CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

Martin Calibration, Inc.
11965 12th Avenue South
Burnsville, MN 55337
Including satellite locations located in: Mundelein, IL and Eau Claire, WI

Fulfills the requirements of

ISO/IEC 17025:2017

and national standard

ANSI/NCSL Z540-1-1994 (R2002)

In the fields of

CALIBRATION and DIMENSIONAL MEASUREMENT

This certificate is valid only when accompanied by a current scope of accreditation document.
The current scope of accreditation can be verified at www.anab.org.

Jason Stine, Vice President

Expiry Date: 06 July 2027

Certificate Number: ACT-1265

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (refer to joint ISO-ILAC-IAF Communiqué dated April 2017).

SCOPE OF ACCREDITATION TO ISO/IEC 17025:2017

AND

ANSI/NCSL Z540-1-1994 (R2002)

Martin Calibration, Inc.

11965 12th Avenue South
Burnsville, MN 55337

Corey Garbers
952-882-1528

CALIBRATION AND DIMENSIONAL MEASUREMENT

ISO/IEC 17025 Accreditation Granted: **06 July 2025**

Certificate Number: **ACT-1265** Certificate Expiry Date: **06 July 2027**

Satellite locations in:

Mundelein, IL

Eau Claire, WI

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Services performed at Main Site laboratory

Martin Calibration, Inc.
11965 12th Avenue South
Burnsville, MN 55337
Corey Garbers
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CALIBRATION

Acoustics and Vibration **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sound Level – Fixed Points	(94, 104, 114) dB	0.2 dB	Comparison to Bruel & Kjaer Sound Pressure Calibrator
Sound Level - Linearity	(50 to 143) dB	0.13 dB	
Sound Level - Frequency	(0.031 to 16) kHz	1 % of reading	
Sound Level - Distortion	(25 to 123) dB (0.031 to 16) kHz	0.14 dB	
Accelerometers	(5 to 9) Hz (10 to 99) Hz 100 Hz (101 to 920) Hz 921 Hz to 5 kHz (5 to 8) kHz (8 to 10) kHz (10 to 15) kHz	2.6 % of reading 1.6 % of reading 0.75 % of reading 1.3 % of reading 2.2 % of reading 3.8 % of reading 4.8 % of reading 8.6 % of reading	Comparison to PCB Shaker Table with PCB Reference Accelerometer

Chemical Quantities **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Conductivity Meters [1]	(0.86 to 10) µS/cm (10 to 100) µS/cm (100 to 1 500) µS/cm 12 800 µS/cm	0.42 µS/cm 0.89 µS/cm 0.42 % of reading 0.42 % of reading	Comparison to Conductivity Standards

Chemical Quantities **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Refractometers	0.00 Brix 10.00 Brix 40.00 Brix 70.00 Brix	0.000 6 Brix 0.018 Brix 0.019 Brix 0.03 Brix	Comparison to Calibration Solutions
pH Meters [1]	4 pH 7 pH 10 pH	0.016 pH 0.016 pH 0.016 pH	Comparison to Buffer Solutions

Electrical – DC/Low Frequency **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source [1] Fixed Point	10V	0.5 µV/V	Comparison to 732B Voltage Standards with Fluke Maps
DC Voltage – Source 1	(0 to 220) mV (0.22 to 2.2) V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1 100) V	7.5 µV/V + 0.4 µV 5 µV/V + 0.7 µV 3.5 µV/V + 2.5 µV 3.5 µV/V + 4 µV 5 µV/V + 40 µV 6.5 µV/V + 0.4 mV	Fluke 5730A Multiproduct Calibrator; Direct Measure
DC Voltage – Measure [1]	0V Up to 1 mV (1 to 10) mV (10 to 100) mV (100 mV to 1) V (1 to 10) V (10 to 100) V (100 to 1 100) V	20 nV 100 nV 22 µV/V + 25 nV 5.3 µV/V 0.5 µV/V 0.31 µV/V 0.35 µV/V 1 µV/V	*Comparison to* Nano Voltmeter Fluke 732BVoltage Standard with MI Potentiometer/ Divider
DC High Voltage – Measure [1]	(1.1 to 10) kV (10 to 30) kV (30 to 50) kV (50 to 70) kV (70 to 100) kV	0.05 % of reading 0.055 % of reading 0.079 % of reading 0.12 % of reading 0.83 % of reading	Comparison to Hipotronics KVM100-A High Voltage Meter
DC Current – Source & Measure [1]	0 A (0 to 200) pA (0.2 to 20) nA (20 to 100) nA	76 fA 1.9 % of reading + 10 fA 0.29 % of reading + 1 pA 8 µA/A + 1.3 pA	Comparison to Electrometer

