

ODOT TM 304
Method of Test for

**NUCLEAR DENSITY/MOISTURE GAUGE CALIBRATION
AND AFFECT OF HOT SUBSTRATE**

1. SCOPE

Determination of the accuracy and/ or to calibrate a Nuclear Density/Moisture Gauge and determine the effect of high temperatures, such as that found in Asphalt Concrete Pavements, on the proper functioning of the Nuclear Gauge.

Significance and Use

A Nuclear Density/Moisture Gauge calibration check and Hot Substrate Test shall be performed every 12 months or any time the calibration of the gauge is in question.

If a Nuclear Density/Moisture Gauge's accuracy is questioned in the field, a check may be performed per Appendix C of the MFTP. During this check process, Sections 3.A and 3.C maybe modified as deemed necessary by the Region QAC. This is to insure timely results of the Gauge's accuracy. If this check uses modifications and the gauge does not meet the requirements in Section 5, the gauge will require a calibration check per the test procedure without modification.

2. APPARATUS

- A.** A Nuclear Gauge capable of making moisture and density determinations. The Gauge shall be so constructed to be licensable in accordance with applicable health and safety standards, established by the Department of Human Services. A copy of the owner's Radioactive Materials License, Current Validation Certificate and a copy of the most current leak test results will accompany the Nuclear Gauge. The Nuclear Gauge shall be in good operating condition or it shall be returned for repairs.
- B.** A carrying /transport case.
- C.** Instruction manual, supplied by the gauge manufacturer, describing the operating procedures for the model of gauge being used.

- D. A reference standard block for obtaining standard counts and checking gauge operation.
- E. Logbook for recording daily counts obtained on the reference block.
- F. Calibration tables, as required, for determining the moisture content and the density from calculated count ratios.
- G. Calibration blocks of approximate densities 1717kg/m^3 (107.2 PCF), 2140kg/m^3 (133.6 PCF), and 2631kg/m^3 (164.3 PCF) large enough to represent an infinite below surface volume to the gauge.
- H. A High Moisture Calibration Block. Made of suitable material, which will produce a moisture reading of 839kg/m^3 (52.4PCF)?
- I. Surface temperature measuring device, capable of a range from -10°C to 150°C (0° to 300°F) readable to 2°C (5°F).
- J. Hot plate device consisting of an aluminum block, of adequate size, that fits on an electric hot plate mounted on a dolly. The electric hot plate requires a 120 volt, 60 hertz power source.
Note: ODOT uses an aluminum block 41cm (16in) x 46cm (18in) x 16cm (6.3in).

3. Nuclear Density Gauge Preparation

- A. The Gauge may need to be placed in a temperature controlled area for no less than 4 hours, to assure component parts are at a room temperature of 16°C (60°F) to 24°C (75°F).
- B. Turn the gauge on and allow it to warm up for a minimum of 10 minutes.
- C. Place the Standard count block in the center of the middle calibration block. With the standard count block in this position, perform five standard counts in accordance with the manufacturer's guidelines. Record the standard counts on the Nuclear Density Gauge Calibration Check Sheet and, check that the variances between counts are within the manufacturer's guidelines. If the variances between counts are within the manufacturer's guidelines go to section 3. E.

D. If, the variances between counts are **not** within the manufacturer's guidelines.

1. Continue performing standard counts in accordance with the manufacturer's guidelines. Record and check each standard count for compliance with manufacturer's guidelines. No more than two additional standard counts should be performed.
2. If the manufacturer's guidelines are met, go to section 3.E.
3. If the manufacturer's guidelines **not** are met within two additional standard counts or the additional standard counts continue to show variances outside the manufacturer's guidelines, contact the gauge owner, inform them of the problem and arrange for the return of the gauge.

