Colorado Procedure – Laboratory 5303-14

Standard Method of Test for

Calibration Check of CDOT Nuclear Moisture/Density Gauges

1. SCOPE

1.1 It is the intent of these procedures to describe the calibration check of a nuclear moisture / density (M/D) gauge to be performed within each CDOT Region. These procedures will apply only to CDOT M/D gauges.

1.2 Since CDOT M/D gauges are calibrated biennially, a calibration check will be performed immediately afterwards by Region Lab personnel. On the year when no calibration is performed, all Regions will run a calibration check.

1.3 The calibration check performed immediately after a calibration is designed to establish values between the gauge and a different set of standards. The calibration check performed on the off year is used as a basis of comparison or to check the validity of the current calibration table and constants.

2. PRE-CALIBRATION CHECK INSPECTION

2.1 Inspect the gauge's U.S. DOT Type "A" carrying case to ensure that all Manufacturer (Troxler, Instrotek, CPN) transportation requirements are met: such as physical integrity and labeling. Clean the carrying case, make any repairs, and replace either of the required two "RADIOACTIVE YELLOW II" labels or the "DOT TYPE "A" RADIOACTIVE" label if necessary.

2.2 Inspect the gauge's reference standard block for any damage. The seating of the gauge on a reference standard block is critical to its repeatability; therefore, any block that allows variable seatings shall be repaired or replaced. If the reference standard block is cracked, split, or delaminating it shall also be replaced because this can affect either the density or moisture counts. Reference standard blocks are not interchangeable; therefore, ensure that it is assigned the same identification number as the gauge.

2.3 Inspect the M/D gauge for damage or non-compliance with required radioactive source labels. If the label on the source rod handle is in any way illegible it shall be replaced. Clean the shell and the base plate of the gauge of any soil or asphalt contamination, being careful to direct the base away from anyone in the immediate area. The On-Site Radiation Safety Officer is the only authorized person in the field to remove the base plate so that proper cleaning and lubrication can be performed. Remove the sliding shield and the shield spring. Clean the old grease and dirt out of the cavity and off all of the parts. Remove the retaining ring and extract the scraper ring from the base plate. Installing a new scraper ring is very important to minimizing moisture and soil contamination within a gauge. The source rod should be extended quickly, to reduce exposure to radiation, and inspected for any damage, as well as to be cleaned. Lubricate the bearings and the sliding shield. Install the sliding shield and spring into the cavity and re-attach the base plate. Extend the source rod through the base plate to verify the proper alignment.

Remove the scaler and inspect both the scaler and the inside of the gauge body. Verify that the electronics are clean, dry, and undamaged. If all electronic connections are solid re-attach the scaler.

2.4 The M/D gauge should be sufficiently charged to allow for four hours of continuous operation. Do not charge the gauge unless it has indicated that it needs a charge. However, if in doubt let the batteries run down and then apply a full 14 hour charge.

2.5 If the Pre-Calibration Inspection has been completed and all necessary repairs have been accomplished the calibration check can begin. If the gauge has been returned from Staff Materials then this inspection has already been performed.

3. APPARATUS

3.1 CDOT calibration check blocks are located at Staff Materials – Nuclear Lab (for Region 1 only).

3.2 Region 2-5, calibration check blocks of:

3.2.1 Moisture Cal-Check Stand,
3.2.2 1/2" Polyethylene Sheet,
3.2.3 3/4" Polyethylene Sheet,
3.2.4 Low-Density Concrete Block,
3.2.5 Medium-Density Concrete Block,
3.2.6 High-Density Concrete Block,

3.3 CDOT Form #1151: NUCLEAR EQUIPMENT STATISTICAL STABILITY / DRIFT TEST.

3.4 CDOT NUCLEAR EQUIPMENT CALIBRATION CHECK WORKSHEET (Regions 2 - 5).

3.5 CDOT NUCLEAR EQUIPMENT MOISTURE/DENSITY ANNUAL CHECK SHEET. (Region 1).

3.6 M/D gauge and reference standard block that have passed the pre-calibration check inspection.

3.7 Operators shall wear a personnel dosimeter, have the gauge binder with all of the required documentation, and a calculator.