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Electrical – DC/Low Frequency **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source & Measure [1]	(0.1 to 1) µA (1 to 10) µA (10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	30 µA/A 6.8 µA/A 6.2 µA/A 4.1 µA/A 4.2 µA/A 3.9 µA/A 17 µA/A	Comparison to Standard resistors and DMM and Multifunction Calibrator
DC Current – Measure [1]	(1 to 20) A (20 to 120) A	26 µA/A 80 µA/A + 4 mA	Comparison to Fluke 52120A Amplifier with shunts
DC Current – Source [1]	(0.2 to 220) µA (0.22 to 2.2) mA (2.2 to 22) mA (22 to 220) mA (0.22 to 2.2) A	40 µA/A + 6 nA 35 µA/A + 7 nA 35 µA/A + 40 nA 45 µA/A + 0.7 µA 80 µA/A + 12 µA	Fluke 5730A Multiproduct Calibrator; Direct Measure
DC Current – Source [1]	Up to 2 A (2.2 to 11) A (2 to 20) A	0.036 % of reading + 0.48 mA 0.012 % of reading + 0.16 mA 0.012 % of reading + 1.6 mA	Fluke 5730A Multiproduct Calibrator, Fluke 5725A Amplifier; Direct Measure
DC Current – Source [1]	(20 to 120) A	0.012 % of reading + 9.6 mA	Fluke 5730A Multiproduct Calibrator, Fluke 52120A Current Amplifier; Direct Measure
DC Current – Source [1]	(100 to 150) A (150 to 1 025) A	5 mA/A + 20 mA 5.1 mA/A + 0.9 A	Comparison to Fluke 5520A Multi Product Calibrator with 50-turn Coil
DC Power – Source	10.9 µW to 10.9 mW 10.9 mW to 3.06 kW (3.06 to 20.9) kW	0.18 mW/W 0.17 mW/W 0.54 mW/W	Comparison to Fluke 5520A Multi Product Calibrator
AC Power – Source (45 to 65) Hz	109 µW to 1.09 mW (1.09 to 297) µW 297 µW to 2.97 mW 2.97 mW to 337 W 337 W to 2.24 kW (2.24 to 20.9) kW	1.1 mW/W 930 µW/W 780 µW/W 620 µW/W 700 µW/W 780 µW/W	Comparison to Fluke 5520A Multi Product Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source [1]	Up to 2.2 mV		Fluke 5730A Multiproduct Calibrator; Direct Measure
	(10 to 20) Hz	0.024 % of reading + 4 µV	
	(20 to 40) Hz	0.009 % of reading + 4 µV	
	40 Hz to 20 kHz	0.008 % of reading + 4 µV	
	(20 to 50) kHz	0.02 % of reading + 4 µV	
	(50 to 100) kHz	0.05 % of reading + 5 µV	
	(100 to 300) kHz	0.11 % of reading + 10 µV	
	(300 to 500) kHz	0.14 % of reading + 20 µV	
	500 kHz to 1 MHz	0.27 % of reading + 20 µV	
	(2.2 to 22) mV		
	(10 to 20) Hz	0.024 % of reading + 4 µV	
	(20 to 40) Hz	0.009 % of reading + 4 µV	
	40 Hz to 20 kHz	0.008 % of reading + 4 µV	
	(20 to 50) kHz	0.02 % of reading + 4 µV	
	(50 to 100) kHz	0.05 % of reading + 5 µV	
	(100 to 300) kHz	0.11 % of reading + 10 µV	
	(300 to 500) kHz	0.14 % of reading + 20 µV	
	500 kHz to 1 MHz	0.27 % of reading + 20 µV	
	(22 to 220) mV		
	(10 to 20) Hz	0.024 % of reading + 12 µV	
	(20 to 40) Hz	0.009 % of reading + 7 µV	
	40 Hz to 20 kHz	0.005 7 % of reading + 7 µV	
	(20 to 50) kHz	0.012 % of reading + 7 µV	
	(50 to 100) kHz	0.031 % of reading + 17 µV	
	(100 to 300) kHz	0.066 % of reading + 20 µV	
	(300 to 500) kHz	0.14 % of reading + 25 µV	
	500 kHz to 1 MHz	0.27 % of reading + 45 µV	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source [1]	(0.22 to 2.2) V		Fluke 5730A Multiproduct Calibrator; Direct Measure
	(10 to 20) Hz	0.024 % of reading + 40 µV	
	(20 to 40) Hz	0.009 % of reading + 15 µV	
	40 Hz to 20 kHz	0.004 2 % of reading + 8 µV	
	(20 to 50) kHz	0.006 7 % of reading + 10 µV	
	(50 to 100) kHz	0.008 5 % of reading + 30 µV	
	(100 to 300) kHz	0.034 % of reading + 80 µV	
	(300 to 500) kHz	0.1 % of reading + 0.2 mV	
	500 kHz to 1 MHz	0.17 % of reading + 0.3 mV	
	(2.2 to 22) V		
	(10 to 20) Hz	0.024 % of reading + 0.4 mV	
	(20 to 40) Hz	0.009 % of reading + 0.15 mV	
	40 Hz to 20 kHz	0.004 2 % of reading + 50 µV	
	(20 to 50) kHz	0.006 7 % of reading + 0.1 mV	
	(50 to 100) kHz	0.008 3 % of reading + 0.2 mV	
	(100 to 300) kHz	0.034 % of reading + 0.6 mV	
	(300 to 500) kHz	0.1 % of reading + 2 mV	
	500 kHz to 1 MHz	0.17 % of reading + 3.2 mV	
	(22 to 220) V		
	(10 to 20) Hz	0.024 % of reading + 4 mV	
	(20 to 40) Hz	0.009 % of reading + 1.5 mV	
	40 Hz to 20 kHz	0.005 2 % of reading + 0.6 mV	
	(20 to 50) kHz	0.008 % of reading + 1 mV	
	(50 to 100) kHz	0.015 % of reading + 2.5 mV	
	(100 to 300) kHz	0.09 % of reading + 16 mV	
	(300 to 500) kHz	0.44 % of reading + 40 mV	
	500 kHz to 1 MHz	0.8 % of reading + 80 mV	
	(220 to 250) V		
	(15 to 50) Hz	0.03 % of reading + 16 mV	
	(250 to 1 100) V		
	50 Hz to 1 kHz	0.007 % of reading + 3.5 mV	
AC Voltage – Source [1]	(220 to 750) V		Fluke 5730A Multiproduct Calibrator, Fluke 5725A Amplifier; Direct Measure
	(30 to 50) kHz	0.06 % of reading + 11 mV	
	(50 to 100) kHz	0.06 % of reading + 11 mV	
	(220 to 1 100) V		
	40 Hz to 1 kHz	0.009 % of reading + 4 mV	
	(1 to 20) kHz	0.017 % of reading + 6 mV	
	(20 to 30) kHz	0.23 % of reading + 45 mV	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source & Measure [1]	(0 to 2.2) mV		Comparison to Fluke 5790A AC Standard w/ 5720A Multi Product Calibrator
	(10 to 20) Hz	1.1 mV/V + 1.3 µV	
	(20 to 40) Hz	490 µV/V + 1.3 µV	
	(0.04 to 20) kHz	280 µV/V + 1.3 µV	
	(20 to 50) kHz	540 µV/V + 2 µV	
	(50 to 100) kHz	800 µV/V + 2.5 µV	
	(100 to 300) kHz	1.5 mV/V + 4 µV	
	(300 to 500) kHz	1.6 mV/V + 8 µV	
	(0.5 to 1) MHz	2.3 mV/V + 8 µV	
	(2.2 to 7) mV		
	(10 to 20) Hz	570 µV/V + 1.3 µV	
	(20 to 40) Hz	250 µV/V + 1.3 µV	
	(0.04 to 20) kHz	140 µV/V + 1.3 µV	
	(20 to 50) kHz	270 µV/V + 2 µV	
	(50 to 100) kHz	400 µV/V + 2.5 µV	
	(100 to 300) kHz	800 µV/V + 4 µV	
	(300 to 500) kHz	870 µV/V + 8 µV	
	(0.5 to 1) MHz	1.5 mV/V + 8 µV	
	(7 to 22) mV		
	(10 to 20) Hz	190 µV/V + 1.3 µV	
	(20 to 40) Hz	130 µV/V + 1.3 µV	
	(0.04 to 20) kHz	73 µV/V + 1.3 µV	
	(20 to 50) kHz	140 µV/V + 2 µV	
	(50 to 100) kHz	210 µV/V + 2.5 µV	
	(100 to 300) kHz	540 µV/V + 4 µV	
	(300 to 500) kHz	590 µV/V + 8 µV	
	(0.5 to 1) MHz	1.1 mV/V + 8 µV	
	(22 to 70) mV		
	(10 to 20) Hz	160 µV/V + 1.5 µV	
	(20 to 40) Hz	80 µV/V + 1.5 µV	
	(0.04 to 20) kHz	43 µV/V + 1.5 µV	
	(20 to 50) kHz	87 µV/V + 2 µV	
	(50 to 100) kHz	170 µV/V + 2.5 µV	
	(100 to 300) kHz	340 µV/V + 4 µV	
	(300 to 500) kHz	450 µV/V + 8 µV	
	(0.5 to 1) MHz	730 µV/V + 8 µV	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source & Measure [1]	(70 to 220) mV		Comparison to Fluke 5790A AC Standard w/ 5720A Multi Product Calibrator
	(10 to 20) Hz	140 µV/V + 1.5 µV	
	(20 to 40) Hz	57 µV/V + 1.5 µV	
	(0.04 to 20) kHz	25 µV/V + 1.5 µV	
	(20 to 50) kHz	46 µV/V + 2 µV	
	(50 to 100) kHz	110 µV/V + 2.5 µV	
	(100 to 300) kHz	170 µV/V + 4 µV	
	(300 to 500) kHz	250 µV/V + 8 µV	
	(0.5 to 1) MHz	670 µV/V + 8 µV	
	(220 to 700) mV		
	(10 to 20) Hz	140 µV/V + 1.5 µV	
	(20 to 40) Hz	51 µV/V + 1.5 µV	
	(0.04 to 20) kHz	22 µV/V + 1.5 µV	
	(20 to 50) kHz	34 µV/V + 2 µV	
	(50 to 100) kHz	53 µV/V + 2.5 µV	
	(100 to 300) kHz	120 µV/V + 4 µV	
	(300 to 500) kHz	200 µV/V + 8 µV	
	(0.5 to 1) MHz	640 µV/V + 8 µV	
	(0.7 to 2.2) V		
	(10 to 20) Hz	130 µV/V	
	(20 to 40) Hz	44 µV/V	
	(0.04 to 20) kHz	16 µV/V	
	(20 to 50) kHz	31 µV/V	
	(50 to 100) kHz	47 µV/V	
	(100 to 300) kHz	110 µV/V	
	(300 to 500) kHz	170 µV/V	
	(0.5 to 1) MHz	600 µV/V	
	(2.2 to 7) V		
	(10 to 20) Hz	130 µV/V	
	(20 to 40) Hz	45 µV/V	
	(0.04 to 20) kHz	16 µV/V	
	(20 to 50) kHz	32 µV/V	
	(50 to 100) kHz	54 µV/V	
	(100 to 300) kHz	130 µV/V	
	(300 to 500) kHz	270 µV/V	
	(0.5 to 1) MHz	800 µV/V	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source & Measure [1]	(7 to 22) V		Comparison to Fluke 5790A AC Standard w/ 5720A Multi Product Calibrator
	(10 to 20) Hz	130 µV/V	
	(20 to 40) Hz	45 µV/V	
	(0.04 to 20) kHz	18 µV/V	
	(20 to 50) kHz	32 µV/V	
	(50 to 100) kHz	54 µV/V	
	(100 to 300) kHz	130 µV/V	
	(300 to 500) kHz	270 µV/V	
	(0.5 to 1) MHz	800 µV/V	
	(22 to 70) V		
	(10 to 20) Hz	130 µV/V	
	(20 to 40) Hz	45 µV/V	
	(0.04 to 20) kHz	21 µV/V	
	(20 to 50) kHz	38 µV/V	
	(50 to 100) kHz	63 µV/V	
	(100 to 300) kHz	130 µV/V	
	(300 to 500) kHz	270 µV/V	
	(0.5 to 1) MHz	800 µV/V	
	(70 to 220) V		
	(10 to 20) Hz	130 µV/V	
	(20 to 40) Hz	45 µV/V	
	(0.04 to 20) kHz	21 µV/V	
	(20 to 50) kHz	46 µV/V	
	(50 to 100) kHz	65 µV/V	
	(100 to 300) kHz	140 µV/V	
	(300 to 500) kHz	330 µV/V	
	(220 to 700) V		
	(10 to 20) Hz	130 µV/V	
	(20 to 40) Hz	66 µV/V	
	(0.04 to 20) kHz	27 µV/V	
	(20 to 50) kHz	87 µV/V	
	(50 to 100) kHz	330 µV/V	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source & Measure Flatness relative to 1 kHz	(0 to 2.2) mV		Comparison to Fluke 5790A AC Standard w/ 5720A Multi Product Calibrator (Wideband)
	(10 to 30) Hz	0.1 % of reading + 1.3 µV	
	(30 to 120) Hz	0.05 % of reading + 1.3 µV	
	(0.12 to 1.2) kHz	0.05 % of reading + 1.3 µV	
	(1.2 to 120) kHz	0.05 % of reading + 2 µV	
	(120 to 500) kHz	0.07 % of reading + 1 µV	
	(0.5 to 1.2) MHz	0.07 % of reading + 1 µV	
	(1.2 to 2) MHz	0.07 % of reading + 1 µV	
	(2 to 10) MHz	0.17 % of reading + 1 µV	
	(10 to 20) MHz	0.32 % of reading + 1 µV	
	(20 to 30) MHz	0.7 % of reading + 2 µV	
	(2.2 to 7) mV		
	(10 to 30) Hz	0.1 % of reading	
	(30 to 120) Hz	0.05 % of reading	
	(0.12 to 1.2) kHz	0.05 % of reading	
	(1.2 to 120) kHz	0.05 % of reading	
	(120 to 500) kHz	0.07 % of reading + 1 µV	
	(0.5 to 1.2) MHz	0.07 % of reading + 1 µV	
	(1.2 to 2) MHz	0.07 % of reading + 1 µV	
	(2 to 10) MHz	0.1 % of reading + 1 µV	
	(10 to 20) MHz	0.17 % of reading + 1 µV	
	(20 to 30) MHz	0.37 % of reading + 1 µV	
	(7 to 22) mV		
	(10 to 30) Hz	0.1 % of reading	
	(30 to 120) Hz	0.05 % of reading	
	(0.12 to 1.2) kHz	0.05 % of reading	
	(1.2 to 120) kHz	0.05 % of reading	
	(120 to 500) kHz	0.07 % of reading	
	(0.5 to 1.2) MHz	0.07 % of reading	
	(1.2 to 2) MHz	0.07 % of reading	
	(2 to 10) MHz	0.1 % of reading	
	(10 to 20) MHz	0.17 % of reading	
	(20 to 30) MHz	0.37 % of reading	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source & Measure Flatness relative to 1 kHz	(22 to 70) mV		Comparison to Fluke 5790A AC Standard w/ 5720A Multi Product Calibrator (Wideband)
	(10 to 30) Hz	0.1 % of reading	
	(30 to 120) Hz	0.05 % of reading %	
	(0.12 to 1.2) kHz	0.05 % of reading	
	(1.2 to 120) kHz	0.05 % of reading	
	(120 to 500) kHz	0.05 % of reading	
	(0.5 to 1.2) MHz	0.05 % of reading	
	(1.2 to 2) MHz	0.05 %% of reading	
	(2 to 10) MHz	0.1 % of reading	
	(10 to 20) MHz	0.15 % of reading	
	(20 to 30) MHz	0.35 % of reading	
	(70 to 220) mV		
	(10 to 30) Hz	0.1 % of reading	
	(30 to 120) Hz	0.04 % of reading	
	(0.12 to 1.2) kHz	0.04 % of reading	
	(1.2 to 120) kHz	0.04 % of reading	
	(120 to 500) kHz	0.04 % of reading	
	(0.5 to 1.2) MHz	0.05 % of reading	
	(1.2 to 2) MHz	0.05 % of reading	
	(2 to 10) MHz	0.1 % of reading	
	(10 to 20) MHz	0.15 % of reading	
	(20 to 30) MHz	0.35 % of reading	
	(220 to 700) mV		
	(10 to 30) Hz	0.1 % of reading	
	(30 to 120) Hz	0.03 % of reading	
	(0.12 to 1.2) kHz	0.03 % of reading	
	(1.2 to 120) kHz	0.03 % of reading	
	(120 to 500) kHz	0.03 % of reading	
	(0.5 to 1.2) MHz	0.05 % of reading	
	(1.2 to 2) MHz	0.05 % of reading	
	(2 to 10) MHz	0.1 % of reading	
	(10 to 20) MHz	0.15 % of reading	
	(20 to 30) MHz	0.35 % of reading	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source & Measure Flatness relative to 1 kHz	(0.7 to 2.2) V		Comparison to Fluke 5790A AC Standard w/ 5720A Multi Product Calibrator (Wideband)
	(10 to 30) Hz	0.1 % of reading	
	(30 to 120) Hz	0.03 % of reading	
	(0.12 to 1.2) kHz	0.03 % of reading	
	(1.2 to 120) kHz	0.03 % of reading	
	(120 to 500) kHz	0.03 % of reading	
	(0.5 to 1.2) MHz	0.05 % of reading	
	(1.2 to 2) MHz	0.05 % of reading	
	(2 to 10) MHz	0.1 % of reading	
	(10 to 20) MHz	0.15 % of reading	
	(20 to 30) MHz	0.35 % of reading	
	(2.2 to 7) V		
	(10 to 30) Hz	0.1 % of reading	
	(30 to 120) Hz	0.03 % of reading	
	(0.12 to 1.2) kHz	0.03 % of reading	
	(1.2 to 120) kHz	0.03 % of reading	
	(120 to 500) kHz	0.03 % of reading	
	(0.5 to 1.2) MHz	0.05 % of reading	
	(1.2 to 2) MHz	0.05 % of reading	
	(2 to 10) MHz	0.1 % of reading	
	(10 to 20) MHz	0.15 % of reading	
	(20 to 30) MHz	0.35 % of reading	
AC Current – Source [1]	Up to 220 µA		Fluke 5730A Multiproduct Calibrator; Direct Measure
	(10 to 20) Hz	0.025 % of reading + 16 nA	
	(20 to 40) Hz	0.016 % of reading + 10 nA	
	40 Hz to 1 kHz	0.011 % of reading + 8 nA	
	(1 to 5) kHz	0.028 % of reading + 12 nA	
	(5 to 10) kHz	0.11 % of reading + 65 nA	
	(0.22 to 2.2) mA		
	(10 to 20) Hz	0.25 % of reading + 40 nA	
	(20 to 40) Hz	0.016 % of reading + 35 nA	
	40 Hz to 1 kHz	0.011 % of reading + 35 nA	
	(1 to 5) kHz	0.02 % of reading + 0.11 µA	
	(5 to 10) kHz	0.11 % of reading + 0.65 µA	
	(2.2 to 22) mA		
	(10 to 20) Hz	0.025 % of reading + 0.4 µA	
	(20 to 40) Hz	0.016 % of reading + 0.35 µA	
	40 Hz to 1 kHz	0.011 % of reading + 0.35 µA	
	(1 to 5) kHz	0.020 % of reading + 0.55 µA	
	(5 to 10) kHz	0.11 % of reading + 5 µA	

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Electrical – DC/Low Frequency **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source [1]	(2.2 to 22) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (22 to 220) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 0.025 % of reading + 0.4 µA 0.016 % of reading + 0.35 µA 0.011 % of reading + 0.35 µA 0.02 % of reading + 0.55 µA 0.11 % of reading + 5 µA 0.025 % of reading + 4 µA 0.016 % of reading + 3.5 µA 0.011 % of reading + 2.5 µA 0.02 % of reading + 3.5 µA 0.11 % of reading + 10 µA	Fluke 5730A Multiproduct Calibrator, Fluke 5725A Amplifier; Direct Measure
AC Current – Source [1]	(0.22 to 2.2) A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (2.2 to 11) A (40 to 100) Hz (1 to 5) kHz (5 to 10) kHz	 0.025 % of reading + 35 µA 0.045 % of reading + 80 µA 0.7 % of reading + 0.16 µA 0.046 % of reading + 0.17 mA 0.095 % of reading + 0.38 mA 0.36 % of reading + 0.75 mA	Fluke 5730A Multiproduct Calibrator, Fluke 5725A Amplifier; Direct Measure
AC Current – Source [1]	Up to 2 A (10 to 850) Hz 850 Hz to 6 kHz (6 to 10) kHz (2 to 20) A (10 to 850) Hz 850 Hz to 6 kHz (6 to 10) kHz	 0.009 % of reading + 40 µA 0.04 % of reading + 80 µA 1.6 % of reading + 62 mA 0.009 % of reading + 0.4 mA 0.04 % of reading + 0.8 mA 2.3 % of reading + 94 mA	Fluke 5730A Multiproduct Calibrator, Fluke 52120A Current Amplifier; Direct Measure
AC Current – Source [1]	(20 to 120) A (10 to 850) Hz 850 Hz to 6 kHz (6 to 10) kHz	 0.009 % of reading + 2.4 mA 0.04 % of reading + 4.8 mA 3.1 % of reading + 0.7 A	Fluke 5730A Multiproduct Calibrator, Fluke 52120A Current Amplifier; Direct Measure
AC Current – Source [1]	9 µA to 1 mA DC to 10 kHz 1 mA to 1 A DC to 10 kHz (1 to 20) A DC to 10 kHz	 75 µA/A 28 µA/A 52 µA/A	Comparison to Fluke 5720A Multi Product Calibrator w/ A40B Shunts

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AC Current – Source [1]	(20 to 120) A DC to 1 kHz (1 to 6) kHz	 3 mA/A 12 mA/A	Comparison to Fluke 5720A Multi Product Calibrator w/ A40B Shunts
AC Current – Measure [1]	9 µA to 1 mA (DC to 30) kHz (30 to 100) kHz 1mA to 1A (DC to 100) kHz (1 to 20) A (DC to 10) kHz (10 to 30) kHz (30 to 100) kHz	 90 µA/A 0.18 mA/A 35 µA/A 61 µA/A 83 µA/A 0.13 mA/A	Comparison to Fluke A40B Shunts
AC Current – Measure [1]	9 µA to 200 µA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz 200 µA to 2 mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz (2 to 20) mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz (20 to 200) mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz	 0.62 mA/A 0.54 mA/A 0.94 mA/A 8.4 mA/A 0.6 mA/A 0.54 mA/A 0.94 mA/A 4.2 mA/A 0.6 mA/A 0.54 mA/A 0.94 mA/A 4.2 mA/A 0.57 mA/A 0.49 mA/A 0.83 mA/A	Comparison to Fluke 8508A Multimeter

