Calibration Results

Oak Ridge National Laboratory

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UT-BATTELLE
Management Contractor for DOE's Oak Ridge National Laboratory

Unit Under Test Information		Customer Information	Test Information	
Description:	HONEYWELL CUSTOM TEMPERATURE/HUMIDITY PROBES	William A. Miller Badge 022400 Mail Stop 6070 Bldg. 3147 Rm. 0222 Phone 865-574-2013	Result:	**PASS**
Serial Number:	N/A		Performed on:	12/17/2009
Asset / ID Number:	NC00031		Next Cal Due:	12/17/2010
Custodian:	MILLER W A		Performed by:	U032763
Work Order Number:	MC857299		Environment:	23.0°C 50 %RH
Notes:			Condition F/L:	FOUND-LEFT
			Procedure used:	Customer Information
			Revision:	

Asset No.

Work Order No.

ORNL Metrology Laboratory (ORNL ML) certifies that the above listed instrument meets or exceeds all specifications as stated in the referenced procedure unless otherwise noted. This Report of Calibration applies only to the item being calibrated, identified above. This report contains data that are not covered by the NVLAP Scope of Accreditation.

This calibration report documents the traceability to national standards, which realize the units of measurement according to the International System of Units (SI). Calibration data and conformity assessment (Pass/Fail decision) is limited to the performance of the instrument at the time of test. The "Next Cal Due" date is based on manufacturer's recommendations or best calibration practices and with customer agreement (in the case of external ORNL customers); the instrument should not be used past this date without recalibration. This report shall not be reproduced, except in full, unless written permission for an approved abstract is obtained from ORNL ML. Any report containing accredited data shall not be used to claim product certification, approval, or endorsement by NVLAP, NIST, or any agency of the Federal Government. Calibration reports without authorizing signature(s) are not valid.

For accredited data, measurement uncertainties at the time of test, expressed in base units, are given on the following pages, where applicable. They are calculated in accordance with the methods described in EA-4/02, NIST TN1297, DKD-3, or other applicable documents that comply with the Guide to the Uncertainty in Measurement (GUM), using a coverage factor of k=2, corresponding to a confidence level of approximately 95%. Unless otherwise indicated, any conformity determination in this report is based on a Test Uncertainty Ratio (TUR) of 4:1 or greater. Any TUR less than 4:1 will be identified in the test data. It is the responsibility of the instrument custodian, with the assistance of his/her Quality Representative, to determine whether this level of confidence for the determination of conformance is adequate for the intended use of this instrument.

This calibration was performed using measurement standards traceable to the appropriate standard(s), maintained by the National Institute of Standards and Technology (NIST), to accepted intrinsic standards of measurement, or is derived by ratio type self-calibration techniques. The calibration system used to derive accredited data complies with the requirements of NIST Handbook 150, ANSI/NCSL Z540.1-1999 (R2002), ISO/IEC 17025.

Standards Used

Asset	Mfg	Model	Description	Cal. Date	Due Date
0078611	ISOTECH	MicroK-100	THERMOMETRY BRIDGE	12-Aug-09	12-Aug-10
X183483	HEWLETT PACKARD	3458A	METER DIGITAL	3-Nov-09	29-Oct-10
0065881	THUNDER SCIENTIFIC	2500ST	HUMIDITY GENERATOR	23-Mar-09	23-Mar-10
M091517	ROSEMOUNT ENGINEERIN	162C	SPRT THERMOMETER	29-Mar-06	18-Dec-09

Test Data

Description of Test:
Six custom fabricated sensors were delivered to Metrology for calibration of the temperature and humidity response curves. Each sensors response was measured at the following nominal conditions; 15.8, 18.5, 21.2, 23.9 and 26.6 Deg C and 25, 50, 75 and 90 %RH as requested by the customer. No Pass/Fail evaluation was performed. Calibration curve equations and coefficients provided by the customer were used to calculate the sensor error. New coefficients were generated to minimize the calibration curve error.
The temperature equation is;
Deg C = A + B * ln(Ohms)+ C * ln(Ohms)^2 + D * ln(Ohms)^3
Where
A = 446.05
B = -77.18
C = 4.346
D = -0.101
The humidity equation is;
%RH = (Output Volts - Zero Offset) / Slope * 1000
Where

