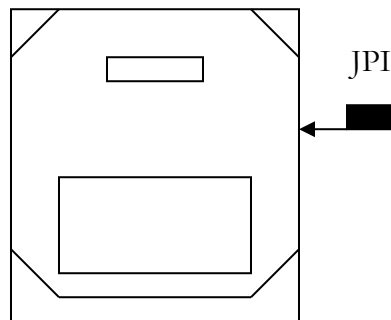
Humboldt EZ:

Changing A, B, C, E & F constants in the H5001EZ gauge:

1. Turn Power ON. (The processor will automatically initialize. Wait approximately 5 seconds)
2. Change A, B, C, E & F constants:
 - a. MAIN MENU
 - b. F3 (ENGINEERING)
 - c. F1 (CALIBRATE)

- d. Enter Password (F2, F2, F2, F3, F4)
- e. F4 (Change A, B, C, E or F)
- f. F1 (A, B & C Parameters)
- g. You will see for example A = 2.82232 and the letter 'A' will be blinking. You can press F2 (INCREASE) to change from the 'A' constant to the 'B' or 'C'.
- h. By pressing F1, you can shift the cursor to the value to be changed.
- i. You can then increment or decrement using the F2 or F3 keys respectively.
- j. Press F4 to go to the next depth.
- k. To exit, press MAIN MENU.
- l. Remove right protect jumper (JPI)
- m. Press F3 (SAVE USER CONSTANTS).
- n. Replace right protect jumper (JPI).

Note: JPI is a small black plastic jumper located at the upper right-hand side between keyboard and CPU board as shown below.



Step V: Requesting EPROM Programming from InstroTek.

1. Email or Fax the following:
 - a) The Calibration report and Verification report insuring the Calibration data reflects the new calibration information. From the Verifier program.
 - b) Your ValiDator Evaluation Form, readings taken on the ValiDator.
 - c) The Gauge Calibration Sheet from the calibration in the gauge during verification.
2. Fees: There is a fee for each gauge that requires an EPROM Programmed.
3. Freight: InstroTek will ship using regular shipping methods (average two or three day delivery). Air shipment is available upon request at applicable rates.

Step VI: EPROM Removal and Installation

(Static charges may damage silicone chips. Ground yourself while installing EPROM.)

1. Loosen the front panel for the gauge requiring EPROM installation.
2. Locate the EPROM on the circuit board of the front panel. (IC that has a sticker with the gauge serial number and last calibration date.)
3. Make a note to the position of the notch in the top of the chip.
4. Remove the old chip with a small flat blade screwdriver or chip removal tool.
5. Reverse this process for installation.

Step VII: Quality Control

*At any point that the Calibration is in error you may revert back to the old calibration by pressing **Ctrl+E**.*

1. To insure proper programming and installation of EPROM and Calibration Constants, the gauge should be verified on the ValiDator using the ValiDator Evaluation Form. Once the new constants are entered, place the gauge on the ValiDator and make sure the density readings obtained with the gauge are within the required ranges provided on the laminated ValiDator sheets.
2. An additional method to check the calibration before requesting the EPROM or entering constants is to use the Calculate Density feature to calculate densities using the new calibration.

Additional Features:

Select **G**auge from the pull down menu to access the functions described below.

Pick is used to choose another gauge from your database.

Modify is used to change or update the information for a specific gauge in the database.

New is for entering new gauge data

Density Tables

Allow for the manual calculation of wet density using the gauge count ratio.

$$CR = \frac{\text{Density Measure Count}}{\text{Density Standard Count}}$$

Calculate Density

This functions as the processor of a gauge in calculating a density from a raw count. Calculates the count ratio and uses the calibration counts to calculate the density. Verification of field readings may be accomplished with using the raw counts to check for operator-induced errors, (i.e. source position switch in the wrong position) plug in the standard count and density count and calculate the density. This function requires activation of the appropriate gauge serial number in the Verifier software.

Gauge Management

Management: This option will allow you to manage your gauges more effectively. The software will report the last verification date, the last calibration date and the next leak test date. The data is sorted by the gauge's Next Leak Test date, and highlighted if the date is over six months for leak test and one year for calibration.