E. Set the gauge to take one-minute counts.

4. Nuclear Density Gauge Hot Substrate Test

- A. Plug in or turn on the heating device for the aluminum block. Heat the block to $85^{\circ}\text{C} \pm 2^{\circ}\text{C}$ or $185^{\circ}\text{F} \pm 4^{\circ}\text{F}$ and check the temperature by using a surface thermometer. (*Heating of the block usually takes 4 to 6 hours.*)
- B. With the gauge at room temperature of 16°C (60°F) to 24°C (75°F) and the block at 85°C (185°F). Place the gauge on the block, immediately move the source into the backscatter position and start a one-minute count.
- C. Record the first wet density in the "Initial Test" column of the Hot Substrate Test portion of the Nuclear Density Gauge Calibration Check Sheet and immediately start a second one-minute count. Continue taking one-minute counts and recording wet densities until there are a total of four.
- D. Leave the gauge on the block for 10 minutes.
- E. At the conclusion of the 10-minute waiting period, immediately start a one-minute count. Record the wet density in the "Final Test" column of the Hot Substrate Test portion of the Nuclear Calibration Check Sheet and immediately start a second one-minute count. Continue taking one-minute counts and recording wet densities until there is a total of four. Remove the gauge from the block to cool.

- F. If, at anytime during the test, the gauge display fogs or becomes unreadable due to moisture, the gauge fails this test. Input no data on the Nuclear Density Gauge Calibration Check Sheet and put an explanation of why the gauge failed in the "Remarks" section, then sign and date the sheet. Contact the gauge owner and arrange for it's return. A copy of the Nuclear Density Gauge Calibration Check Sheet shall be made available to the gauge owner.
- G. Average the "Initial test" column and average the "Final test" column. Compare the Initial test average to the Final test average. If the averaged densities are within 16 kg/m^3 (1.0 lbs/ft^3) the gauge passes this test. If the averaged densities are not within 16 kg/m^3 (1.0 lbs/ft^3) the gauge fails.
- H. If the results "Pass", indicate the result on the Nuclear Density Gauge Calibration Check Sheet under "Hot Substrate Results". Allow the gauge to cool to room temperature and then proceed with the calibration check.
- I. If the results "Fail", indicate the result on the Nuclear Density Gauge Calibration Check Sheet under "Hot Substrate Results", then sign and date it. If an O.D.O.T. Quality Assurance Program Inspection Tag is currently on the gage, remove it from the gage and place it with Nuclear Density Gauge Calibration Check Sheet in your records. Inform the owner of the failure and arrange for the return of the gauge. A copy of the Nuclear Density Gauge Calibration Check Sheet shall be made available to the gauge owner.

5. NUCLEAR DENSITY/MOISTURE GAUGE ANNUAL CHECK OF ACCURCY FOR GAUGES WITH INTERNAL COMPUTERS

- A. The calibration blocks shall be located in accordance with the manufacturer's recommendations, and no other unshielded Nuclear gauge shall be within 15 meters (50 feet) during annual check of accuracy or calibration. An example of a the Nuclear Density Gauge Calibration Check sheet is enclosed with this procedure
- B. Block Values used by ODOT.

	Back Scatter	Direct Transmission
Low Density	1735 kg/m^3 (108.3 PCF)	1717 kg/m^3 (107.2PCF)
Medium Density	2161 kg/m^3 (134.9PCF)	2140 kg/m^3 (133.6PCF)
High Density	2657 kg/m^3 (165.9PCF)	2632 kg/m^3 (164.3PCF)

- C. With the gauge at room temperature 16°C (60°F) to 24°C (75°F). Locate the gauge on the Low-Density block so the edge of the gauge closes to the probe is 2.5cm (1inch) from the edge of the transmission hole and the gauge is in the center of the block. The gauge shall not be placed on the block in such a manner so that it covers the transmission hole during backscatter reading. Move the handle into the backscatter position. Perform two one-minute counts and record the wet density results.
- D. Repeat this process on the Medium and High Density blocks.
- E. Locate the source rod in the 50 mm(two inch) direct transmission position and seat in the transmission hole of the Low density block. Perform two one-minute counts and record the wet densities.
- F. Repeat the counting and recording procedures for all depth increments to the maximum depth on the Low, Medium, and High Density Blocks.
- G. Average each individual depth's results and compare the averaged result with the respective block densities listed above. If this is an annual check then the averaged results must be within $\pm 16\text{kg/m}^3$ (1.0 lbs/ft^3) on the low and Medium Density blocks and $\pm 24\text{kg/m}^3$ (1.5 lbs/ft^3) on the High Density Block of the values given in section 5B or the gauge fails and must be recalibrated, go to section 7. If this is a check of a gauge recalibrated in accordance with section 7 of this procedure then the results are all to be within the within $\pm 16\text{kg/m}^3$ (1.0 lbs/ft^3) of the values given in section 5B. If the above parameters are met, continue to 5H. If the above parameters are **not** met the gauge must be recalibrated in accordance with section 7.
- H. Place the gauge on the Low Density Block so as not to be influenced by the transmission hole. Move the handle into the backscatter position. Perform one four-minute count and record the moisture density. The moisture density must be within $\pm 8\text{ kg/m}^3$ (0.5 lbs/ft^3) of 0 kg/m^3 (0.0 lbs/ft^3), if it is not the gauge must be recalibrated according to section 7.
- I. Place the High Moisture Block on the High Density Block. Place the gauge on the High Moisture Block. Move the handle into the backscatter position. Perform one four-minute count and record the moisture density. The moisture density must be within $\pm 16\text{ kg/m}^3$ (1.0 lbs/ft^3) of 839 kg/m^3 (52.4 lbs/ft^3), if it is not the gauge must be recalibrated according to section 7.