Probe No.	Slope	Offset
309	0.8043235	31.1715305
312	0.8090865	31.0471045
322	0.8117950	30.9661380
324	0.8077610	30.8767660
412	0.8117130	30.7049500
417	0.8156720	30.7630710

Observations:
The manufactures specification for the temperature response is +/-0.2 Deg C. All probes met this requirement with the exception of No. 309. If the user software can accommodate custom coefficients for each temperature probe, the measurement error can be reduced considerably. The custom coefficients for this are found in the table below.
If the user software is limited to common coefficients for all temperature probes, a slight correction of the A coefficient will bring all probes within the +/-0.2 Deg C tolerance. Use 445.95 instead of 446.05.
New coefficients for the humidity curves are also included in the table below.
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Test Data

Measured Data Temperature	Probe No.	Standard Temperature (Deg C)	Probe Resistance (Ohms)	Calculated Temperature Users Coefficients (Deg C)	Error (Deg C)	Measurement Uncertainty (Deg C)
	309	15.777	14932.84	16.046	0.27	0.015
		18.476	13238.22	18.672	0.20	0.015
		21.185	11749.74	21.315	0.13	0.015
		23.909	10429.84	23.998	0.09	0.015
		26.622	9275.32	26.682	0.06	0.015
	312	15.753	15145.59	15.740	-0.01	0.015
		18.475	13356.78	18.476	0.00	0.015
		21.184	11789.36	21.240	0.06	0.015
		23.905	10423.82	24.011	0.11	0.015
		26.627	9274.03	26.685	0.06	0.015
	322	15.752	15071.59	15.846	0.09	0.015
		18.473	13319.69	18.538	0.06	0.015
		21.186	11788.36	21.242	0.06	0.015
		23.905	10447.46	23.959	0.05	0.015
		26.631	9285.94	26.655	0.02	0.015
	324	15.753	15074.80	15.842	0.09	0.015
		18.472	13323.49	18.531	0.06	0.015
		21.188	11800.36	21.219	0.03	0.015
		23.905	10472.94	23.904	0.00	0.015
		26.636	9302.34	26.615	-0.02	0.015
	412	15.755	15174.63	15.699	-0.06	0.015
		18.472	13383.59	18.432	-0.04	0.015
		21.188	11831.04	21.161	-0.03	0.015
		23.906	10478.85	23.891	-0.01	0.015
		26.636	9294.93	26.633	0.00	0.015
	417	15.758	15158.25	15.722	-0.04	0.015
		18.471	13369.95	18.455	-0.02	0.015
		21.182	11822.87	21.176	-0.01	0.015
		23.908	10461.60	23.929	0.02	0.015
		26.636	9285.68	26.656	0.02	0.015

Test Data

Humidity		Standard Humidity (%RH)	Probe Output (Volts)	Calculated Humidity Users Coefficients (%RH)	Error (%RH)	Measurement Uncertainty (%RH)
	309	25.02	1.64907	27.1	2.1	1.2
		49.99	2.43513	52.3	2.3	1.2
		75.04	3.28383	79.5	4.5	1.2
		90.00	3.80473	96.3	6.3	1.2
	312	24.99	1.64029	26.8	1.8	1.2
		50.01	2.42312	52.0	2.0	1.2
		75.01	3.27004	79.3	4.3	1.2
		90.00	3.78083	95.7	5.7	1.2
	322	24.99	1.65186	27.1	2.1	1.2
		50.00	2.43734	52.5	2.5	1.2
		75.04	3.28332	79.8	4.8	1.2
		90.00	3.80349	96.6	6.6	1.2
	324	25.00	1.64889	27.2	2.2	1.2
		49.99	2.43162	52.6	2.6	1.2
		74.99	3.27811	80.0	5.0	1.2
		89.99	3.78574	96.4	6.5	1.2
	412	25.01	1.64865	27.3	2.2	1.2
		50.01	2.42617	52.6	2.6	1.2
		74.99	3.27313	80.2	5.2	1.2
		90.00	3.77540	96.5	6.5	1.2
	417	24.99	1.65155	27.2	2.2	1.2
		50.00	2.42811	52.4	2.4	1.2
		75.00	3.27454	79.9	4.9	1.2
		90.00	3.77615	96.2	6.2	1.2