Leak Test: The software will allow you to enter the last leak test date for each gauge in the database. The software will keep up with this information and will alert you of the next leak test date (six months) under the *Management* report option. An overdue leak test will be highlighted in red.

Expected Standard Count: This calculation is based on the decay of the CS-137 gamma source. The limit on these standard counts is based on the gauge manufacturer's limit of $\pm 1\%$ of the actual standard count. The software will automatically access the most recent calibration date and standard counts for the calculations. *Note: Gauge counts may change due to many different factors. Radioactive decay is the only variation that could be estimated accurately and does not necessarily correct for all deviations in the gauge.*

Notes: The notes function will allow you to document repairs and items used to identify service trends or any gauge related information.

5. Theory of Operation

Verification Theory

ASTM and AASHTO requirements dictate calibration verification at an interval of 12 months. The ValiDator is a known and stable density reference that can be used for verification of gauge calibration accuracy. The ValiDator device is calibrated by InstroTek, assigning reference densities to each of the measurement depths. Gauge measurements are taken on the ValiDator and the results compared to the documented ValiDator density range, which indicates pass or fail. The ranges are based on a $\pm 1.5\%$ limit about the actual density of the ValiDator. The limits are based on the combined errors in gauges due to precision, composition and surface roughness errors.

If a calibration is needed, the optional Verifier Software may be used to calculate new calibration coefficients derived from the counts taken on the ValiDator device. New calibration parameters are calculated using a fitting routine according to the gauge manufacturer calibration method.

Gauge Calibration Theory

Nuclear density gauges utilize two systems that are used to calculate an in-place density and moisture content of construction materials. The density system generally uses Cesium 137 and detector tubes which output analog signals that are converted to counts by a micro-processor inside the gauge. Moisture systems use a neutron source of Americium-241: beryllium and a detector tube that also generate signals that are converted to counts. The calibration process establishes a relationship between these raw counts and known densities and moisture content references. In the construction density range, the higher the density, the lower the counts. For moisture, the counts increase with increasing moisture content.

Density Calibration

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. CPN, Humboldt and Troxler use an equation such as:

$$CR = A \exp(-BD) - C$$

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 displayed on the screen is calculated by:

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

3-Block Method or 5-Block Method:

Presently there are no authorities that certify nuclear gauge calibration. Therefore, gauge manufacturers and numerous other calibration facilities use a different number of blocks to facilitate the calibration process. The Validation and Calibration process simulate counts to replicate the number of blocks used in the most recent calibration. CPN, InstroTek and Troxler use the Three-block method and Humboldt uses the Five-block method.

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) and a combination block of magnesium and polyethylene (~ 35 lb/ft³, ~560 kg/m³). The gauge standard count, along with the counts on these blocks, is used in a linear equation such as:

$$MCR = E + FM$$

To calculate the parameters E (intercept) and F (slope), MCR is the count ratio, which is the ratio of the measured counts and the daily reference standard count. The daily reference standard count is performed on a high-density polyethylene block provided with each gauge. M is the test material moisture content. The E and F parameters are placed in the gauge memory. They are then used in the field with the count ratio obtained on the test material to calculate the moisture content from the equation.

$$M = \left(\frac{MCR - E}{F}\right)$$

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7. Warranty

InstroTek products are guaranteed against defective material and workmanship for a period of 12 months from the date of receipt by the customer.

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.

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.

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Manufacturer's Recommended Recertification for ValiDator System:

InstroTek, Inc. recommends that the ValiDator be recertified every 5 years in accordance with established US standards, such as the AASHTO T310 specification. Recertification of the ValiDator ensures gauges verified and calibrated using the ValiDator produce the most accurate results.

Since ValiDator is a portable block and has the potential of being moved from one location to another, recertification provides the confidence to the users that the system continues to be reliable and in specification.

Recertification includes checking all components for compliance, performing hardware updates and establishing new density/moisture tables for all nuclear gauge models supported by the ValiDator.

For more information regarding recertification of the ValiDator please contact us at +1 919 875 8371 or email us at sales@instrotek.com





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

email: sales@instrotek.com ✦ visit: InstróTek.com

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