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AC Current – Measure	(0.2 to 2) A 1 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (2 to 20) A 10 Hz to 2 kHz (2 to 10) kHz (20 to 30) A 10 Hz to 2 kHz (2 to 10) kHz	 0.3 mA/A + 0.1 mA 0.56 mA/A + 0.1 mA 0.8 mA/A + 0.1 mA 0.84 mA/A + 0.5 mA 0.86 mA/A + 0.5 mA 0.84 mA/A + 12 mA 1.2 mA/A + 12 mA	Fluke 8588A 8.5 Digit Multimeter; Direct Measure
Resistance – Source [1]	0.001 Ω 0.01Ω 0.1 Ω 1Ω 10Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ 1 GΩ (1 to 10) GΩ (10 to 100) GΩ (100 to 900) GΩ 1 TΩ 10 TΩ	3.5 µΩ/Ω 4.3 µΩ/Ω 1.5 µΩ/Ω 0.67 µΩ/Ω 0.56 µΩ/Ω 0.68 µΩ/Ω 0.51 µΩ/Ω 0.8 µΩ/Ω 0.57 µΩ/Ω 1.3 µΩ/Ω Ω 14 µΩ/Ω 130 µΩ/Ω 26 µΩ/Ω 0.16 % of reading 0.54 % of reading 0.56 % of reading 1.6 % of reading 1.7 % of reading	Comparison to Standard resistors
Resistance – Measure [1]	(10 to 100) µΩ (0.1 to 1) mΩ (1 to 10) mΩ (10 o 100) mΩ (0.1 to 1) Ω (1 to 10) Ω (10 to 100) Ω (0.1 to 1) kΩ (1 to 10) kΩ (10 o 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ	0.15 % of reading 15 µΩ/Ω 5.1 µΩ/Ω 1.8 µΩ/Ω 0.67 µΩ/Ω 0.56 µΩ/Ω 0.68 µΩ/Ω 0.51 µΩ/Ω 0.8 µΩ/Ω 0.57 µΩ/Ω 1.3 µΩ/Ω 14 µΩ/Ω	Comparison to Standard resistors with bridge and DMM

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Resistance – Measure [1]	(10 to 200) MΩ (0.2 to 2) GΩ (2 to 20) GΩ	72μΩ/Ω + 1kΩ 0.18 mΩ/Ω + 100 kΩ 0.67 mΩ/Ω + 10 MΩ	Comparison to Decade resistors with bridge and DMM
Resistance – Measure [1] High Voltage Mode up to 200 V	(2 to 20) MΩ (20 to 200) MΩ 200 MΩ to 2 GΩ (2 to 20) GΩ	15 μΩ/Ω + 10 Ω 60 μΩ/Ω + 1 kΩ 0.15 mΩ/Ω + 100 kΩ 0.53 mΩ/Ω + 10 MΩ	Comparison to Decade resistors with bridge and DMM
AC Resistance (Impedance)	(1, 500) kHz, 1 MHz 25 Ω 375 Ω (1, 250, 500) kHz, 1 MHz 6 kΩ (1, 25, 50) kHz 100 kΩ	100 μΩ/Ω	Comparison to AC Resistor Set
Capacitance – Measure [1]	1 pF @ 1 kHz 10 pF @ 1 kHz 100 pF @ 1kHz 1 nF 1kHz 1 μF @ 1 kHz	1.9 mF/F 1.1 mF/F 1.2 mF/F 1.2 mF/F 1.2 mF/F	Comparison to QuadTech 1730 LCR Meter
Capacitance – Source [1] (fixed values) @ 100 Hz @ 1 kHz	1 pF 1 nF 10 nF 100 nF 1 μF	1.8 mF/F 0.23 mF/F 0.25 mF/F 0.21 mF/F 0.25 mF/F	Comparison to Standard Capacitors
Capacitance – Source [1] 10 Hz to 10 kHz 10 Hz to 3 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz (10 to 600) Hz 10 Hz to 300 Hz 10 Hz to 150 Hz 10 Hz to 120 Hz	 0.19 nF to 1.1 nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 110) nF (110 to 330) nF 330 nF to 1.1 μF (1.1 to 3.3) μF (3.3 to 11) μF (11 to 33) μF	 15 mF/F 8.4 mF/F 3.6 mF/F 3.6 mF/F 3.7 mF/F 3.6 mF/F 3.6 mF/F 3.6 mF/F 5.1 mF/F	Comparison to Fluke 5520A Multi Product Calibrator

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Capacitance – Source [1]			Comparison to Fluke 5520A Multi Product Calibrator
10 Hz to 80 Hz	(33 to 110) µF	5.6 mF/F	
(0 to 50) Hz	(110 to 330) µF	5.6 mF/F	
(0 to 20) Hz	330 µF to 1.1 mF	8.7 mF/F	
(0 to 6) Hz	(1.1 to 3.3) mF	5.5 mF/F	
(0 to 2) Hz	(3.3 to 11) mF	5.5 mF/F	
(0 to 0.6) Hz	(11 to 33) mF	8.5 mF/F	
(0 to 0.2) Hz	(33 to 110) mF	12 mF/F	
Inductance – Measure [1]	100 µH @ 1 kHz 1 mH @ 1 kHz 10 mH @ 1 kHz 100 mH @ 1 kHz 1 H @ 1 kHz	1.3 mH/H	Comparison to QuadTech 1730 LCR Meter
Inductance – Source [1]	500 µH @ 100 Hz 500 µH @ 1 kHz 2 mH @ 100 Hz 2 mH @ 1 kHz 20 mH @ 100 Hz 20 mH @ 1 kHz 1 H @ 100 Hz 1 H @ 1 kHz 10 H @ 100 Hz 10 H @ 1 kHz	1.2 mH/H 1 mH/H 1.1 mH/H 1 mH/H 1.1 mH/H 1 mH/H 1 mH/H 1 mH/H 1 mH/H 1 mH/H	Comparison to Standard Inductors
Oscilloscopes [1]			Comparison to Fluke 9500B/3200/9530 Oscilloscope Calibrator
Square Wave Signal 50 Ω at 1 kHz	40 µV to 5 V	1 mV/V	
Square Wave Signal 1 MΩ at 1 kHz	40 µV to 5 V	1 mV/V	
DC Voltage, 50 Ω	1 mV to 5 V	0.26 mV/V	
DC Voltage, 1 MΩ	1 mV to 200 V	0.25 mV/V	
Leveled Sine Wave Amplitude	5 mV to 5 V	15 mV/V	
Leveled Sine Wave Flatness (relative to 50 kHz)	4.4 mVpp to 5.6 Vpp 0.1 Hz to 300 MHz (300 to 550) MHz	 43 mV/V 43 mV/V	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes [1]			Comparison to Fluke 9500B/3200/9530 Oscilloscope Calibrator
Leveled Sine Wave Flatness (relative to 50 kHz)	4.4 mVpp to 3.3 Vpp		
	550 MHz to 1.1 GHz	52 mV/V	
	(1.1 to 3.2) GHz	52 mV/V	
Time Marker 50 Ω Source and Period	9 ns to 55 s	0.25 µs/s	
Rise/Fall Time - Source	150 ps	27 ps	
Pulse Width - Source	(1 to 100) ns	52 ms/s	
Electrical Simulation of Thermocouple Indicators [1]	Type B		Comparison to Ectron 1140A Thermocouple Simulator
	(250 to 350) ºC	1.1 °C	
	(350 to 445) ºC	0.85 °C	
	(445 to 580) ºC	0.67 °C	
	(580 to 750) °C	0.52° C	
	(750 to 1 000) °C	0.43 °C	
	(1 000 to 1 820) °C	0.33° C	
	Type C		
	(0 to 250) ºC	0.23 ºC	
	(250 to 1 000) ºC	0.18 ºC	
	(1 000 to 1 500) ºC	0.21 ºC	
	(1 500 to 1 800) ºC	0.24 ºC	
	(1 800 to 2 000) ºC	0.27 ºC	
	(2 000 to 2 250) ºC	0.33 ºC	
	(2 250 to 2 315) ºC	0.37 ºC	
	Type E		
	(-270 to -245) ºC	1.38 ºC	
	(-245 to -195) ºC	0.21 ºC	
	(-195 to -155) ºC	0.12 ºC	
	(-155 to -90) ºC	0.09 ºC	
	(-90 to 15) ºC	0.08 ºC	
	(15 to 890) ºC	0.07 ºC	
	(890 to 1 000) ºC	0.08 ºC	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicators [1]	Type J		Comparison to Ectron 1140A Thermocouple Simulator
	(-210 to -180) ºC	0.14 ºC	
	(-180 to -120) ºC	0.12 ºC	
	(-120 to -50) ºC	0.09 ºC	
	(-50 to 990) ºC	0.08 ºC	
	(990 to 1 200) ºC	0.08 ºC	
	Type K		
	(-270 to -255) ºC	2.5 ºC	
	(-255 to -195) ºC	0.81 ºC	
	(-195 to -115) ºC	0.14 ºC	
	(-115 to -55) ºC	0.1 ºC	
	(-55 to 1 000) ºC	0.08 ºC	
	(1 000 to 1 372) ºC	0.09 ºC	
	Type N		
	(-270 to -260) ºC	5.8 ºC	
	(-260 to -200) ºC	1.2 ºC	
	(-200 to -140) ºC	0.27 ºC	
	(-140 to -70) ºC	0.17 ºC	
	(-70 to 25) ºC	0.14 ºC	
	(25 to 160) ºC	0.12 ºC	
	(160 to 1 300) ºC	0.1 ºC	
	Type R		
	(-50 to -30) ºC	0.75 ºC	
	(-30 to 45) ºC	0.63 ºC	
	(45 to 160) ºC	0.46 ºC	
	(160 to 380) ºC	0.35 ºC	
	(380 to 775) ºC	0.3 ºC	
	(775 to 1 768) ºC	0.25 ºC	
	Type S		
	(-50 to -30) ºC	0.71 ºC	
	(-30 to -45) ºC	0.64 ºC	
	(-45 to -105) ºC	0.46 ºC	
	(-105 to 310) ºC	0.38 ºC	
	(310 to 615) ºC	0.33 ºC	
	(615 to 1 768) ºC	0.3 ºC	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicators [1]	Type T (-270 to -255) ºC (-255 to -240) ºC (-240 to -210) ºC (-210 to -150) ºC (-150 to -40) ºC (-40 to 100) ºC (100 to 400) ºC	 2.1 ºC 0.56 ºC 0.35 ºC 0.21 ºC 0.14 ºC 0.09 ºC 0.08 ºC	Comparison to Ectron 1140A Thermocouple Simulator
Electrical Simulation of RTD Indicators [1]	PT 395 100 Ω (-200 to 0) ºC (0 to 100) ºC (100 to 300) ºC (300 to 400) ºC (400 to 630) ºC (630 to 800) ºC PT 3926 100 Ω (-200 to 0) ºC (0 to 100) ºC (100 to 300) ºC (300 to 400) ºC (400 to 630) ºC PT 3916 100 Ω (-200 to -190) ºC (-190 to -80) ºC (-80 to 0) ºC (0 to 100) ºC (100 to 260) ºC (260 to 300) ºC (300 to 400) ºC (400 to 600) ºC (600 to 630) ºC PT 385 200 Ω (-200 to 100) ºC (100 to 260) ºC (260 to 300) ºC (300 to 400) ºC (400 to 600) ºC (600 to 630) ºC	 0.06 ºC 0.08 ºC 0.11 ºC 0.12 ºC 0.14 ºC 0.27 ºC 0.06 ºC 0.08 ºC 0.11 ºC 0.12 ºC 0.14 ºC 0.29 ºC 0.05 ºC 0.06 ºC 0.07 ºC 0.08 ºC 0.09 ºC 0.11 ºC 0.12 ºC 0.27 ºC 0.05 ºC 0.06 ºC 0.14 ºC 0.15 ºC 0.16 ºC 0.19 ºC	Comparison to Fluke 5520A Multi Product Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicators [1]	PT 385 500 Ω		Comparison to Fluke 5520A Multi Product Calibrator
	(-200 to -80) ºC	0.05 ºC	
	(-80 to 100) ºC	0.06 ºC	
	(100 to 260) ºC	0.07 ºC	
	(260 to 400) ºC	0.09 ºC	
	(400 to 600) ºC	0.01 ºC	
	(600 to 630) ºC	0.13 ºC	
	PT 395 100 Ω		
	(-200 to 0) ºC	0.06 ºC	
	(0 to 100) ºC	0.08 ºC	
	(100 to 300) ºC	0.11 ºC	
	(300 to 400) ºC	0.12 ºC	
	(400 to 630) ºC	0.14 ºC	
	(630 to 800) ºC	0.27 ºC	
	PT 3926 100 Ω		
	(-200 to 0) ºC	0.06 ºC	
	(0 to 100) ºC	0.08 ºC	
	(100 to 300) ºC	0.11 ºC	
	(300 to 400) ºC	0.12 ºC	
	(400 to 630) ºC	0.14 ºC	
	PT 3916 100 Ω		
	(-200 to -190) ºC	0.29 ºC	
	(-190 to -80) ºC	0.05 ºC	
	(-80 to 0) ºC	0.06 ºC	
	(0 to 100) ºC	0.07 ºC	
	(100 to 260) ºC	0.08 ºC	
	(260 to 300) ºC	0.09 ºC	
	(300 to 400) ºC	0.11 ºC	
	(400 to 600) ºC	0.12 ºC	
	(600 to 630) ºC	0.27 ºC	
	PT 385 200 Ω		
	(-200 to 100) ºC	0.05 ºC	
	(100 to 260) ºC	0.06 ºC	
	(260 to 300) ºC	0.14 ºC	
	(300 to 400) ºC	0.15 ºC	
	(400 to 600) ºC	0.16 ºC	
	(600 to 630) ºC	0.19 ºC	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicators [1]	PT 385 500 Ω (-200 to -80) ºC (-80 to 100) ºC (100 to 260) ºC (260 to 400) ºC (400 to 600) ºC (600 to 630) ºC PT 385 1 000 Ω (-200 to 0) ºC (0 to 100) ºC (100 to 260) ºC (260 to 300) ºC (300 to 600) ºC (600 to 630) ºC PtNi 120 Ω (-80 to 100) ºC (100 to 260) ºC Cu 427 10 Ω (-100 to 260) ºC	 0.05 ºC 0.06 ºC 0.07 ºC 0.09 ºC 0.01 ºC 0.13 ºC 0.04 ºC 0.05 ºC 0.06 ºC 0.07 ºC 0.08 ºC 0.27 ºC 0.09 ºC 0.16 ºC 0.35 ºC	Comparison to Fluke 5520A Multi Product Calibrator