4. CALIBRATION CHECK PROCEDURE

4.1 **STATISTICAL STABILITY TEST**

4.1.1 The M/D gauge should be turned on allowing the electronics to warm up for a 30 minute period before proceeding.

4.1.2 For Regions 2 - 5, the reference standard block shall be placed upon the High-Density Transmission block and centered. The long axis of the reference standard block should match that of the cal-check block, with the butt plate end being in the front. There must be at least one meter of clearance on all sides of this block. For Region 1 the reference standard block shall be placed on the Magnesium/Aluminum block.

4.1.3 Place the M/D gauge on the reference standard block. Follow Manufacturer instructions for reference standard block placement. The scaler end is toward the front of the blocks.

4.1.4 Complete the reference information on the NUCLEAR EQUIPMENT STATISTICAL STABILITY TEST, CDOT Form 1151 (page 1 of 2). Write the date, operator, CDOT No., model of gauge, gauge #, and serial #.

4.1.5 Perform the Statistical Stability Test. Most gauges will be prompted to the Stat Mode. In Stat Mode the gauge will run a twenty-minute test and perform the mathematics internally. When the gauge is finished record the average counts, ratio, and each of the twenty, one- minute counts. CPN model gauges will need to be placed into a one-minute time base. Twenty one-minute counts will need to be performed, recording both the density standard count and the moisture standard count. Perform the required mathematics and enter the values on the worksheet.

The ideal ratio for Troxler 3430 and 3440 gauges is 0.25, with acceptable limits of 0.17 to 0.33.

For Troxler 3450 gauges; record the density counts for both systems. The ideal ratio is 0.354 with acceptable limits of 0.225 to 0.465.

For Troxler 4640 gauges; record the density counts for both systems. The ideal ratio is 0.35, with acceptable limits of 0.25 to 0.45

The ideal ratio for CPN gauges is 1.00, with acceptable limits of 0.75 to 1.25.

The acceptable limits on Instrotek 3500 gauges are 0.18 to 0.35.

4.1.6 If the gauge passes the statistical stability test proceed with the calibration check. If the gauge fails the statistical stability test, verify the mathematics. If the mathematics check, perform another statistical stability test. A second failure will require the equipment to be repaired. If a second statistical stability test passes, then proceed with the calibration check.

COLORADO DEPARTMENT OF TRANSPORTATION

NUCLEAR EQUIPMENT STATISTICAL STABILITY/DRIFT TEST

Statistical stability test, (Allow gauge to warm up 30 minutes, perform 20 one minute counts)

Counts N (or X)	Density standard count (M/D or TLD gauge)	Moisture standard count (M/D or AC gauge)
1	3667	640
2	3703	633
3	3697	633
4	3694	638
5	3688	640
6	3664	627
7	3690	644
8	3705	639
9	3692	637
10	3682	627
11	3719	638
12	3699	629
13	3683	640
14	3705	631
15	3695	636
16	3689	635
17	3666	643
18	3701	648
19	3681	635
20	3697	641
Average counts $\bar{N}$ (or $\bar{X}$)	3690.85	636.7
Standard deviation σ (or S)	14.0872	5.5923
Ratio [$S \div (\sqrt{\bar{X}})$]	.232	.222

Ideal ratio .25 / Acceptable limits .17 - .33
(Values found in the calibration procedures)

Date: 11-1-00	Operator: Steve Gonser
CDOT no.: 8198	Model of gauge: Troxler 3430-A
Gauge no.: 43448	Serial no.: 23271

CDOT Form #1151 1/93
page 1 of 2

CDOT Form # 1151

4.2 EQUIPMENT STANDARDIZATION

4.2.1 Center the reference standard block on the High-Density Concrete block. The long axis of the reference standard block should match that of the block, with the butt plate being in the front.

4.2.2 Place the M/D gauge on the reference standard block according to the manufacturer's instructions. Perform a standard count according to the manufacturer's instructions.