6. NUCLEAR DENSITY/MOISTURE GAUGE CALIBRATION AND CHECK FOR GAUGES THAT DO NOT HAVE INTERNAL CALIBRATION CAPABILITY.

The use of this type of gauge is rare, Contact ODOT for the appropriate procedure if required.

7. NUCLEAR DENSITY/MOISTURE GAUGE CALIBRATION PROCEDURE.

- A.** Gauges must have a new calibration performed if any of the parameters in section 5 are not met. An example of a recording sheet is enclosed with this procedure.
- B.** With the gauge at room temperature 16⁰C (60⁰F) to 24⁰C (75⁰F). Locate the gauge on the Low-Density block so as not to be influenced by the transmission hole. Move the handle into the backscatter position. Set the gauge to take four-minute counts and if applicable set to read in counts. Perform two four-minute counts and record the Density counts.
- C.** Repeat this process on the Medium and High Density blocks. Average the two counts for each individual block.
- D.** Locate the source rod in the 50 mm(two inch) direct transmission position on the Low density block and seat in the transmission hole. Perform one four-minute count and record the depth and Density count for that depth.
- E.** Repeat the counting and recording procedures for all depth increments to the gauge's maximum depth on all three blocks.
- F.** Input the data into NCAL or other calibration program in accordance with the programmer's guidelines.
 - 1. Note - must use the averaged backscatter counts that have been rounded to the nearest whole number when entering into NCAL.
 - 2. Note - when counts are too large to enter into NCAL, all counts, including standard counts must be divided by ten.
- G.** Print out the new constants.
- H.** Before the new constants are entered into the gauge, record the constants currently being used by the gauge.

- I. Input the new constants in the gauge in accordance with the manufacturer's recommendations.
 - J. With the new constants in the gauge, the gauge must be checked for accuracy. Perform the accuracy check in accordance with section 5.
 - K. For gauges calibrated by ODOT:
 - 1) Upon successful completion of the accuracy check, record in a log the manufacturer and model of the gauge, the serial number, and the owner of the gauge.
 - 2) Complete the Nuclear Density Gauge Calibration Check Sheet. Make a copy of the Check Sheet, which is to be kept with the gauge.
 - 3) Contact the owner and arrange for the return of the gauge.
- 8. Gauges calibrated by others:**
- A. All gages must be verified by ODOT in accordance with section 5.
 - B. Upon successful verification by ODOT, record in a log the manufacturer and model of the gauge, the serial number, and the owner of the gauge.
 - C. A copy of the calibration and ODOT verification is to be kept with the gauge.
 - D. Arrange for the return of the gauge.