Electrical – RF/Microwave **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power - Measure Absolute Level [1]	(-36 to 20) dBm 9 kHz to 6 GHz (20 to 30) dBm (6 to 18) GHz (18 to 26.5) GHz	 0.16 dB 0.44 dB 0.5 dB	Comparison to Agilent E9304A/N1912A Agilent N5531S Measuring Receiver with N5532A Sensor Module
RF Power - Measure Absolute Level [1]	(-20 to 20) dBm 100 kHz to 30 MHz 30 MHz to 2 GHz (1 to 18) GHz (18 to 26.5) GHz	 0.2 dB 0.21 dB 0.31 dB 0.4 dB	Comparison to Agilent N5531S Measuring Receiver with N5532A Sensor Module
RF Power - Measure Absolute Level [1]	(-30 to 20) dBm 100 kHz to 30 MHz	 3.1 % of reading	Comparison to Agilent N5531S Measuring Receiver with 8482A Sensor

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Power – Measure [1] 100 kHz to 26.5 GHz	(-10 to 0) dB (-20 to -10) dB (-30 to -20) dB (-40 to -30) dB (-50 to -40) dB (-60 to -50) dB (-70 to -60) dB (-80 to -70) dB	0.02 dB 0.03 dB 0.03 dB 0.05 dB 0.06 dB 0.06 dB 0.07 dB 0.07 dB	Comparison to Agilent N5531S Measuring Receiver with N5532A Sensor Module
Relative Power – Measure [1] 100 kHz to 26.5 GHz	(-90 to -80) dB (-100 to -90) dB (-110 to -100) dB (-120 to -110) dB (-130 to -120) dB (-140 to -130) dB	0.08 dB 0.08 dB 0.09 dB 0.1 dB 0.1 dB 0.1 dB	Comparison to Agilent N5531S Measuring Receiver with N5532A Sensor Module
RF Power – Source [1]	(-90 to -75) dBm 250 kHz to 2 GHz (2 to 20) GHz (20 to 32) GHz (-75 to -10) dBm 250 kHz to 2 GHz (2 to 20) GHz (20 to 32) GHz (-20 to -10) dBm 250 kHz to 2 GHz (2 to 20) GHz (20 to 32) GHz	 0.73 dB 1 dB 1.2 dB 0.72 dB 1 dB 1.2 dB 1.4 dB 1.3 dB 1.3 dB	Comparison to Agilent N5183A Signal Generator
RF Power – Source [1]	(-10 to 10) dBm 250 kHz to 2 GHz (2 to 20) GHz (20 to 32) GHz > 10 dBm 250 kHz to 2 GHz (2 to 20) GHz (20 to 32) GHz	 0.61 dB 0.91 dB 0.93 dB 0.63 dB 0.92 dB 1 dB	Comparison to Agilent N5183A Signal Generator
Phase Modulation - Source [1] 100 kHz to 32 GHz	Rate: DC to 1 MHz DC to 4 MHz	0.59 % of reading + 0.01 rad	Comparison to Agilent N5183A Signal Generator

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LO Phase Noise @ 1GHz	(-50 to 20) dBc Frequency offset: (0.10 to 1 000) Hz (1 to 9 900) kHz	 0.48 dB 0.64 dB	Comparison to Keysight E4440A Spectrum Analyzer
Amplitude Modulation [1] - Source 100 kHz to 32 GHz	Rate: DC to 10 kHz Depths: (1 to 90) %	4.1 % of reading	Comparison to Agilent N5183A Signal Generator
Amplitude Modulation - Measure [1] 100 kHz to 10 MHz 10 MHz to 3 GHz 10 MHz to 3 GHz (3 to 26.5) GHz (3 to 26.5) GHz	 Rate: 20 Hz to 10 kHz Depths: (5 to 99) % Rate: 50 Hz to 100 kHz Depths: (20 to 99) % Rate: 50 Hz to 100 kHz Depths: (5 to 20) % Rate: 50 Hz to 100 kHz Depths: (20 to 99) % Rate: 50 Hz to 100 kHz Depths: (5 to 20) %	 0.83 % of reading 0.59 % of reading 2.6 % of reading 1.6 % of reading 4.7 % of reading	Comparison to Agilent N5531S Measuring Receiver with N5532A Sensor Modules
Pulse Generation – Source [1] Repetition Frequency: 0.10 Hz to 10.0 MHz	30 ns to 42 s	10 ns	Agilent N5183A Signal Comparison to Generator
Frequency Modulation [1] - Source 100 kHz to 32 GHz	1 dB Rate: DC to 3 MHz 3 dB Rate: DC to 7 MHz	2 % of setting + 20 Hz	Comparison to Agilent N5183A Signal Generator

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Phase Modulation-Measure [1]			
100 kHz to 6.6 GHz	Rate: 200 Hz 20 kHz Dev.: > 0.7 rad	1.1 % of reading	
100 kHz to 6.6 GHz	Rate:200 Hz, 20 kHz Dev.>0.3 rad	3.1 % of reading	
(6.6 to 13.2) GHz	Rate: 200 Hz 20 kHz Dev.: > 2.0 rad	1.1 % of reading	Comparison to Agilent N5531S Measuring Receiver with N5532A Sensor Modules
(6.6 to 13.2) GHz	Rate: 200 Hz 20 kHz Dev.: > 0.6 rad	3.1 % of reading	
(13.2 to 26.5) GHz	Rate: 200 Hz 20 kHz Dev.: > 2.0 rad	1.1 % of reading	
(13.2 to 26.5) GHz	Rate: 200 Hz 20 kHz Dev.: > 0.6 rad	3.1 % of reading	
Freq Modulation-Measure [1] Freq. Dev. Mod Rate Ratio >0.2			
250 kHz to 10 MHz	Rate: 20 Hz to 10 kHz Dev.: 200 Hz to 40 kHz peak Freq. Dev. Mod Rate Ratio >0.2	1.6 % of reading	
250 kHz to 10 MHz	Rate: 20 Hz to 10 kHz Dev.: 200 Hz to 40 kHz peak Freq. Dev. Mod Rate Ratio >1.2	1.1 % of reading	Comparison to Agilent N5531SMeasuring Receiver with N5532A Sensor Modules
10 MHz to 6.6 GHz	Rate: 50 Hz to 200kHz Dev.: 250 Hz to 400 kHz peak Freq. Dev. Mod Rate Ratio >0.2	1.6 % of reading	

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Electrical – RF/Microwave **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Freq Modulation-Measure [1] Freq. Dev. Mod Rate Ratio >0.2 10 MHz to 6.6 GHz	Rate: 50 Hz to 200kHz Dev.: 250 Hz to 400 kHz peak Freq. Dev. Mod Rate Ratio >0.45	1.1 % of reading	Comparison to Agilent N5531SMeasuring Receiver with N5532A Sensor Modules
(6.6 to 13.2) GHz	Rate: 50 Hz to 200kHz Dev.: 250 Hz to 400 kHz peak Freq. Dev. Mod Rate Ratio >0.2	2.6 % of reading	
(6.6 to 13.2) GHz	Rate: 50 Hz to 200kHz Dev.: 250 Hz to 400 kHz peak Freq. Dev. Mod Rate Ratio >8	1.1 % of reading	
(13.2 to 26.5) GHz	Rate: 50 Hz to 200kHz Dev.: 250 Hz to 400 kHz peak Freq. Dev. Mod Rate Ratio >0.2	3.9 % of reading	
(13.2 to 26.5) GHz	Rate: 50 Hz to 200kHz Dev.: 250 Hz to 400 kHz peak	1.1 % of reading	

Length – Dimensional Metrology **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Angle	(0.25 to 365)°	2.4 arc sec	Comparison to Gage Blocks, Gage Amplifier, Sine Bar

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Length – Dimensional Metrology **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Angle Plates – Squareness [2]	Up to 18 in	0.32 m° (5.6 µin/ in)	Comparison to Gage Amplifier with probe, Master Square(s)
Gage Blocks [2]	(0.01 to 1) in (2 to 3) in 4 in	(1.1 + 0.4*L*) µin (1.2 + 0.7*L*) µin 4.6 µin	Comparison to Gage Blocks Gage Block Comparator
	(5 to 20) in	(0.96 + 1.2*L*) µin	Comparison to Horizontal Measuring Machine
	100 mm (125 to 500) mm	0.17 µm (0.06 + 0.000 6*L*) µm	Comparison to Comparison to Primary Master Gage Blocks
Indicators [1,2]	(0.000 1 to 6) in	(5+8*L*) µin	Comparison to Horizontal Measuring Machine
Calipers [1,2]	Up to 60 in (60 to 80) in	(5+8*L*) µin (410 + 2*L*) µin	Comparison to Gage Blocks
Micrometers OD [1,2] Anvil Flatness	Up to 12 in (12 to 24) in Up to 1 in*D* (0 to 84) µin	(5+8*L*) µin (34 + 4.6*L*) µin 4 µin	Comparison to Gage Blocks, Optical Parallels
Height Measuring Devices [1,2]	Up to 36 in (36 to 48) in	(43 + 1.7*L*) µin (7 + 3*L*) µin	Comparison to Gage Blocks
Grind Gages	Up to 100 mm	0.35 mm	Comparison to Digital Indicator
Coating Thickness Gages [1,2]	Up to 0.02 in	58 µin + 0.6*R*	Comparison to Coating Thickness Standards
Coating Thickness Gage Standards	Up to 0.10 in	21 µin	Comparison to Horizontal Measuring Machine
External Diameter [1,2]	(0.000 1 to 1) in (1 to 12) in	(3 + 1*L*) µin (3 + 3*L*) µin	Comparison to Horizontal Measuring Machine
Internal Diameter [1,2]	(0.04 to 13) in	(3 + 3*L*) µin	Comparison to Horizontal Measuring Machine
Thread Plugs [1,2] Pitch Diameter Major Diameter	Up to 8 in Pitch (0.2 to 5) mm Pitch 90 – 4 TPI Up to 4 in	(81 + 2.3*L*) µin (3.5 + 4.6*L*) µin	Comparison to Horizontal Measuring Machine Thread Measuring Wires

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thread Rings (Adjustable) Pitch Diameter Tactile Fit (Set to Plug)	Up to 4 in	See footnote[5]	Comparison to Thread Setting Plug
Optical Comparators[1,2] Linear Accuracy Magnification	 Up to 6 in 6 to 12 in (5 to 100) X	 (43 + 11*L*) µin (30 + 7.5*L*) µin 350 µin	Comparison to Glass Scale Glass Scale (Sphere)
Surface Plates [1,2] Overall Flatness Local Area Flatness	 Up to 54 in*DL* (54 to 238) in*DL* Up to 238 in*DL*	 (17 + 0.7*DL*) µin (1 + 1.4*DL*) µin 34 µin	Comparison to Laser System Repeat-O-Meter
Roundness/Cylindricity Artifacts	Up to 150 mm	0.02 µm	Comparison to Rondcom41c
Surface Finish Artifacts	Up to 118 µin 118.1 to 500 µin	0.5 µin + 1 % of nominal 0.6 µin + 1.1 % of nominal	Comparison to Profilometer, Master Patch
Profilometers [1]	Up to 500 µin	0.7 µin + 1.1 % of nominal	Comparison to Master Patch
Optical Flats Parallelism Flatness	Up to 6 in*D* (0 to 80) µin	 2.7 µin 3.5 µin	Gage Block Comparator, Master Flat
CMMs [1,2] Linearity Volumetric Repeatability	(0 to 144) in (6 to 24) in (0.5 to 2) in	(25 + 2.4*L*) µin 66 µin 45 µin	Comparison to Laser Measuring System Ball Bar CMM Sphere
VMMs [1,2]	Linearity	(32 + 4.1*L*) µin	Comparison to Glass Scales
Graduated Scales [1,2] Glass, Steel, Tape	Up to 12 in (1 to 200) ft	(40 + 1*L*) µin (10+ 3*L*) µin	Comparison to Laser Measuring System
Horizontal Measuring Systems [1,2]	Up to 8 in (8 to 60) in	(6 + 1.7*L*) µin (3 + 2.5*L*) µin	Comparison to Gage Blocks

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Length – Dimensional Metrology **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Bore Gages [2] 2-point 3-point	(0.24 to 9) in	(4.3 + 3*L*) µin + 0.6*R* (85 + 7*L*) µin + 0.6*R*	Comparison to Horizontal Measuring Machine Cylindrical Rings
Protractors	(0 to 90)º	0.16º	Comparison to Sine Bar, Gage Blocks
Chamfer Gages [2]	(0.179 to 2.749) in	280 µin + 0.6*R*	Comparison to Chamfer Rings
Cylindrical Squares - Squareness Cylindricity	Up to 12 in	1.5 arc seconds 0.02 µm	Comparison to Gage Amplifier w/ probe, Master Square(s) Roundness Machine
Feeler/Thickness Gages [2]	Up to 0.2 in	(4.3 + 3*L*) µin	Comparison to Horizontal Measuring System
Gage Amplifier w/ Probe(s)	Up to 0.1 in	10 µin	Comparison to Gage Blocks
Gage Balls/Spheres [2] – Diameter Roundness	Up to 6 in	(4.3 + 3*D*) µin 0.02 µm	Comparison to Gage Blocks, Horizontal Measuring System Roundness Machine
Indicator Calibrator [2] - Linearity	Up to 6 in	60 µin + 0.6*R*	Comparison to Horizontal Measuring System
Groove Micrometers [2]	Up to 12 in	(44 + 2.6*L*) µin+ 0.6*R*	Comparison to Gage Blocks
Machinist Levels [2] – Zero Check Linearity	Up to 24 in	350 µin (100 + 0.83*L*) µin	Comparison to Master Level Gage Blocks
Microscopes, Stereo Reticle Linearity	Up to 2 in	870 µin	Comparison to Stage Micrometer
Microscopes – Toolmakers [2] Scale Linearity	Up to 4 in	(774 + 70*L*) µin + 0.6*R*	Comparison to Stage Micrometer
Length Standards [2]	(1 to 60) in	(3.4 + 3.5*L*) µin	Comparison to Horizontal Measuring System