4.3 MOISTURE CALIBRATION CHECK

[REGIONS 2 - 5]

4.3.1 Complete the reference information on the CDOT NUCLEAR EQUIPMENT CALIBRATION CHECK WORKSHEET. This information is the same as the information provided on CDOT Form 1151.

4.3.2 Set up the moisture cal-check stand in an area with a meter of clearance on all sides. Set the 1/2" Polyethylene sheet within the stand. The sheet should be marked, such as FR for front-right, because repeatability can only be attained through minimizing variables.

4.3.3 Place the gauge on the 1/2" Polyethylene sheet within the outline. Place the gauge in the backscatter position and record four one-minute moisture content readings [Note 1]. Average the four readings and record the average

Note 1: Gauges may report moisture contents as percent moisture. Prompt the gauge to report moisture content in pounds per cubic foot of water.

4.3.4 Place the 3/4" Polyethylene sheet beneath the 1/2" sheet within the stand. The sheet should also be marked to ensure consistency.

4.3.5 Place the gauge on the 3/4" Polyethylene sheet within the outline. Place the gauge in the backscatter position and record four one-minute moisture content readings [Note 1]. Average the four readings and record the average

[REGION 1]

4.3.6 Follow Subsections 4.3.1 through 4.3.3 of Colorado Procedure L 5306.

4.4 BACKSCATTER CALIBRATION CHECK [REGIONS 2 - 5]

4.4.1 Place the gauge on the Low-Density Concrete Block and place the source rod in the backscatter position. CDOT defines the backscatter positions as the positioning in which the tip of the source rod attains near contact with the block surface. Perform and record four one-minute **wet** density readings [Note 2]. Average the four readings and record the average.

Note 2: Gauges may report both wet density and dry density. It is important to record the wet density because the reading will be compared to the wet density of the calibration blocks. Some gauges have automatic depth sensors, for those that don't make sure to prompt the gauge to the correct depth.

4.4.2 Place the gauge on the Medium-Density Concrete Block and place the source rod in the backscatter position. Perform and record four one-minute **wet** density readings. Average the four readings and record the average. Repeat this step for the High-Density Concrete Block.

[REGION 1]

4.4.3 Follow Subsections 4.4.1 through 4.4.2 of Colorado Procedure L 5306. The only deviation to CP-L 5306 will be not utilizing the Limestone and the Granite blocks.

4.5 TRANSMISSION CALIBRATION CHECKS [REGIONS 2 - 5]

4.5.1 Place the gauge on the Low-Density Concrete Block and extend the source rod no more than two inches until it has been inserted into the rod hole.

4.5.2 Extend the source rod to the 4" depth. Pull the gauge forward to eliminate any air gap between the block and source rod. Perform and record four one-minute **wet** density readings [Note 3]. Average the four readings and record the average.

4.5.3 Extend the source rod to 6". Pull the gauge forward to eliminate any air gap between the block and source rod and perform and record four one-minute **wet** density readings [Note 3]. Average the four readings and record the average.

4.5.4 Extend the source rod to 8". Pull the gauge forward to eliminate any air gap between the block and source rod and perform and record four one-minute **wet** density readings [Note 3]. Average the four readings and record the average.

Note 3: Gauges may report both wet density and dry density. It is important to record the wet density because the reading will be compared to the wet density of the calibration blocks. Some gauges have automatic depth sensors, for those that don't make sure to prompt the gauge to the correct depth.

4.5.5 Repeat procedures 4.5.2 through 4.5.4 on the Medium-Density and High-Density Blocks.

[REGION 1]

4.5.6 Follow Subsections 4.5.1 through 4.5.5 of Colorado Procedure L 5306. The only deviation to CP-L 5306 will be not utilizing the Limestone and the Granite blocks.