9. Report

Each work sheet shall include:

- Manufacturer and model number of gauge
- Serial number of gauge
- Gauge owner
- Date of calibration check
- Name of technician performing calibration check
- Block densities to the nearest 1 Kg/m^3 or 0.1 lbs/ft^3
- Moisture Block densities to the nearest 0.1 Kg/m^3 or 0.1 lbs/ft^3
- Gauge, wet density readings to the nearest 1 Kg/m^3 or 0.1 lbs/ft^3
- Moisture reading check to the nearest 0.1 Kg/m^3 or 0.1 lbs/ft^3
- Signature of technician performing calibration check

10. File

A file should be generated (electronic or paper) for each gauge checked. This file should at a minimum contain the following information:

- Initial check documentation report
Worksheet from Section 9
- If calibration was performed:
Initial check documentation report
Generated Constants
Check documentation report Worksheet from Section 9

The work sheets included with this test method are available in an Excel format. Contact the closest Quality Assurance Coordinator to your location.



Nuclear Density Gauge Calibration Check ODOT TM304

MAKE: _____ MODEL: _____ DATE: _____
SERIAL NO: _____ GAUGE OWNER: _____

Standard Block has been verified: to have the same SN as the gauge being checked and that it is not cracked, split, delaminated or otherwise damaged.

	1st	2nd	3rd	4th	Average	5th	% Diff
DENSITY STANDARD:							
MOISTURE STANDARD:							

HOT SUBSTRATE TEST @ 185° F ± 4° F

BS Four one- minute counts	INITIAL TEST	Lb/cu.Ft	Wait Ten Minutes	FINAL TEST	Lb/cu.Ft
	1			1	
	2			2	
	3			3	
	4			4	
	AVE			AVE	

RESULTS:

CALIBRATION CHECK

Probe Depth	BS	2	4	6	8	10	12
	108.3	107.2					
LOW BLOCK READINGS							
Average Readings							

	134.9	133.6					
MEDIUM BLOCK READINGS							
Average Readings							

	165.9	164.3					
HIGH BLOCK READINGS							
Average Readings							

LO BLOCK MOIST	0.0 Lb
FOUR-MINUTE COUNT	H2O (Lb)

RESULTS:

HI BLOCK MOIST	52.4 Lb
FOUR-MINUTE COUNT	H2O (Lb)

RESULTS:

New Calibration by ODOT?

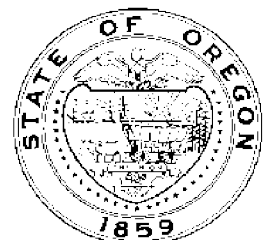
YES ☐

NO ☐

NOTES:

SIGNATURE: _____

DATE: _____





Nuclear Density Gauge Calibration Check ODOT TM304

MAKE: Troxler MODEL: 3430 DATE: 10/14/2010
SERIAL NO: 12345 GAUGE OWNER: Nuke Gauge Testers inc

Standard Block has been verified: to have the same SN as the gauge being checked and that it is not cracked, split, delaminated or otherwise damaged.

	1st	2nd	3rd	4th	Average	5th	% Diff
DENSITY STANDARD:	3000.0	3050.0	3050.0	3000.0	3025.0	3055.0	1.0
MOISTURE STANDARD:	430.0	430.0	420.0	420.0	425.0	420.0	-1.2

HOT SUBSTRATE TEST @ 185° F ± 4° F

BS	INITIAL TEST		Wait Ten Minutes	FINAL TEST	
		Lb/cu.Ft			Lb/cu.Ft
Four one-minute counts	1	165.5		1	165.5
	2	165.5		2	165.5
	3	165.5		3	165.5
	4	165.5		4	165.5
	AVE	165.5		AVE	165.5

RESULTS:
PASS

CALIBRATION CHECK

Probe Depth	BS	2	4	6	8	10	12
	108.3	107.2					
LOW BLOCK READINGS	108.3	107.2	107.2	107.2	107.2	107.2	107.2
	108.3	107.2	107.2	107.2	107.2	107.2	107.2
Average Readings	108.3	107.2	107.2	107.2	107.2	107.2	107.2
	PASS	PASS	PASS	PASS	PASS	PASS	PASS

	134.9	133.6					
MEDIUM BLOCK READINGS	134.9	133.6	133.6	133.6	133.6	133.6	133.6
	134.9	133.6	133.6	133.6	133.6	133.6	133.6
Average Readings	134.9	133.6	133.6	133.6	133.6	133.6	133.6
	PASS	PASS	PASS	PASS	PASS	PASS	PASS

	165.9	164.3					
HIGH BLOCK READINGS	165.9	164.3	164.3	164.3	164.3	164.3	164.3
	165.9	164.3	164.3	164.3	164.3	164.3	164.3
Average Readings	165.9	164.3	164.3	164.3	164.3	164.3	164.3
	PASS	PASS	PASS	PASS	PASS	PASS	PASS

LO BLOCK MOIST	0.0 Lb
FOUR-MINUTE COUNT	H2O (Lb)
	0.0

RESULTS: **PASS**

HI BLOCK MOIST	52.4 Lb
FOUR-MINUTE COUNT	H2O (Lb)
	52.4

RESULTS: **PASS**

New Calibration by ODOT?