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Length – Dimensional Metrology **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Micrometers – Inside [2]	Up to 8 in 8 to 60 in	(6 + 1.7*L*) µin (3 + 2.5*L*) µin	Comparison to Horizontal Measuring System
Pi Tapes [2] – Length Thickness	 Up to 12 in (12 to 200) in	 (40 + 1*L*) µin (10+ 3*L*) µin 240 µin	 Comparison to Laser System Micrometer
Parallels [2] – Steel Granite	 Up to 18 in 	 (96 + 1.8*L*) µin (49 + 0.7*L*) µin	 Comparison to Electronic Amplifier with Probe Surface Plate
Pitch Micrometer Standard [2] Length Angle	 (1 to 65) in 60°	 (3.4 + 3.5*L*) µin 0.004° (70 µin/ in)	 Horizontal Measuring System Vision System
Radius Gages	(0.015 625 to 0.5) in	300 µin	Comparison to Vision System
Sine Plates/Bars [2] – Top Surface Flatness Overall Length	 Up to 0.1 in Up to 10 in	 (41 + 2.2*L*) µin (3.4 + 3.5*L*) µin	 Comparison to Electronic Amplifier with Probe Horizontal Measuring System
Squares [2]	Up to 18 in	0.32 m° (5.6 µin/ in)	Comparison to Electronic Amplifier with Probe, Master Square
Straightness and Straight Edges [2]	Up to 60 in	(208 + 2.3*L*) µin	Comparison to Electronic Amplifier with Probe, Surface Plate
Tapered Plugs [2] - Pitch Diameter Major Diameter Step Height	(0.0625 to 6) in	(137 + 3.3*L*) µin (123 + 6.7*L*) µin 280 µin	Comparison to Horizontal Measuring System, Sine Block Thread Wires Height Gage
Roundness Machine - Roundness (Spindle Performance)	Up to 0.016 in	15 µin	Comparison to Master Sphere

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Length – Dimensional Metrology **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Tapered Rings - Pitch Diameter Step Height	(0.0625 to 6) in	160 µin 5 µin	Comparison to NPT Master Plug, Electronic Amplifier with Probe Height Gage
Thickness Gages [2] - Dial Digital	Up to 1 in	410 µin + 0.6*R* 44 µin+ 0.6*R*	Comparison to Gage Blocks
Thread Micrometers [2] (Screw Thread, Pitch Point) Linearity Anvil Wear	Up to 12 in	(44 + 2.6*L*) µin + 0.6*R* 690 µin	Comparison to Gage Blocks Thread Setting Plug
Granite V Blocks - Side Parallelism V Parallelism Squareness	Up to 12 in	(51 + 0.47*L*) µin	Comparison to Electronic Amplifier with Probe, Surface Plate
Extensometers [1]	Up to 2 in	16 µin	Comparison to Extensometer Calibrator
Extensometers [1] Gage Length	(0 to 2) in	78 µin	Comparison to Caliper

Mass and Mass Related **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force [1] Source and Measure	(0.035 to 16) ozf (1 to 10) lbf (10 to 50) lbf (50 to 500) lbf	0.017 % of reading 0.018 % of reading 0.018 % of reading 0.036 % of reading	Comparison to Dead Weight
	(500 to 100 000) lbf	0.04 % of reading	Comparison to Load Cells
	(30 000 to 400 000) lbf	0.29 % of applied value	Comparison to Load Cells, Class A (compression only)
Test Machine Crosshead Displacement [1,2]	Up to 1 in (1 to 36) in	0.000 3 in (150 + 146*L*) µin	Comparison to Indicator Indicator/Gage Blocks

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Mass and Mass Related **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Cable Tensiometers	Up to 600 lb (600 to 2 000) lb	1.2 % of applied value 1.3 % of applied value	Comparison to Dead Weight Load Cells
Viscometers [1]	Up to 25 cP (25 to 1 500) cP (1 500 to 75 000) cP	0.33 % of reading 0.52 % of reading 0.55 % of reading	Comparison to Viscosity Standards
Pressure [1]	(10 to 17) psia	0.000 4 psi	Comparison to Pressure Calibrator
Pressure	(-14.5 to -0.5) psi (1 to 500) psi (500 to 10 000) psi	65 µpsi/psi 65 µpsi/psi 70 µpsi/psi	Comparison to Dead Weight Tester
Pressure	(0 to 2) inH2O (2 to 60) inH2O	0.000 35 inH2O 0.009 1 % of reading + 0.000 3 inH2O	Comparison to Fluke 7250LP Low Pressure Calibrator
Mass Flow (Gas)	(5 to 50 000) SCCM (0.5 to 50) SLPM (50 to 500) SLPM	0.25 % of reading 0.22 % of reading 0.2 % of reading	Comparison to Mesa Flow System
Air Velocity	30 FPM (40 to 60) FPM (60 to 150) FPM (150 to 275) FPM (275 to 9000) FPM	5.1 % of reading 2.6 % of reading 1.2 % of reading 0.99 % of reading 0.74 % of reading	Comparison to Wind Tunnel with Pitot Tube
Torque Tools [1]	(2 to 20) ozf·in (20 to 200) ozf·in (5 to 50) lbf·in (50 to 400) lbf·in (400 to 1000) lbf·in (80 to 250) lbf·ft (250 to 600) lbf·ft (600 to 2 000) lbf·ft	0.1 % of reading + 0.006 1 ozf·in 0.08% of reading + 0.14 ozf·in 0.33 % of reading 0.36 % of reading 0.4 % of reading 0.28 % of reading 0.51 % of reading 0.75 % of reading	Comparison to Torque Tester
Torque Transducers [1]	0.5 ozf·in to 1 000 lbf·ft (1 000 to 2 000) lbf·ft	0.08 % of reading 0.09 % of reading	Comparison to Dead Weight Torque Arms
Graduated Cylinders	(1 to 200) mL (100 to 1 000) mL (600 to 6 000) mL	1.9 µL 3.2 µL 26 µL	Comparison to Balances

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Mass and Mass Related **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pipettes	Up to 1 µL (1 to 5) µL (5 to 10) µL (10 to 20) µL (20 to 50) µL (50 to 100) µL (100 to 200) µL (200 to 500) µL (500 to 1 000) µL (1 000 to 10 000) µL (10 to 20) mL	0.041 µL 0.033 µL 0.028 µL 0.034 µL 0.046 µL 0.061 µL 0.27 µL 0.3 µL 0.79 µL 2.7 µL 5.8 µL	Comparison to Pipette Calibration System
Scales and Balances [1,6]	Up to 5 mg (5 to 500) mg 500 mg to 5 g (5 to 10) g (10 to 20) g (20 to 50) g (50 to 100) g (100 to 250) g	0.005 mg 0.006 mg 0.007 mg 0.012 mg 0.014 mg 0.024 mg 0.086 mg 0.092 mg	Comparison to OIML E2 Class 1 Weights
Scales and Balances [1,6]	250 g to 1.1 kg (1.1 to 6.1) kg (6.1 to 33) kg	1.4 mg 9 mg 90 mg	Comparison to OIML E2 Class 1 Weights
	(0.5 to 2 000) lb	0.01 % of reading	Comparison to Class 6 Weights
Mass	1 mg to 50 g (50 to 100) g (100 to 250) g (250 to 500) g (500 to 1 kg (1 to 6) kg (6 to 25) kg	0.01 mg 0.03 mg 0.12 mg 0.17 mg 0.9 mg 9 mg 90 mg	Comparison to Class 1 Weights
Microindentation Hardness Testers [1] (Knoop and Vickers)	Repeatability under forces (gf): 100 ≤ HK ≥ 500 HV = 100	 2.1 % of Reading 4.1 % of Reading	Indirect Verification to Test Blocks

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Brinell Hardness Testers [1]	Repeatability at: 500 kgf ≤ 100 HBW ≥ 64 HBW 1 500 kgf ≤ 257 HBW ≥ 91 HBW 3 000 kgf ≤ 587 HBW ≥ 186 HBW	 0.025 mm 0.025 mm 0.025 mm 0.03 mm 0.025 mm 0.025 mm	Indirect Verification to Test Blocks
Rockwell Hardness Testers [1]	HRA Low HRA Middle HRA High HRBW Low HRBW Middle HRBW High HRC Low HRC Middle HRC High HREW Low HREW Middle HREW High HRMW Low HRMW Middle HRMW High HR15N Low HR15N Middle HR15N High HR15TW Low HR15TW Middle HR15TW High	0.69 HRA 0.62 HRA 0.36 HRA 0.71 HRBW 0.53 HRBW 0.9 HRBW 0.54 HRC 0.7 HRC 1.2 HRC 0.49 HREW 0.39 HREW 0.88 HREW 0.65 HRMW 0.55 HRMW 0.65 HRMW 0.69 HR15N 0.69 HR15N 0.36 HR15N 0.87 HR15TW 0.72 HR15TW 0.72 HR15TW	Indirect Verification to Test Blocks

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Mass and Mass Related **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Rockwell Hardness Testers [1]	HR30N Low HR30N Middle HR30N High HR30TW Low HR30TW Middle HR30TW High HR45N Low HR45N Middle HR45N High HR45TW Low HR45TW Middle HR45TW High	0.87 HR30N 0.91 HR30N 0.36 HR30N 0.54 HR30TW 0.72 HR30TW 0.39 HR30TW 0.64 HR45N 1.2 HR45N 0.34 HR45N 0.92 HR45TW 0.92 HR45TW 0.61 HR45TW	Indirect Verification to Test Blocks
Durometers Spring Force Types A, B, E, O Types C, D, and DO Types M, OO, OOO, OOO-S Indenter Angle Indenter Length Indenter Radius	 Up to 100 Duro Up to 100 Duro Up to 100 Duro (20 to 40)° (0.049 to 0.198) in (0.05 to 0.1) in	 0.31 Duro 0.15 Duro 0.32 Duro 0.004° 220 µin 250 µin	Full Direct Verification Shore Durometer Calibrator Balance VMM

Thermodynamic **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature - Measure	(-200 to -20) ºC (-20 to 120) ºC (120 to 200) ºC (200 to 300) ºC (300 to 660) ºC	0.006 2 ºC 0.001 7 ºC 0.023 ºC 0.023 ºC 0.024 ºC	Comparison to Fluke 5699 SPRT Fluke 1590 Super Thermometer

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Thermodynamic **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Source	(-95 to -20) ºC (-20 to 120) ºC (120 to 425) ºC (425 to 660) ºC	0.032 ºC 0.001 7 ºC 0.038 ºC 0.063 ºC	***Comparison to*** SPRT, Fluke 1590 Super Thermometer With liquid baths and Metrology Well
Radiation (Infrared) Thermometers	(-15 to 0) ºC (0 to 100) ºC (100 to 200) ºC (200 to 350) ºC (350 to 500) ºC	0.54 ºC 0.69 ºC 1.1 ºC 1.6 ºC 2.4 ºC	Comparison to Fluke 4180 and 4181 Black Body Calibrators λ = (8 to 14) µm, ε = (0.9 to 1.0)
Humidity Measure [1]	(0 to 2) %RH (5 to 10) %RH (10 to 50) %RH (50 to 90) %RH (90 to 95) %RH	1.2 %RH 0.56 %RH 0.5 %RH 0.55 %RH 0.58 %RH	Comparison to Humidity Indicator
Humidity Source	0 %RH (5 to 10) %RH (10 to 98) %RH	0.62 %RH 0.56 %RH 0.5 % of reading	Comparison to Nitrogen with Rotronic Humidity Indicator Thunder Scientific 2900

Time and Frequency **Burnsville, MN**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Reference [4]	10 MHz	5 x 10^{-11} MHz	Comparison to SRS FS Rubidium GPS Disciplined Oscillator

DIMENSIONAL MEASUREMENT

2 Dimensional **Burnsville, MN**

Specific Tests and / or Properties Measured	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Angle	(0.25 to 365)°	0.69m° (12 µin/ in)	Comparison to Gage Blocks, Gage Amplifier, Sine Bar

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2 Dimensional **Burnsville, MN**

Specific Tests and / or Properties Measured	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Angle	(0.25 to 365)°	0.004°	Comparison to Coordinate Measuring Machine
Non-contact	(12 x 8 x 4) in	(44 + 1*L*) µin	Comparison to Vision System
Roundness/Cylindricity	Up to 150 mm	0.02 µm	Comparison to Rondcom41c
Surface Finish Analysis	Up to 118 µin (118.1 to 500) µin	0.5 µin + 1 % of nominal 0.6 µin + 1.1 % of nominal	Comparison to Profilometer, Master Patch

3 Dimensional **Burnsville, MN**

Specific Tests and / or Properties Measured	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Dimensional Inspection Contact	(28 x 40 x 28) in	(74 + 4.7*L*) µin	Comparison to Coordinate Measuring Machine

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CALIBRATION

Chemical Quantities **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters [1]	4 pH 7 pH 10 pH	0.016 pH 0.016 pH 0.016 pH	Comparison to Buffer Solutions

Electrical – DC/Low Frequency **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source [1] fixed point	10V	0.3 µV/V	Comparison to 732BVoltage Standards with Fluke Maps
DC Voltage – Source [1]	0V Up to 1 mV (1 to 10) mV (10 to 100) mV (100 mV to 1) V (1 to 10) V (10 to 100) V (100 to 1 100) V	20 nV 100 nV 22 µV/V + 25 nV 5.3 µV/V 0.5 µV/V 0.31 µV/V 0.35 µV/V 1 µV/V	Comparison to MI Potentiometer/ Divider & Fluke 5720A Multi Product Calibrator
DC Voltage – Measure [1]	0V Up to 1 mV (1 to 10) mV (10 to 100) mV (100 mV to 1) V (1 to 10) V (10 to 100) V (100 to 1 100) V	20 nV 100 nV 22 µV/V + 25 nV 5.3 µV/V 0.5 µV/V 0.31 µV/V 0.35 µV/V 1 µV/V	*Comparison to Nano Voltmeter, Fluke 732BVoltage Standard with MI Potentiometer/ Divider*
DC Voltage – Measure [1]	(1.05 to 100) kV	0.1 % of reading	Comparison to Hipotronics KVM100-A High Voltage Meter