Metrology Coefficients

Probe No.	309	312	322	324	412	417
Slope	33.131144	32.952174	33.136988	32.938836	32.781404	32.586565
Offset	0.8009131	0.7959995	0.8021276	0.8052109	0.8077810	0.8210703
A	137.77590	5676.18687	2361.70414	27.02980	333.84351	1127.52521
B	17.163450	-1745.572243	-690.252295	56.830502	-41.152592	-294.419126
C	-5.21379	181.69059	69.74586	-9.91401	0.48035	27.41210
D	0.2192586	-6.3826823	-2.4265499	0.4038274	0.0376286	-0.9167426

Test Data

Temperature	Probe No.	Standard Temperature (Deg C)	Probe Resistance (Ohms)	Calculated Temperature ORNL ML Coefficients (Deg C)	Error (Deg C)	Measurement Uncertainty (Deg C)
	309	15.777	14932.84	15.776	-0.001	0.015
		18.476	13238.22	18.477	0.001	0.015
		21.185	11749.74	21.181	-0.004	0.015
		23.909	10429.84	23.910	0.001	0.015
		26.622	9275.32	26.621	-0.001	0.015
	312	15.753	15145.59	15.753	0.000	0.015
		18.475	13356.78	18.479	0.004	0.015
		21.184	11789.36	21.180	-0.004	0.015
		23.905	10423.82	23.909	0.004	0.015
		26.627	9274.03	26.627	0.000	0.015
	322	15.752	15071.59	15.752	0.000	0.015
		18.473	13319.69	18.474	0.001	0.015
		21.186	11788.36	21.184	-0.002	0.015
		23.905	10447.46	23.906	0.001	0.015
		26.631	9285.94	26.630	-0.001	0.015
	324	15.753	15074.80	15.755	0.002	0.015
		18.472	13323.49	18.472	0.000	0.015
		21.188	11800.36	21.191	0.003	0.015
		23.905	10472.94	23.905	0.000	0.015
		26.636	9302.34	26.637	0.001	0.015
	412	15.755	15174.63	15.751	-0.004	0.015
		18.472	13383.59	18.468	-0.004	0.015
		21.188	11831.04	21.184	-0.004	0.015
		23.906	10478.85	23.903	-0.003	0.015
		26.636	9294.93	26.632	-0.004	0.015
	417	15.758	15158.25	15.759	0.001	0.015
		18.471	13369.95	18.477	0.006	0.015
		21.182	11822.87	21.178	-0.004	0.015
		23.908	10461.60	23.914	0.006	0.015
		26.636	9285.68	26.637	0.001	0.015