YES

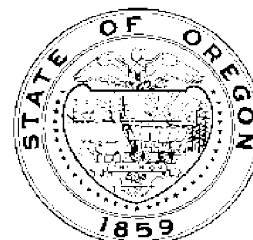
X

NO

NOTES:

SIGNATURE: _____

DATE: 10/14/2010



OREGON DEPARTMENT OF TRANSPORTATION
CALIBRATION DATA SHEET

10/31/2007
PAGE 5

MAKE: _____ CALIB. DATE: _____

MODEL: _____ TECHNICIAN: _____

SERIAL NUMBER: _____

OWNER OF GAUGE: _____

DENSITY STANDARD: _____

MOISTURE STANDARD: _____

		Count	Kg/m3	Count	Kg/m3	Count	Kg/m3
BLOCK WT.			1734		2161		2658
BS 4 Min	1						
	2						
	A						

BLOCK WT.			1717		2140		2632
50	4Min						
100	4Min						
150	4Min						
200	4Min						
250	4Min						
300	4Min						

LO BLOCK MOISTURE
FOUR-MINUTE
COUNT: _____

HI BLOCK MOISTURE
FOUR-MINUTE
COUNT: _____

☐ **CAL. CHANGE** RECALIBRATE GAUGE DATA

SIGNATURE \ DATE: _____

Recalibrate

MAKE: CALIB. DATE:

MODEL: TECHNICIAN:

SERIAL NUMBER:

OWNER OF GAUGE:

DENSITY STANDARD: 2829

MOISTURE STANDARD: 689

		Count	Kg/m3	Count	Kg/m3	Count	Kg/m3
BLOCK WT.		1734		2161		2658	
BS 4 Min	1	8721		6547		4847	
	2	8670		6545		4817	
	A	8696		6546		4832	

BLOCK WT.		1717		2140		2632	
50	4Min	52609		35916		23503	
100	4Min	46386		29489		17719	
150	4Min	32499		19261		10657	
200	4Min	20580		11205		5933	
250	4Min						
300	4Min						

LO BLOCK MOISTURE

FOUR-MINUTE
COUNT: 744.0

HI BLOCK MOISTURE

FOUR-MINUTE
COUNT: 12601.0

☒ CAL. CHANGE RECALIBRATE GAUGE DATA

SIGNATURE \ DATE: _____

Recalibrate



Nuclear Density Gauge Calibration Check ODOT TM304

MAKE:

MODEL:

DATE:

SERIAL NO:

GAUGE OWNER:

HOT SUBSTRATE TEST @ 185 F + or - 4 F

BS	INITIAL TEST		Wait Ten Minutes	FINAL TEST	
		Lb/cu.Ft			Lb/cu.Ft
Four one- minute counts	1			1	
	2			2	
	3			3	
	4			4	
	AVE			AVE	

RESULTS:

DENSITY STANDARD:					
MOISTURE STANDARD:					

CALIBRATION CHECK

Probe Depth	BS	2	4	6	8	10	12
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LOW BLOCK READINGS	108.3	107.2					
Average Readings							

MEDIUM BLOCK READINGS	134.9	133.6					
Average Readings							

HIGH BLOCK READINGS	165.9	164.3					
Average Readings							

LO BLOCK MOIST	0.0 Lb
FOUR-MINUTE COUNT	H2O (Lb)

RESULTS:

HI BLOCK MOIST	52.4 Lb
FOUR-MINUTE COUNT	H2O (Lb)

RESULTS:

New Calibration by ODOT?