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source & Measure [1]	Up to 100 nA (0.1 to 1) µA (1 to 10) µA (10 to 100) µA (0.1 to 1) mA (1 to 10) mA (10 to 100) mA (0.1 to 1) A	22 pA 30 µA/A 6.8 µA/A 6.2 µA/A 4.1 µA/A 4.2 µA/A 3.9 µA/A 17 µA/A	Comparison to Standard resistors and DMM and Multifunction Calibrator
DC Current – Source & Measure [1]	(1 to 10) A (10 to 20) A (20 to 100) A	80 µA/A + 80 µA 80 µA/A + 800 µA 80 µA/A + 40 mA	Comparison to Fluke 52120A Amplifier
DC Current – Source [1]	(100 to 150) A (150 to 1 025) A	5 mA/A + 20 mA 5.1 mA/A + 0.9 A	Comparison to Fluke 5520A Multi Product Calibrator with 50-turn Coil
AC Voltage – Source & Measure [1]	(0 to 2.2) mV (10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz (2.2 to 7) mV (10 to 20) Hz (20 to 40) Hz (0.04 to 20) kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz (0.5 to 1) MHz	 0.035 % of reading + 1.3 µV 0.037 % of reading + 1.3 µV 0.04 % of reading + 1.3 µV 0.025 % of reading + 2 µV 0.027 % of reading + 2.5 µV 0.033 % of reading + 4 µV 0.036 % of reading + 8 µV 0.02 % of reading + 8 µV 0.023 % of reading + 1.3 µV 0.024 % of reading + 1.3 µV 0.022 % of reading + 1.3 µV 0.014 % of reading + 2 µV 0.009 % of reading + 2.5 µV 0.029 % of reading + 4 µV 0.055 % of reading + 8 µV 0.056 % of reading + 8µV	Comparison to Fluke 5790A AC Standard w/ 5720A Multi Product Calibrator
AC Current – Source and Measure[1]	Up to 10 mA (0.01 to 100) kHz (10 to 20) mA (0.01 to 100) kHz (20 to 200) mA (0.01 to 100) kHz	 250 µA/A 250 µA/A 250 µA/A	Comparison to Fluke 5720A Multi Product Calibrator and Fluke 5725A Amplifier w/ A40B Shunts

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Electrical – DC/Low Frequency **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source and Measure [1]	(0.2 A to 20) A 0.01 to 1) kHz (1 to 10) kHz (10 to 30) kHz (30 to 100) kHz	 250 µA/A 250 µA/A 300 µA/A 350 µA/A	Comparison to Fluke 5720A Multi Product Calibrator and Fluke 5725A Amplifier w/ A40B Shunts
AC Current – Source and Measure [1]	(20 to 100) A	0.015 % of reading	Comparison to Fluke 52120A Amplifier
AC Current – Source [1] (45 to 65) Hz (65 to 440) Hz	 (10 to 16.5) A (16.5 to 150) A (150 to 1 025) A (10 to 16.5) A (16.5 to 150) A (150 to 1 025) A	 5.9 mA/A + 30 mA 5.7 mA/A + 25 mA 5.7 mA/A + 0.9 A 11 mA/A + 30 mA 10 mA/A + 0.25 A 13 mA/A + 0.9 A	Comparison to Fluke 5520A Multi Product Calibrator with 50-turn Coil
AC Current – Measure [1]	Up to 200 µA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz 200 µA to 2 mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz (2 to 20) mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz (20 to 200) mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz 200 mA to 2 A 10 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz	 0.62 mA/A 0.54 mA/A 0.94 mA/A 8.4 mA/A 0.6 mA/A 0.54 mA/A 0.94 mA/A 4.2 mA/A 0.6 mA/A 0.54 mA/A 0.94 mA/A 4.2 mA/A 0.57 mA/A 0.49 mA/A 0.83 mA/A 0.83 mA/A 0.93 mA/A 3.2 mA/A	Comparison to Fluke 8508A Multimeter

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure [1]	(2 to 20) A 10 Hz to 2 kHz (2 to 10) kHz	1 mA/A 2.7 mA/A	Comparison to Fluke 8508A Multimeter
Resistance – Source [1]	0.001 Ω 0.01Ω 0.1 Ω 1Ω 10Ω 100 Ω 1 kΩ 10 kΩ 100 kΩ 1 MΩ 10 MΩ 100 MΩ 1 GΩ	3.5 µΩ/Ω 4.3 µΩ/Ω 1.5 µΩ/Ω 0.85 µΩ/Ω 0.66 µΩ/Ω 1.7µΩ/Ω 1.2 µΩ/Ω 2.4 µΩ/Ω 0.57 µΩ/Ω 1.3 µΩ/Ω Ω 14 µΩ/Ω 130 µΩ/Ω 0.32 µΩ/Ω	Comparison to Standard resistors
Resistance – Source [1]	(0.01 to 10) MΩ (0.01 to 10) GΩ	10 µΩ/Ω 0.5 % of reading	Comparison to Decade resistors with bridge and DMM
Resistance – Source [1]	(10 to 100) GΩ	1.2 % of reading	Comparison to Decade Resistor
Resistance – Measure [1] Normal Mode	(10 to 100) µΩ (0.1 to 1) mΩ (1 to 10) mΩ (10 o 100) mΩ (0.1 to 1) Ω (1 to 10) Ω (10 to 100) Ω (0.01 to 1) kΩ (1 to 10) kΩ (10 o 100) kΩ (0.1 to 1) MΩ (1 to 10) MΩ (10 to 200) MΩ (0.2 to 2) GΩ (2 to 20) GΩ	0.15 % of reading 15 µΩ/Ω 5.1 µΩ/Ω 1.8 µΩ/Ω 0.92 µΩ/Ω 0.74 µΩ/Ω 1.7 µΩ/Ω 1.3 µΩ/Ω 2.4 µΩ/Ω 1.1 µΩ/Ω 8.2 µΩ/Ω 21µΩ/Ω 72µΩ/Ω + 1kΩ 0.18 mΩ/Ω + 100 kΩ 0.67 mΩ/Ω + 10 MΩ	Comparison to Decade resistors with bridge and DMM

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Measure [1] High Voltage Mode up to 200 V	(2 to 20) MΩ (20 to 200) MΩ 200 MΩ to 2 GΩ (2 to 20) GΩ	15 μΩ/Ω + 10 Ω 60 μΩ/Ω + 1 kΩ 0.15 mΩ/Ω + 100 kΩ 0.53 mΩ/Ω + 10 MΩ	Comparison to Decade resistors with bridge and DMM
Capacitance – Measure [1]	1 pF @ 1 kHz 10 pF @ 1 kHz 100 pF @ 1kHz 1 nF 1kHz 1 μF @ 1 kHz	1.9 mF/F 1.1 mF/F 1.2 mF/F 1.2 mF/F 1.2 mF/F	Comparison to QuadTech 1730 LCR Meter
Capacitance – Source [1] (fixed values) @ 100 Hz @ 1 kHz	1 pF 1 nF 10 nF 100 nF 1 μF	1.8 mF/F 0.23 mF/F 0.25 mF/F 0.21 mF/F 0.25 mF/F	Comparison to Standard Capacitors
Capacitance – Source [1] 10 Hz to 10 kHz 10 Hz to 3 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz 10 Hz to 1 kHz (10 to 600) Hz 10 Hz to 300 Hz 10 Hz to 150 Hz 10 Hz to 120 Hz 10 Hz to 80 Hz (0 to 50) Hz (0 to 20) Hz (0 to 6) Hz (0 to 2) Hz (0 to 0.6) Hz (0 to 0.2) Hz	 0.19 nF to 1.1 nF (1.1 to 3.3) nF (3.3 to 11) nF (11 to 110) nF (110 to 330) nF 330 nF to 1.1 μF (1.1 to 3.3) μF (3.3 to 11) μF (11 to 33) μF (33 to 110) μF (110 to 330) μF 330 μF to 1.1 mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	 15 mF/F 8.4 mF/F 3.6 mF/F 3.6 mF/F 3.7 mF/F 3.6 mF/F 3.6 mF/F 3.6 mF/F 5.1 mF/F 5.6 mF/F 5.6 mF/F 8.7 mF/F 5.5 mF/F 5.5 mF/F 8.5 mF/F 12 mF/F	Comparison to Fluke 5520A Multi Product Calibrator
Inductance – Measure [1]	100 μH @ 1 kHz 1 mH @ 1 kHz 10 mH @ 1 kHz 100 mH @ 1 kHz 1 H @ 1 kHz	1.2 mH/H	Comparison to QuadTech 1730 LCR Meter

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Electrical – DC/Low Frequency **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Source [1]	500 µH @ 100 Hz 500 µH @ 1 kHz 2 mH @ 100 Hz 2 mH @ 1 kHz 20 mH @ 100 Hz 20 mH @ 1 kHz	1.2 mH/H 1 mH/H 1.1 mH/H 1 mH/H 1.1 mH/H 1 mH/H	Comparison to Standard Inductors
Inductance – Source [1]	1 H @ 100 Hz 1 H @ 1 kHz 10 H @ 100 Hz 10 H @ 1 kHz	1 mH/H 1 mH/H 1 mH/H 1 mH/H	Comparison to Standard Inductors
Oscilloscopes [1] Square Wave Signal 50 Ω at 1 kHz Square Wave Signal 1 MΩ at 1 kHz	 40 µV to 5 V 40 µV to 5 V	 1 mV/V 1 mV/V	Comparison to Fluke 9500B/3200/9530 Oscilloscope Calibrator
Oscilloscopes [1] DC Voltage, 50 Ω DC Voltage, 1 MΩ Leveled Sine Wave Amplitude Leveled Sine Wave Flatness (relative to 50 kHz) Time Marker 50 Ω Source and Period Rise/Fall Time - Source Pulse Width - Source	 1 mV to 5 V 1 mV to 200 V 5 mV to 5 V 4.4 mVpp to 5.6 Vpp 0.1 Hz to 300 MHz (300 to 550) MHz 4.4 mVpp to 3.3 Vpp 550 MHz to 1.1 GHz (1.1 to 3.2) GHz 9 ns to 55 s 150 ps (1 to 100) ns	 0.26 mV/V 0.25 mV/V 15 mV/V 43 mV/V 43 mV/V 52 mV/V 52 mV/V 0.25 µs/s 27 ps 52 ms/s	Comparison to Fluke 9500B/3200/9530 Oscilloscope Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicators [1]	Type B		Comparison to Ectron 1140A Thermocouple Simulator
	(250 to 350) ºC	1.1 °C	
	(350 to 445) ºC	0.85 °C	
	(445 to 580) ºC	0.67 °C	
	(580 to 750) °C	0.52° C	
	(750 to 1 000) °C	0.43 °C	
	(1 000 to 1 820) °C	0.33° C	
	Type C		
	(0 to 250) ºC	0.23 ºC	
	(250 to 1 000) ºC	0.18 ºC	
	(1 000 to 1 500) ºC	0.21 ºC	
	(1 500 to 1 800) ºC	0.24 ºC	
	(1 800 to 2 000) ºC	0.27 ºC	
	(2 000 to 2 250) ºC	0.33 ºC	
	(2 250 to 2 315) ºC	0.37 ºC	
	Type E		
	(-270 to -245) ºC	1.4 ºC	
	(-245 to -195) ºC	0.21 ºC	
	(-195 to -155) ºC	0.12 ºC	
	(-155 to -90) ºC	0.09 ºC	
	(-90 to 15) ºC	0.08 ºC	
	(15 to 890) ºC	0.07 ºC	
	(890 to 1 000) ºC	0.08 ºC	
	Type J		
	(-210 to -180) ºC	0.14 ºC	
	(-180 to -120) ºC	0.12 ºC	
	(-120 to -50) ºC	0.09 ºC	
	(-50 to 990) ºC	0.08 ºC	
	(990 to 1 200) ºC	0.08 ºC	
	Type K		
	(-270 to -255) ºC	2.5 ºC	
	(-255 to -195) ºC	0.81 ºC	
	(-195 to -115) ºC	0.14 ºC	
	(-115 to -55) ºC	0.10 ºC	
	(-55 to 1 000) ºC	0.08 ºC	
	(1 000 to 1 372) ºC	0.09 ºC	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicators [1]	Type N		Comparison to Ectron 1140A Thermocouple Simulator
	(-270 to -260) ºC	5.8 ºC	
	(-260 to -200) ºC	1.2 ºC	
	(-200 to -140) ºC	0.27 ºC	
	(-140 to -70) ºC	0.17 ºC	
	(-70 to 25) ºC	0.14 ºC	
	(25 to 160) ºC	0.12 ºC	
	(160 to 1 300) ºC	0.1 ºC	
	Type R		
	(-50 to -30) ºC	0.75 ºC	
	(-30 to 45) ºC	0.63 ºC	
	(45 to 160) ºC	0.46 ºC	
	(160 to 380) ºC	0.35 ºC	
	(380 to 775) ºC	0.3 ºC	
	(775 to 1 768) ºC	0.25 ºC	
	Type S		
	(-50 to -30) ºC	0.71 ºC	
	(-30 to -45) ºC	0.64 ºC	
	(-45 to -105) ºC	0.46 ºC	
	(-105 to 310) ºC	0.38 ºC	
	(310 to 615) ºC	0.33 ºC	
	(615 to 1 768) ºC	0.3 ºC	
	Type T		
	(-270 to -255) ºC	2.1 ºC	
	(-255 to -240) ºC	0.56 ºC	
	(-240 to -210) ºC	0.35 ºC	
	(-210 to -150) ºC	0.21 ºC	
	(-150 to -40) ºC	0.14 ºC	
	(-40 to 100) ºC	0.09 ºC	
	(100 to 400) ºC	0.08 ºC	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicators [1]	PT 395 100 Ω		Comparison to Fluke 5520A Multi Product Calibrator
	(-200 to 0) ºC	0.06 ºC	
	(0 to 100) ºC	0.08 ºC	
	(100 to 300) ºC	0.11 ºC	
	(300 to 400) ºC	0.12 ºC	
	(400 to 630) ºC	0.14 ºC	
	(630 to 800) ºC	0.27 ºC	
	PT 3926 100 Ω		
	(-200 to 0) ºC	0.06 ºC	
	(0 to 100) ºC	0.08 ºC	
	(100 to 300) ºC	0.11 ºC	
	(300 to 400) ºC	0.12 ºC	
	(400 to 630) ºC	0.14 ºC	
	PT 3916 100 Ω		
	(-200 to -190) ºC	0.29 ºC	
	(-190 to -80) ºC	0.05 ºC	
	(-80 to 0) ºC	0.06 ºC	
	(0 to 100) ºC	0.07 ºC	
	(100 to 260) ºC	0.08 ºC	
	(260 to 300) ºC	0.09 ºC	
	(300 to 400) ºC	0.11 ºC	
	(400 to 600) ºC	0.12 ºC	
	(600 to 630) ºC	0.27 ºC	
	PT 385 200 Ω		
	(-200 to 100) ºC	0.05 ºC	
	(100 to 260) ºC	0.06 ºC	
	(260 to 300) ºC	0.14 ºC	
	(300 to 400) ºC	0.15 ºC	
	(400 to 600) ºC	0.16 ºC	
	(600 to 630) ºC	0.19 ºC	
	PT 385 500 Ω		
	(-200 to -80) ºC	0.05 ºC	
	(-80 to 100) ºC	0.06 ºC	
	(100 to 260) ºC	0.07 ºC	
	(260 to 400) ºC	0.09 ºC	
	(400 to 600) ºC	0.01 ºC	
	(600 to 630) ºC	0.13 ºC	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicators [1]	PT 395 100 Ω		Comparison to Fluke 5520A Multi Product Calibrator
	(-200 to 0) ºC	0.06 ºC	
	(0 to 100) ºC	0.08 ºC	
	(100 to 300) ºC	0.11 ºC	
	(300 to 400) ºC	0.12 ºC	
	(400 to 630) ºC	0.14 ºC	
	(630 to 800) ºC	0.27 ºC	
	PT 3926 100 Ω		
	(-200 to 0) ºC	0.06 ºC	
	(0 to 100) ºC	0.08 ºC	
	(100 to 300) ºC	0.11 ºC	
	(300 to 400) ºC	0.12 ºC	
	(400 to 630) ºC	0.14 ºC	
	PT 3916 100 Ω		
	(-200 to -190) ºC	0.29 ºC	
	(-190 to -80) ºC	0.05 ºC	
	(-80 to 0) ºC	0.06 ºC	
	(0 to 100) ºC	0.07 ºC	
	(100 to 260) ºC	0.08 ºC	
	(260 to 300) ºC	0.09 ºC	
	(300 to 400) ºC	0.11 ºC	
	(400 to 600) ºC	0.12 ºC	
	(600 to 630) ºC	0.27 ºC	
	PT 385 200 Ω		
	(-200 to 100) ºC	0.05 ºC	
	(100 to 260) ºC	0.06 ºC	
	(260 to 300) ºC	0.14 ºC	
	(300 to 400) ºC	0.15 ºC	
	(400 to 600) ºC	0.16 ºC	
	(600 to 630) ºC	0.19 ºC	
	PT 385 500 Ω		
	(-200 to -80) ºC	0.05 ºC	
	(-80 to 100) ºC	0.06 ºC	
	(100 to 260) ºC	0.07 ºC	
	(260 to 400) ºC	0.09 ºC	
	(400 to 600) ºC	0.01 ºC	
	(600 to 630) ºC	0.13 ºC	