Test Data

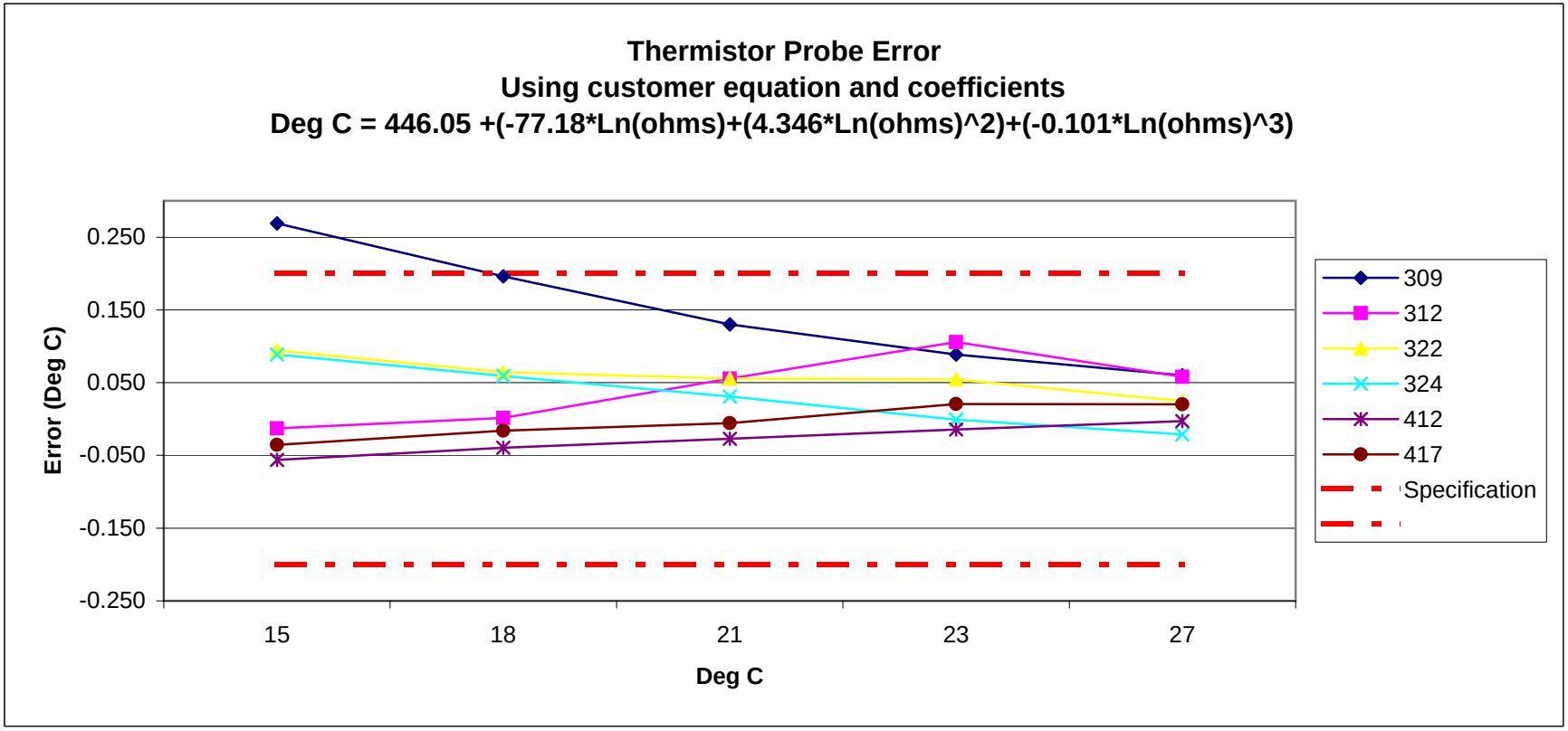
Humidity	Standard Humidity (%RH)	Probe Output (Volts)	Calculated Humidity ORNL ML Coefficients (%RH)	Error (%RH)	Measurement Uncertainty (%RH)
309	25.02	1.64907	25.6	0.6	1.2
	49.99	2.43513	49.3	-0.7	1.2
	75.04	3.28383	74.9	-0.1	1.2
	90.00	3.80473	90.7	0.7	1.2
312	24.99	1.64029	25.6	0.6	1.2
	50.01	2.42312	49.4	-0.6	1.2
	75.01	3.27004	75.1	0.1	1.2
	90.00	3.78083	90.6	0.6	1.2
322	24.99	1.65186	25.6	0.7	1.2
	50.00	2.43734	49.3	-0.7	1.2
	75.04	3.28332	74.9	-0.2	1.2
	90.00	3.80349	90.6	0.6	1.2
324	25.00	1.64889	25.6	0.6	1.2
	49.99	2.43162	49.4	-0.6	1.2
	74.99	3.27811	75.1	0.1	1.2
	89.99	3.78574	90.5	0.5	1.2
412	25.01	1.64865	25.7	0.6	1.2
	50.01	2.42617	49.4	-0.6	1.2
	74.99	3.27313	75.2	0.2	1.2
	90.00	3.77540	90.5	0.5	1.2
417	24.99	1.65155	25.5	0.5	1.2
	50.00	2.42811	49.3	-0.7	1.2
	75.00	3.27454	75.3	0.3	1.2
	90.00	3.77615	90.7	0.7	1.2

See attached graphs.