YES

☐

NO

☐

NOTES:



SIGNATURE: _____

DATE: _____



Nuclear Density Gauge Calibration Check ODOT TM304

MAKE:

MODEL:

DATE:

SERIAL NO:

GAUGE OWNER:

HOT SUBSTRATE TEST @ 185 F + or - 4 F

BS	INITIAL TEST		Wait Ten Minutes	FINAL TEST	
		Lb/cu.Ft			Lb/cu.Ft
Four one- minute counts	1	165.4		1	166.9
	2	165.3		2	165.8
	3	166.7		3	165.9
	4	168.8		4	165.9
	AVE	166.6		AVE	166.1

RESULTS:

PASS

DENSITY STANDARD:	2826.0	2831.0	2820.0	2829.0	2829.0
MOISTURE STANDARD:	693	682.0	685.0	690.0	689.0

CALIBRATION CHECK

Probe Depth	BS	2	4	6	8	10	12
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LOW BLOCK READINGS	108.3	107.2					
	108.9	107.6	107.8	107.4	107.0	107.1	107.0
	109.2	107.7	106.8	107.3	107.1	108.0	107.3
	Average Readings	109.1	107.7	107.3	107.4	107.1	107.6
	PASS	PASS	PASS	PASS	PASS	PASS	PASS

MEDIUM BLOCK READINGS	134.9	133.6					
	134.5	132.8	132.8	133.3	134.1	133.5	133.7
	134.4	133.3	132.9	133.1	134.0	133.9	133.8
	Average Readings	134.5	133.1	132.9	133.2	134.1	133.7
	PASS	PASS	PASS	PASS	PASS	PASS	PASS

HIGH BLOCK READINGS	165.9	164.3					
	165.1	165.1	164.7	164.4	165.0	164.4	165.8
	165.0	164.1	164.4	164.7	165.1	165.5	165.7
	Average Readings	165.1	164.6	164.6	164.6	165.1	165.8
	PASS	PASS	PASS	PASS	PASS	PASS	FAIL

LO BLOCK MOIST	0.0 Lb
FOUR-MINUTE COUNT	H2O (Lb)
	0.3

RESULTS: **PASS**

HI BLOCK MOIST	52.4 Lb
FOUR-MINUTE COUNT	H2O (Lb)
	51.4

RESULTS: **PASS**

New Calibration by ODOT?

YES

X

NO

NOTES:



SIGNATURE: _____

DATE: _____

MAKE:

CALIB. DATE:

MODEL:

TECHNICIAN:

SERIAL NUMBER:

OWNER OF GAUGE:

DENSITY STANDARD:

MOISTURE STANDARD:

		Count	Lb/Ft3	Count	Lb/Ft3	Count	Lb/Ft3
BLOCK WT.			108.3		134.9		165.9
BS 4 Min	1						
	2						
	A						

BLOCK WT.			107.2		133.6		164.3
2	4Min						
4	4Min						
6	4Min						
8	4Min						
10	4Min						
12	4Min						

LO BLOCK MOISTURE

FOUR-MINUTE
COUNT:

HI BLOCK MOISTURE

FOUR-MINUTE
COUNT:

☐ CAL. CHANGE

Calibration Data

SIGNATURE \ DATE: _____

Recalibrate

MAKE:

CALIB. DATE:

MODEL:

TECHNICIAN:

SERIAL NUMBER:

OWNER OF GAUGE:

DENSITY STANDARD:	2829
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MOISTURE STANDARD:	689
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Count			Lb/Ft3	Count	Lb/Ft3	Count	Lb/Ft3
BLOCK WT.			108.3	134.9			165.9
BS 4 Min	1	8721		6547		4847	
	2	8670		6545		4817	
	A	8696		6546		4832	

BLOCK WT.			107.2	133.6			164.3
2	4Min	52609		35916		23503	
4	4Min	46386		29489		17719	
6	4Min	32499		19261		10657	
8	4Min	20580		11205		5933	
10	4Min						
12	4Min						

LO BLOCK MOISTURE

FOUR-MINUTE COUNT:	744.0
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HI BLOCK MOISTURE

FOUR-MINUTE COUNT:	12601.0
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X	CAL. CHANGE	Calibration Data
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SIGNATURE \ DATE: _____

Recalibrate