COLORADO DEPARTMENT OF TRANSPORTATION
NUCLEAR EQUIPMENT CALIBRATION CHECK WORKSHEET

CDOT Equipment No.	Serial No.	Gauge No. (consultant)	Type of Gauge (Model)
8257	34551	33448	3430

Moisture Standard Count	Density Standard Count	Circle One
703	2960	Post Calibration Check / One Year Check

Moisture Block 1/2" Readings (Wet PCF)	
1 min.	4.2
1 min.	4.2
1 min.	4.1
1 min.	4.1
Average	4.2

Moisture Block 1/2" & 3/4" Readings (Wet PCF)	
1 min.	27.1
1 min.	27.5
1 min.	27.6
1 min.	27.1
Average	27.3

Check Date: 1/25/2006

Operator: [illegible]

	L Block Readings	M Block Readings	H Block Readings
	0 Inches	0 Inches	0 Inches
1 min.	104.5	134.6	150.8
1 min.	105.0	134.8	150.3
1 min.	104.5	136.0	150.9
1 min.	104.6	136.3	150.5
Average	104.7	134.9	150.6
Error			
	4 Inches	4 Inches	4 Inches
1 min.	103.6	129.9	147.5
1 min.	103.6	129.9	147.4
1 min.	103.8	130.2	147.7
1 min.	103.6	130.2	147.9
Average	103.7	130.1	147.6
Error			
	6 Inches	6 Inches	6 Inches
1 min.	103.1	128.3	147.1
1 min.	103.1	128.3	147.0
1 min.	103.1	128.6	146.7
1 min.	103.2	128.3	147.3
Average	103.1	128.4	147.0
Error			
	8 Inches	8 Inches	8 Inches
1 min.	103.5	127.4	146.5
1 min.	103.5	127.5	146.4
1 min.	103.4	127.5	146.2
1 min.	103.5	127.1	146.2
Average	103.5	127.4	146.3
Error			

4.6 DRIFT TEST

4.6.1 The M/D gauge should be on and active a minimum of 3 hours after the completion of the Statistical Stability Test. If a calibration check has been performed, a minimum of three hours has passed, with the gauge extremely active.

4.6.2 The reference standard block shall be placed upon the High-Density Block and centered. Establish the same placement that existed during the stat test. For Regions 1and 6 the reference standard block shall be placed on the Magnesium/Aluminum block..

4.6.3 NUCLEAR EQUIPMENT DRIFT TEST, CDOT Form #1151 (page 2 of 2), will be used to record the respective counts.

4.6.4 Perform the Drift Test. Most gauges can be prompted to the Drift Mode. In Drift Mode the gauge will run a twenty-minute test and perform the mathematics internally. When the gauge is finished record the average counts, drift, and each of the five four-minute counts. CPN model gauges will need to be placed into a four-minute time base. Five four-minute counts will need to be performed, recording both the density standard count and the moisture standard count.

The acceptable drift for Instrotek 3500 and Troxler 3430, 3440 and 3450 gauges is less than 0.50% for density and less than 1.00% for moisture.

For Troxler 4640 gauges; record the density counts for both systems. The acceptable drift for System 1 is less than 0.50%, and for System 2 is less than 0.80%.

On CPN gauges the Drift Average Counts (DAC) are either acceptable or unacceptable based on the Statistical Stability Average Counts (SSAC). The DAC acceptable range is:

$$SSAC +/- 2.0 \sqrt{SSAC}$$

4.6.5 If the M/D gauge passes the drift test, then proceed to Subsection 4.7. If the gauge fails the drift test, verify the mathematics. If the failure is valid perform another drift test, whereby a second failure will require the equipment to be repaired.

4.7 ANALYSIS OF CALIBRATION CHECK

4.7.1 If this calibration check has been performed after a Calibration at Staff Materials, check your PCF of water and PCF of each of the three density blocks against the established ranges of other gauges. If the gauge falls outside of the range, contact Staff Materials-Nuclear Lab.

4.7.2 If this calibration check has been performed on an "off" year, the values need to be compared against the previous year's calibration check. The moisture content and wet density readings will be compared to the block's moisture contents and densities that were established after the Calibration. The acceptable deviance from the moisture content is less than or equal to 1.0 PCF. The acceptable deviance from the known wet density in the backscatter position is less than or equal to 2.0 PCF. The acceptable deviance from the known wet density in the transmission positions is less than or equal to 1.0 PCF.