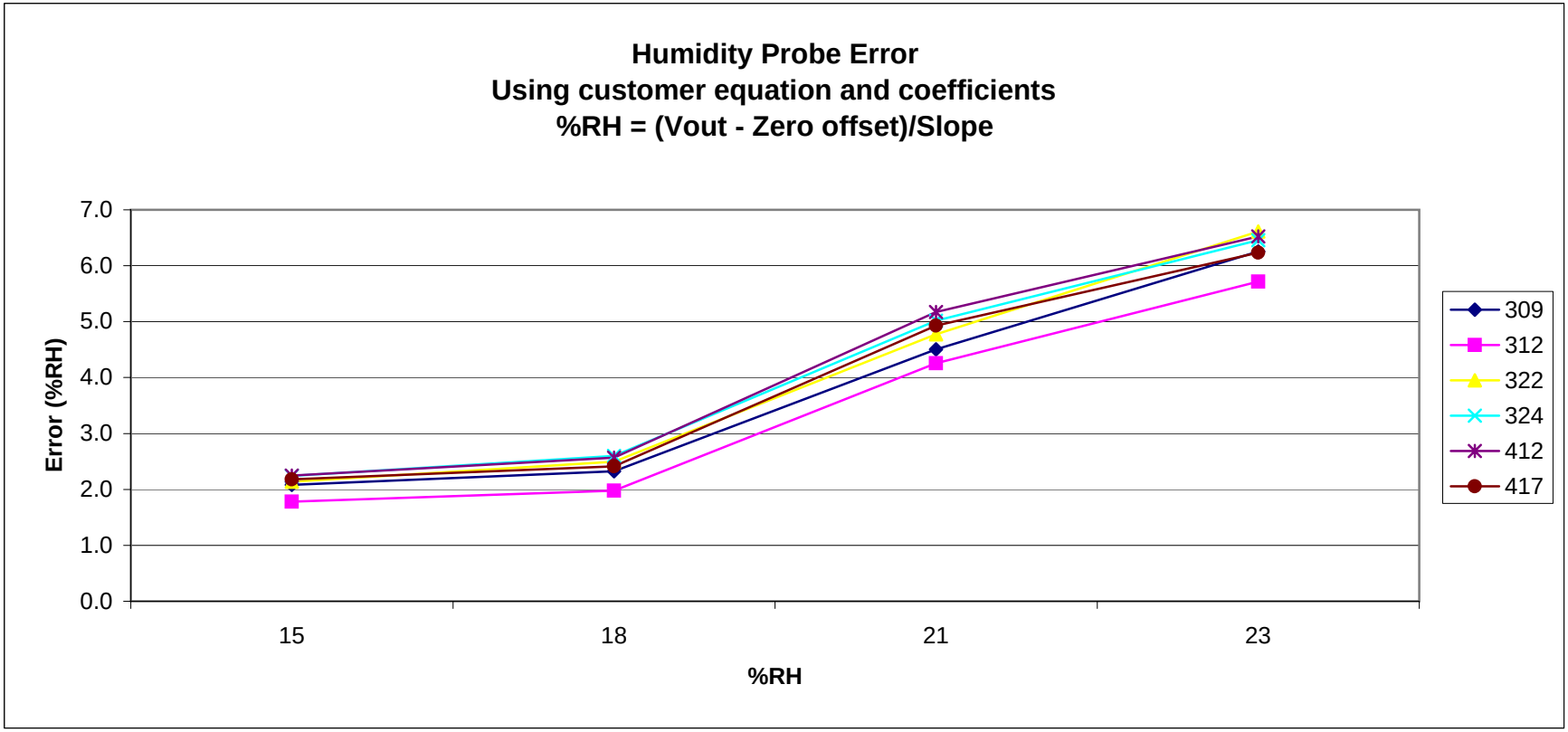
***** End of Data *****