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Electrical – DC/Low Frequency **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicators [1]	PT 385 1 000 Ω (-200 to 0) ºC (0 to 100) ºC (100 to 260) ºC (260 to 300) ºC (300 to 600) ºC (600 to 630) ºC PtNi 120 Ω (-80 to 100) ºC (100 to 260) ºC Cu 427 10 Ω (-100 to 260) ºC	 0.04 ºC 0.05 ºC 0.06 ºC 0.07 ºC 0.08 ºC 0.27 ºC 0.09 ºC 0.16 ºC 0.35 ºC	Comparison to Fluke 5520A Multi Product Calibrator

Length – Dimensional Metrology **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gage Blocks [2]	(0.01 to 1) in (1 to 2) in 4 in	(1.4 + 1.3*L*) µin (1 + 1.3*L*) µin 9.4 µin	Comparison to Gage Blocks Gage Block Comparator
Gage Blocks [2]	100 mm (125 to 500) mm	0.17 µm (0.06 + 0.000 6*L*) µm	Comparison to Primary Master Gage Blocks
Indicators [1,2]	(0.000 1 to 6) in	(5+8*L*) µin	Comparison to Horizontal Measuring Machine
Calipers [1,2]	Up to 60 in (60 to 80) in	(5+8*L*) µin (410 + 2*L*) µin	Comparison to Gage Blocks
Micrometers OD [1,2] Anvil Flatness	Up to 12 in (12 to 24) in Up to 1 in*D* (0 to 84) µin	(5+8*L*) µin (34 + 4.6*L*) µin 4 µin	Comparison to Gage Blocks, Optical Parallels
Height Measuring Devices [1,2]	Up to 36 in (36 to 48) in	(45 + 2*L*) µin (7 + 3*L*) µin	Comparison to Gage Blocks
Grind Gages	Up to 100 mm	0.35 mm	Comparison to Digital Indicator
Coating Thickness Gages [1,2]	Up to 0.02 in	58 µin + 0.6*R*	Comparison to Coating Thickness Standards

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Length – Dimensional Metrology **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Coating Thickness Gage Standards	Up to 0.10 in	21 µin	Horizontal Measuring Comparison to Machine
External Diameter [1,2]	(0.000 1 to 12) in	(3 + 3*L*) µin	Comparison to Horizontal Measuring Machine
Internal Diameter [1,2]	(0.04 to 13) in	(3 + 3*L*) µin	Comparison to Horizontal Measuring Machine
Thread Rings (Adjustable) Pitch Diameter Tactile Fit (Set to Plug)	Up to 4 in	See footnote[5]	Comparison to Thread Setting Plug
Thread Plugs [1,2] Pitch Diameter Major Diameter	Up to 8 in Pitch (0.2 to 5) mm Pitch 90 – 4 TPI Up to 4 in	(87 + 1.9*L*) µin (3.5 + 4.6*L*) µin	Comparison to Horizontal Measuring Machine Thread Measuring Wires
Optical Comparators [1,2] Linear Accuracy Magnification	Up to 6 in 6 to 12 in (5 to 100) X	(43 + 11*L*) µin (30 + 7.5*L*) µin 350 µin	Comparison to Glass Scale Glass Scale (Sphere)
Surface Plates [1,2] Overall Flatness Local Area Flatness	Up to 238 in*DL* Up to 238 in*DL*	(25 + 2.9*L*) µin 34 µin	Comparison to Laser System Repeat-O-Meter
Surface Finish Artifacts	Up to 500 µin	2.4 µin	Comparison to Profilometer, Master Patch
Profilometers [1]	Up to 500 µin	3.1 µin	Comparison to Master Patch
Optical Flats Parallelism Flatness	Up to 6 in*D* (0 to 80) µin	2.7 µin 3.5 µin	Comparison to Gage Block Comparator, Master Flat
CMMs [1,2] Linearity Volumetric Repeatability	(0 to 144) in (6 to 24) in (0.5 to 2) in	(25 + 2.4*L*) µin 66 µin 45 µin	Comparison to Laser Measuring System Ball Bar, CMM Sphere

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Length – Dimensional Metrology **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
VMMs [1,2]	Linearity	(32 + 4.1*L*) µin	Comparison to Glass Scales
Rulers and Pi Tapes	Up to 12 in	0.000 88 in	Comparison to Optical Slide w/ Indicator
Horizontal Measuring Systems [1,2]	Up to 8 in 8 to 60 in	(6 + 1.7*L*) µin (3 + 2.5*L*) µin	Comparison to Gage Blocks
Protractors	(0 to 90)º	0.16º	Comparison to Sine Bar, Gage Blocks
Length Standards [2]	(1 to 60) in	(3.4 + 3.5*L*) µin	Comparison to Horizontal Measuring System
Micrometers - Inside[2]	Up to 8 in 8 to 60 in	(6 + 1.7*L*) µin (3 + 2.5*L*) µin	Comparison to Horizontal Measuring System

Mass and Mass Related **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force [1] Source and Measure	(0.035 to 16) ozf (1 to 10) lbf (10 to 50) lbf (50 to 500) lbf	0.018 % of reading + 0.21 µozf 0.018 % of reading + 0.33 µlbf 0.018 % of reading + 9.3 mlbf 0.036 % of reading + 5.3 mlbf	Comparison to Dead Weight
	(500 to 1 000) lbf (1 000 to 10 000) lbf (10 to 100) klbf	0.05 % of reading 0.06 % of reading 0.06 % of reading	Comparison to Load Cells, Class AA
Force [1] Source and Measure	(30 000 to 400 000) lbf	0.29 % of applied value	Comparison to Load Cells, Class A (compression only)
Pressure [1]	(10 to 17) psia	0.000 4 psi	Comparison to Pressure Calibrator
Pressure [1]	(-14.5 to -0.5) psi (1 to 16 000) psi	65 µpsi/psi 65 µpsi/psi	Comparison to Deadweight Tester

Mass and Mass Related **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Torque Tools [1]	0.5 ozf·in to 200 ozf·in (5 to 50) lbf·in (50 to 400) lbf·in (400 to 1000) lbf·in (80 to 250) lbf·ft (250 to 600) lbf·ft (600 to 1 000) lbf·ft	0.56 % of reading 0.33 % of reading 0.36 % of reading 0.4 % of reading 0.28 % of reading 0.51 % of reading 0.75 % of reading	Comparison to Torque Tester
Scales and Balances [1,6]	Up to 5 mg (5 to 500) mg 500 mg to 5 g (5 to 10) g (10 to 20) g (20 to 50) g (50 to 100) g (100 to 250) g 250 g to 1.1 kg (1.1 to 6.1) kg (6.1 to 33) kg	0.005 mg 0.006 mg 0.007 mg 0.012 mg 0.014 mg 0.024 mg 0.086 mg 0.092 mg 1.4 mg 9 mg 90 mg	Comparison to OIML E2 Class 1 Weights
Scales and Balances [1,6]	(0.5 to 2 000) lb	0.01 % of reading	Comparison to Class 6 Weights
Indirect Verification of Microindentation Hardness Testers [1] (Knoop and Vickers)	Repeatability under forces (gf): 100 ≤ HK ≥ 500 HV = 100	 2.1 % of Reading 4.1 % of Reading	Indirect Verification to Test Blocks
Brinell Hardness Testers [1] Repeatability	500 kgf ≤ 100 HBW ≥ 64 HBW 1 500 kgf ≤ 257 HBW ≥ 91 HBW 3 000 kgf ≤ 587 HBW ≥ 186 HBW	 0.025 mm 0.025 mm 0.025 mm 0.03 mm 0.025 mm 0.025 mm	Indirect Verification to Test Blocks

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Mass and Mass Related **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Rockwell Hardness Testers [1]	HRA Low HRA Middle HRA High HRBW Low HRBW Middle HRBW High HRC Low HRC Middle HRC High	0.69 HRA 0.62 HRA 0.362 HRA 0.71 HRBW 0.53 HRBW 0.9 HRBW 0.54 HRC 0.7 HRC 0.38 HRC	Indirect Verification to Test Blocks

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Mass and Mass Related **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Rockwell Hardness Testers [1]	HREW Low HREW Middle HREW High HRMW Low HRMW Middle HRMW High HR15N Low HR15N Middle HR15N High HR15TW Low HR15TW Middle HR15TW High HR30N Low HR30N Middle HR30N High HR30TW Low HR30TW Middle HR30TW High HR45N Low HR45N Middle HR45N High HR45TW Low HR45TW Middle HR45TW High	0.49 HREW 0.39 HREW 0.88 HREW 0.65 HRMW 0.55 HRMW 0.65 HRMW 0.69 HR15N 0.69 HR15N 0.36 HR15N 0.87 HR15TW 0.72 HR15TW 0.72 HR15TW 0.87 HR30N 0.91 HR30N 0.36 HR30N 0.54 HR30TW 0.72 HR30TW 0.39 HR30TW 0.64 HR45N 1.2 HR45N 0.34 HR45N 0.92 HR45TW 0.92 HR45TW 0.61 HR45TW	Indirect Verification to Test Blocks
Durometers Spring Force Types A, B, E, O Types C, D, and DO Types OO, OOO, OOO-S Indenter Angle Indenter Length Indenter Radius	 (1.3 to 8.05) N (4.445 to 44.5) N (0.294 to 1.932) N (20 to 40) ° (0.049 to 0.198) in (0.05 to 0.1) in	 0.023 N 0.06 N 0.002 N 0.05 ° 220 µin 250 µin	Full Direct Verification Shore Durometer Calibrator Balance VMM

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Thermodynamic **Mundelein, IL**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature - Measure	(-200 to -20) ºC (-20 to 120) ºC (120 to 200) ºC (200 to 300) ºC (300 to 600) ºC	0.006 2 ºC 0.001 7 ºC 0.023 ºC 0.023 ºC 0.024 ºC	Comparison to Fluke 5699 SPRT Fluke 1590 Super Thermometer
Temperature – Source	(-20 to 120) ºC (120 to 425) ºC (425 to 660) ºC	0.001 7 ºC 0.038 ºC 0.063 ºC	***Comparison to*** SPRT Fluke 1590 Super Thermometer With liquid baths and Metrology Well
Radiation (Infrared) Thermometers	(50 to 100) ºC (100 to 200) ºC (200 to 250) ºC (250 to 300) ºC (300 to 400) ºC (400 to 500) ºC	0.8 ºC 0.93 ºC 0.96 ºC 1 ºC 1.1 ºC 1.2 ºC	Comparison to Black Body Calibrator Monitored with a PRT $\varepsilon = 0.95$, $\lambda = (8 \text{ to } 14)$ µm
Humidity Measure [1]	(10 to 90) %RH (95 to 98) %RH	1.1 %RH 2 %RH	Comparison to Humidity Indicator

DIMENSIONAL MEASUREMENT

2 Dimensional **Mundelein, IL**

Specific Tests and / or Properties Measured	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Non-contact	(6 x 8) in	(239 + 1.4*L*) µin	Comparison to Vision System
Surface Finish Analysis	Up to 500 µin	2.4 µin	Comparison to Profilometer, Master Patch

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3 Dimensional **Mundelein, IL**

Specific Tests and / or Properties Measured	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Dimensional Inspection Contact	(16 x 18 x 14) in	(209 + 1.2*L*) µin	Comparison to Coordinate Measuring Machine

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Services performed at satellite laboratory

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Eau Claire, WI 54703
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CALIBRATION AND DIMENSIONAL MEASUREMENT