4.7.3 If the gauges readings are outside the acceptable deviances on a block, rerun that block and compare the readings to the known wet density or moisture content. If after the second readings, the gauge is outside the acceptable deviance, the gauge will have to be calibrated.

COLORADO DEPARTMENT OF TRANSPORTATION

NUCLEAR EQUIPMENT STATISTICAL STABILITY/DRIFT TEST

DRIFT TEST (Gauge must be on and active a minimum of 3 hours after the completion of the Statistical Stability Test, perform 5 four minute counts)

Counts N (or X)	Density standard count (M/D or TLD gauge)	Moisture standard count (M/D or AC gauge)
1	3681	636
2	3684	637
3	3679	635
4	3693	634
5	3686	638
Average counts $\bar{N}$ (or $\bar{X}$)	3684.6	636.0

[Total average = the sum of the Statistical Stability average count and the Drift Test average count, divided by 2]

Density total average = (3690.85 + 3684.6) ÷ 2 = 3687.725

Moisture total average = (636.7 + 636.0) ÷ 2 = 636.35

[Difference = the value between the Statistical Stability average count and the Drift Test average count]

Density difference = 3690.85 - 3684.6 = 6.25

Moisture difference = 636.7 - 636.0 = 0.7

[Drift = $\frac{\text{Difference}}{\text{Total average}}$ X 100 = _____ %]

Density drift = 6.25/3687.725 X 100 = 0.169 %

Moisture drift = 0.7/636.35 X 100 = 0.110 %

CDOT Form #1151 1/93
page 2 of 2

CDOT Form 1151

COLORADO DEPARTMENT OF TRANSPORTATION

Nuclear Equipment Moisture/Density Annual Check Sheet for Region 1 CPL 5303

CDOT Equipment No.	Serial No.	Gauge No.	Type of Gauge (Model)
Moisture Reference Standard Count	Density Reference Standard Count		

MOISTURE MAGNESIUM

Block 1 PCF

	Initial Check	Annual Check	Diff
1 min.			
1 min.			
1 min.			
1 min.			
AVE			

MOISTURE MAGNESIUM/POLY

Block 2 PCF

	Initial Check	Annual Check	Diff
1 min.			
1 min.			
1 min.			
1 min.			
AVE			

Calibration Date

Operator

	DENSITY MAGNESIUM				DENSITY MAGNESIUM/ALUMINUM				DENSITY ALUMINUM		
	Backscatter WD				**Backscatter WD**				**Backscatter WD**		
	Initial Check	Annual Check	Diff		Initial Check	Annual Check	Diff		Initial Check	Annual Check	Diff
1 min.				1 min.				1 min.			
1 min.				1 min.				1 min.			
1 min.				1 min.				1 min.			
1 min.				1 min.				1 min.			
AVE				AVE				AVE			
	4 Inches WD				**4 Inches WD**				**4 Inches WD**		
	Initial Check	Annual Check	Diff		Initial Check	Annual Check	Diff		Initial Check	Annual Check	Diff
1 min.				1 min.				1 min.			
1 min.				1 min.				1 min.			
1 min.				1 min.				1 min.			
1 min.				1 min.				1 min.			
AVE				AVE				AVE			
	6 Inches WD				**6 Inches WD**				**6 Inches WD**		
	Initial Check	Annual Check	Diff		Initial Check	Annual Check	Diff		Initial Check	Annual Check	Diff
1 min.				1 min.				1 min.			
1 min.				1 min.				1 min.			
1 min.				1 min.				1 min.			
1 min.				1 min.				1 min.			
AVE				AVE				AVE			
	8 Inches WD				**8 Inches WD**				**8 Inches WD**		
	Initial Check	Annual Check	Diff		Initial Check	Annual Check	Diff		Initial Check	Annual Check	Diff
1 min.				1 min.				1 min.			
1 min.				1 min.				1 min.			
1 min.				1 min.				1 min.			
1 min.				1 min.				1 min.			
AVE				AVE				AVE			

Revised 7/01/2014

CDOT NUCLEAR EQUIPMENT CALIBRATION CHECK WORKSHEET for REGION 1

{Page Intentionally Left Blank}