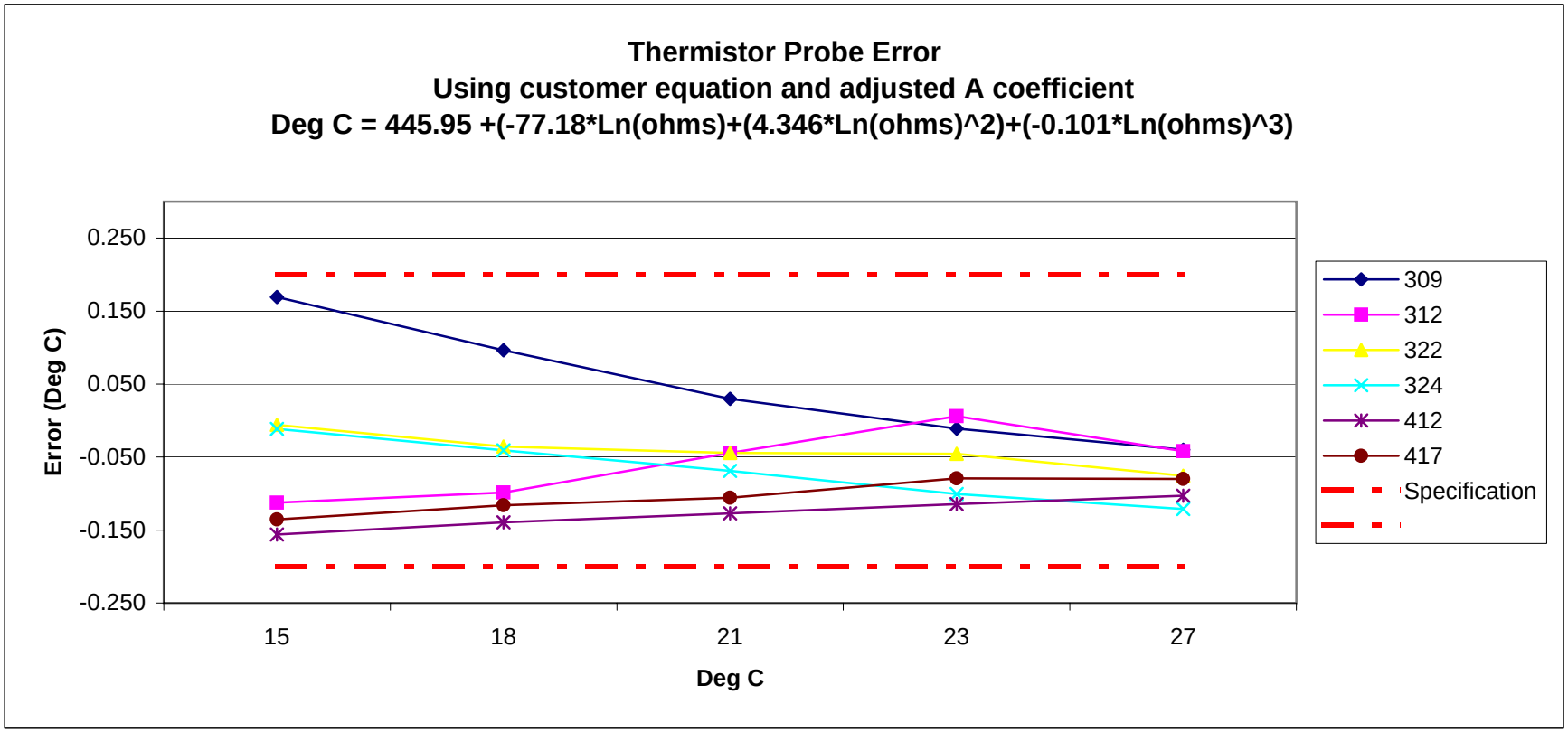
Approved by: Gregory A. Strickland (33416) Date: 12/31/2009

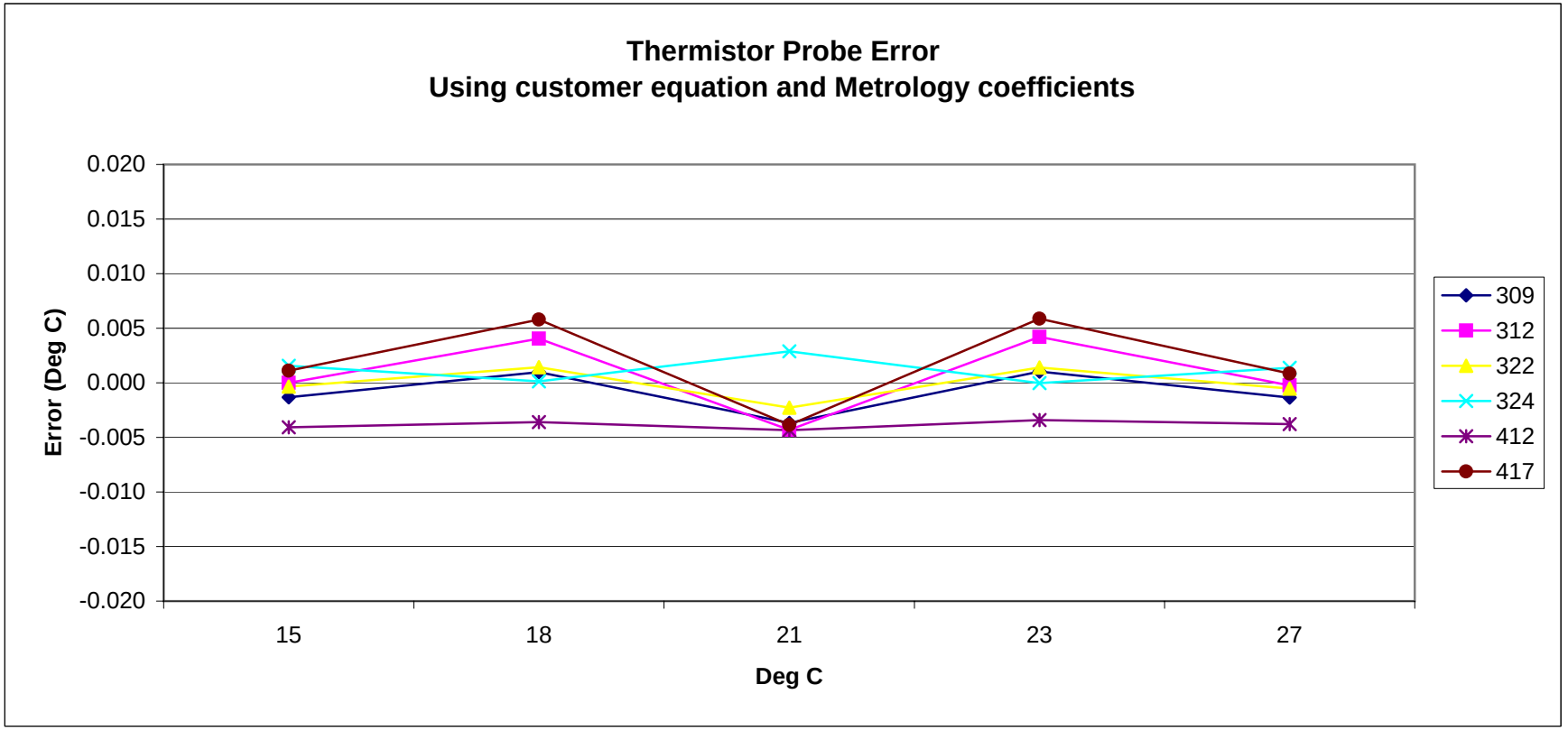
Standards Manager/Operations Coordinator

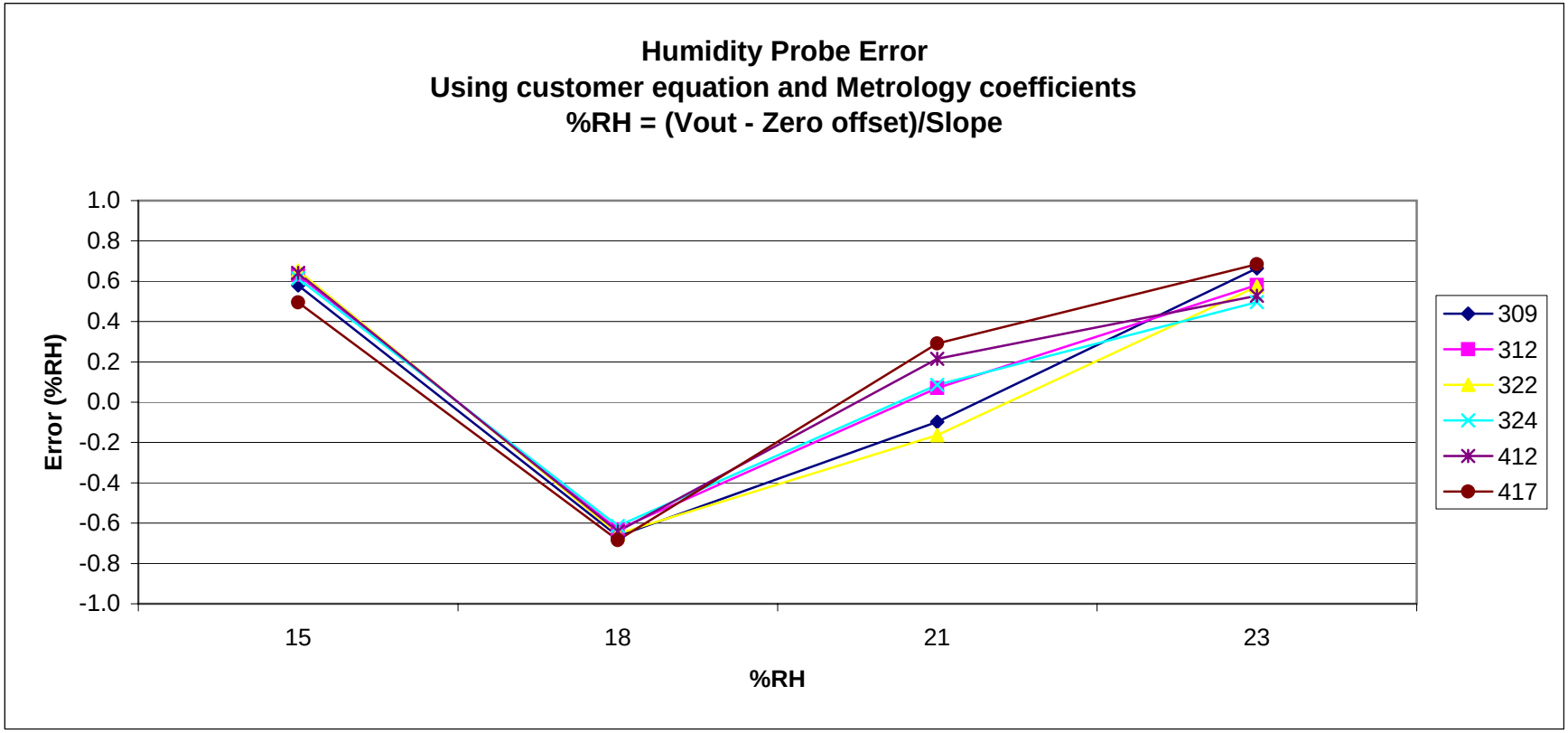

Thermistor Probe Error
Using customer equation and coefficients
Deg C = 446.05 +(-77.18*Ln(ohms)+(4.346*Ln(ohms)^2)+(-0.101*Ln(ohms)^3)
Error (Deg C)
0.250
0.150
0.050
-0.050
-0.150
-0.250
15
18
21
23
27
Deg C
309
312
322
324
412
417
Specification

COPY


Humidity Probe Error
Using customer equation and coefficients
%RH = (Vout - Zero offset)/Slope
Error (%RH)
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
15
18
21
23
%RH
309
312
322
324
412
417


Thermistor Probe Error
Using customer equation and adjusted A coefficient
Deg C = 445.95 +(-77.18*Ln(ohms)+(4.346*Ln(ohms)^2)+(-0.101*Ln(ohms)^3)
0.250
0.150
0.050
-0.050
-0.150
-0.250
Error (Deg C)
15
18
21
23
27
Deg C
309
312
322
324
412
417
Specification


Thermistor Probe Error
Using customer equation and Metrology coefficients
Error (Deg C)
0.020
0.015
0.010
0.005
0.000
-0.005
-0.010
-0.015
-0.020
15
18
21
23
27
Deg C
309
312
322
324
412
417


Humidity Probe Error
Using customer equation and Metrology coefficients
%RH = (Vout - Zero offset)/Slope
Error (%RH)
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
15
18
21
23
%RH
309
312
322
324
412
417