CALIBRATION

Electrical – DC/Low Frequency **Eau Claire, WI**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source [1]	Up to 330 mV 330 mV to 3.3 V (3.3 to 33) V (33 to 330) V (330 to 1 020) V	21 µV/V + 1 µV 11 µV/V + 2 µV 13 µV/V + 20 µV 18 µV/V + 150 µV 18 µV/V + 1.5 mV	Comparison to 5522A Multi Product Calibrator
DC Voltage – Measure [1]	Up to 100 mV 100 mV to 1 V (1 to 10) V (10 to 100) V 100 V to 1 kV	12 µV/V + 0.3 µV 10 µV/V + 0.3 µV 10 µV/V + 0.5 µV 13 µV/V + 30 µV 13 µV/V + 100 µV	Comparison to Keysight 3458A Multimeter
DC Current – Source [1]	Up to 330 µA 330 µA to 3.3 mA (3.3 to 33) mA (33 to 330) mA 330 mA to 1.1 A (1.1 to 3) A (3 to 11) A (11 to 20) A	151 µA/A + 20 nA 101 µA/A + 50 nA 101 µA/A + 250 nA 102 µA/A + 2.5 µA 201 µA/A + 40 µA 386 µA/A + 40 µA 504 µA/A + 0.5 mA 1 mA/A + 0.75 mA	Comparison to 5522A Multi Product Calibrator
DC Current – Measure [1]	(10 to 100) µA 100 µA to 1 mA (1 to 10) mA (10 to 100) mA 100 mA to 1 A	29 µA/A + 0.8 nA 27 µA/A + 5 nA 28 µA/A + 50 nA 46 µA/A + 0.5 µA 121 µA/A + 10 µA	Comparison to Keysight 3458A Multimeter

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source	Up to 33 mV		Comparison to 5522A Multi Product Calibrator
	(10 to 45) Hz	806 µV/V + 6 µV	
	45 Hz to 10 kHz	176 µV/V + 6 µV	
	(10 to 20) kHz	220 µV/V + 6 µV	
	(20 to 50) kHz	1 mV/V + 6 µV	
	(50 to 100) kHz	3.5 mV/V + 12 µV	
	(100 to 500) kHz	8 mV/V + 50 µV	
	(33 to 330) mV		
	(10 to 45) Hz	302 µV/V + 8 µV	
	45 Hz to 10 kHz	148 µV/V + 8 µV	
	(10 to 20) kHz	163 µV/V + 8 µV	
	(20 to 50) kHz	353 µV/V + 8 µV	
	(50 to 100) kHz	804 µV/V + 32 µV	
	(100 to 500) kHz	2 mV/V + 70 µV	
	330 mV to 3.3 V		
	(10 to 45) Hz	302 µV/V + 50 µV	
	45 Hz to 10 kHz	153 µV/V + 60 µV	
	(10 to 20) kHz	192 µV/V + 60 µV	
	(20 to 50) kHz	302 µV/V + 50 µV	
	(50 to 100) kHz	703 µV/V + 125 µV	
	(100 to 500) kHz	2.4 mV/V + 0.6 mV	
	(3.3 to 33) V		
	(10 to 45) Hz	302 µV/V + 650 µV	
	45 Hz to 10 kHz	153 µV/V + 600 µV	
	(10 to 20) kHz	242 µV/V + 600 µV	
	(20 to 50) kHz	353 µV/V + 600 µV	
	(50 to 100) kHz	903 µV/V + 1.6 mV	
	(33 to 330) V		
	45 Hz to 1 kHz	194 µV/V + 2 mV	
	(1 to 10) kHz	204 µV/V + 6 mV	
	(10 to 20) kHz	253 µV/V + 6 mV	
	(20 to 50) kHz	314 µV/V + 6 mV	
	(50 to 100) kHz	2 mV/V + 50 mV	
	(330 to 1020) V		
	45 Hz to 1 kHz	302 µV/V + 10 mV	
	(1 to 5) kHz	252 µV/V + 10 mV	
	(5 to 10) kHz	302 µV/V + 10 mV	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure	Up to 10 mV		Comparison to Keysight 3458A Multimeter
	(1 to 40) Hz	300 µV/V + 3 µV	
	40 Hz to 1 kHz	219 µV/V + 1.1 µV	
	(1 to 20) kHz	324 µV/V + 1.1 µV	
	(20 to 50) kHz	1 mV/V + 6 µV	
	(50 to 100) kHz	5.1 mV/V + 1.1 µV	
	(100 to 300) kHz	41 mV/V + 2 µV	
	(10 to 100) mV		
	(1 to 40) Hz	70 µV/V + 4 µV	
	40 Hz to 1 kHz	83.8 µV/V + 2 µV	
	(1 to 20) kHz	157 µV/V + 2 µV	
	(20 to 50) kHz	308 µV/V + 2 µV	
	(50 to 100) kHz	878 µV/V + 2 µV	
	(100 to 300) kHz	3.1 mV/V + 10 µV	
	300 kHz to 1 MHz	10 mV/V + 10 µV	
	(1 to 2) MHz	15 mV/V + 10 µV	
	100 mV to 1 V		
	(1 to 40) Hz	70 µV/V + 40 µV	
	40 Hz to 1 kHz	80.7 µV/V + 20 µV	
	(1 to 20) kHz	154 µV/V + 20 µV	
	(20 to 50) kHz	327 µV/V + 20 µV	
	(50 to 100) kHz	825 µV/V + 20 µV	
	(100 to 300) kHz	3.1 mV/V + 0.1 mV	
	300 kHz to 1 MHz	10 mV/V + 0.1 mV	
	(1 to 2) MHz	15 mV/V + 0.1 mV	
	(1 to 10) V		
	(1 to 40) Hz	77 µV/V + 400 µV	
	40 Hz to 1 kHz	81 µV/V + 200 µV	
	(1 to 20) kHz	154 µV/V + 200 µV	
	(20 to 50) kHz	324 µV/V + 200 µV	
	(50 to 100) kHz	816 µV/V + 200 µV	
	(100 to 300) kHz	3.1 mV/V + 1 mV	
	300 kHz to 1 MHz	10 mV/V + 1 mV	
	(1 to 2) MHz	15 mV/V + 1 mV	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure	(10 to 100) V		Comparison to Keysight 3458A Multimeter
	(1 to 40) Hz	200 µV/V + 4 mV	
	40 Hz to 1 kHz	205 µV/V + 2 mV	
	(1 to 20) kHz	215 µV/V + 2 mV	
	(20 to 50) kHz	358 µV/V + 2 mV	
	(50 to 100) kHz	1.2 mV/V + 2 mV	
	(100 to 300) kHz	4 mV/V + 2 mV	
	300 kHz to 1 MHz	15 mV/V + 10 mV	
	(100 to 1 000) V		
	(1 to 40) Hz	400 µV/V + 40 mV	
	40 Hz to 1 kHz	405 µV/V + 20 mV	
	(1 to 20) kHz	600 µV/V + 20 mV	
	(20 to 50) kHz	1.2 mV/V + 20 mV	
	(50 to 100) kHz	3 mV/V + 20 mV	
AC Current – Measure	Up to 100 µA		Comparison to Keysight 3458A Multimeter
	(10 to 20) Hz	4 mA/A + 30 nA	
	(20 to 45) Hz	1.5 mA/A + 30 nA	
	(45 to 100) Hz	605 µA/A + 30 nA	
	100 Hz to 1 kHz	610 µA/A + 30 nA	
	100 µA to 1 mA		
	(10 to 20) Hz	4 mA/A + 0.2 µA	
	(20 to 45) Hz	1.5 mA/A + 0.2 µA	
	(45 to 100) Hz	605 µA/A + 0.2 µA	
	100 Hz to 5 kHz	325 µA/A + 0.2 µA	
	(5 to 20) kHz	605 µA/A + 0.2 µA	
	(20 to 50) kHz	4 mA/A + 0.4 µA	
	(50 to 100) kHz	5.5 mA/A + 1.5 µA	
	(1 to 10) mA		
	(10 to 20) Hz	4 mA/A + 2 µA	
	(20 to 45) Hz	1.5 mA/A + 2 µA	
	(45 to 100) Hz	605 µA/A + 2 µA	
	100 Hz to 5 kHz	325 µA/A + 2 µA	
	(5 to 20) kHz	605 µA/A + 2 µA	
	(20 to 50) kHz	4 mA/A + 4 µA	
	(50 to 100) kHz	5.5 mA/A + 15 µA	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure	(10 to 100) mA		Comparison to Keysight 3458A Multimeter
	(10 to 20) Hz	4 mA/A + 20 µA	
	(20 to 45) Hz	1.5 mA/A + 20 µA	
	(45 to 100) Hz	605 µA/A + 20 µA	
	100 Hz to 5 kHz	325 µA/A + 20 µA	
	(5 to 20) kHz	605 µA/A + 20 µA	
	(20 to 50) kHz	4 mA/A + 40 µA	
	(50 to 100) kHz	5.5 mA/A + 150 µA	
	100 mA to 1 A		
	(10 to 20) Hz	4 mA/A + 0.2 mA	
	(20 to 45) Hz	1.6 mA/A + 0.2 mA	
	(45 to 100) Hz	805 µA/A + 0.2 mA	
	100 Hz to 5 kHz	1 mA/A + 0.2 mA	
	(5 to 20) kHz	3 mA/A + 0.2 mA	
	(20 to 50) kHz	10 mA/A + 0.4 mA	
AC Current – Source	(29 to 330) µA		Comparison to 5522A Multi Product Calibrator
	(10 to 20) Hz	2 mA/A + 0.1 µA	
	(20 to 45) Hz	1.5 mA/A + 0.1 µA	
	45 Hz to 1 kHz	1.3 mA/A + 0.1 µA	
	(1 to 5) kHz	3 mA/A + 0.15 µA	
	(5 to 10) kHz	8 mA/A + 0.2 µA	
	(10 to 30) kHz	16 mA/A + 0.4 µA	
	(0.33 to 3.3) mA		
	(10 to 20) Hz	2 mA/A + 0.15 µA	
	(20 to 45) Hz	1.3 mA/A + 0.15 µA	
	45 Hz to 1 kHz	1 mA/A + 0.15 µA	
	(1 to 5) kHz	2 mA/A + 0.2 µA	
	(5 to 10) kHz	5.1 mA/A + 0.3 µA	
	(10 to 30) kHz	10 mA/A + 0.6 µA	
	(3.3 to 33) mA		
	(10 to 20) Hz	1.8 mA/A + 2 µA	
	(20 to 45) Hz	910 µA/A + 2 µA	
	45 Hz to 1 kHz	423 µA/A + 2 µA	
	(1 to 5) kHz	813 µA/A + 2 µA	
	(5 to 10) kHz	2 mA/A + 3 µA	
	(10 to 30) kHz	4.1 mA/A + 4 µA	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source	(33 to 330) mA		Comparison to 5522A Multi Product Calibrator
	(10 to 20) Hz	1.8 mA/A + 20 µA	
	(20 to 45) Hz	909 µA/A + 20 µA	
	45 Hz to 1 kHz	417 µA/A + 20 µA	
	(1 to 5) kHz	1 mA/A + 50 µA	
	(5 to 10) kHz	2 mA/A + 100 µA	
	(10 to 30) kHz	4.1 mA/A + 200 µA	
	(0.33 to 1.1) A		
	(10 to 45) Hz	1.8 mA/A + 100 µA	
	45 Hz to 1 kHz	512 µA/A + 100 µA	
	(1 to 5) kHz	6 mA/A + 1 mA	
	(5 to 10) kHz	25 mA/A + 5 mA	
	(1.1 to 3) A		
	(10 to 45) Hz	1.8 mA/A + 100 µA	
	45 Hz to 1 kHz	664 µA/A + 100 µA	
	(1 to 5) kHz	6 mA/A + 1 mA	
	(5 to 10) kHz	25 mA/A + 5 mA	
	(3 to 11) A		
	(45 to 100) Hz	1.8 mA/A + 100 µA	
	100 Hz to 1 kHz	664 µA/A + 100 µA	
	(1 to 5) kHz	6 mA/A + 1 mA	
	(11 to 20.5) A		
	(45 to 100) Hz	1.2 mA/A + 5 mA	
	100 Hz to 1 kHz	1.5 mA/A + 5 mA	
	(1 to 5) kHz	30 mA/A + 5 mA	
Resistance – Measure [1]	100 µΩ to 10 Ω	20 µΩ/Ω + 50 µΩ	Comparison to Keysight 3458A Multimeter
	(10 to 100) Ω	17 µΩ/Ω + 5 µΩ	
	100 Ω to 1 kΩ	15 µΩ/Ω + 500 µΩ	
	(1 to 10) kΩ	15 µΩ/Ω + 5 mΩ	
	(10 to 100) kΩ	15 µΩ/Ω + 50 mΩ	
	100 kΩ to 1 MΩ	20 µΩ/Ω + 2 Ω	
	(1 to 10) MΩ	83 µΩ/Ω + 100 Ω	
	(10 to 100) MΩ	820 µΩ/Ω + 1 kΩ	

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Electrical – DC/Low Frequency **Eau Claire, WI**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance - Source[1]	Up to 11 Ω	36 µΩ/Ω	Comparison to 5522A Multi Product Calibrator
	(11 to 33) Ω	26 µΩ/Ω	
	(33 to 110) Ω	23 µΩ/Ω	
	(110 to 330) Ω	23 µΩ/Ω	
	330 Ω to 1.1 kΩ	23 µΩ/Ω	
	(1.1 to 3.3) kΩ	23 µΩ/Ω	
	(3.3 to 11) kΩ	23 µΩ/Ω	
	(11 to 33) kΩ	23 µΩ/Ω	
	(33 to 110) kΩ	24 µΩ/Ω	
	(110 to 330) kΩ	26 µΩ/Ω	
	330 kΩ to 1.1 MΩ	26 µΩ/Ω	
	(1.1 to 3.3) MΩ	42 µΩ/Ω	
	(3.3 to 11) MΩ	110 µΩ/Ω	
	(11 to 33) MΩ	201 µΩ/Ω	
	(33 to 110) MΩ	400 µΩ/Ω	
	(110 to 330) MΩ	2.5 mΩ/Ω	
	330 MΩ to 1.1 GΩ	12 mΩ/Ω	
Capacitance – Source	10 Hz to 10 kHz		Comparison to 5522A Multi Product Calibrator
	(220 to 400) pF	6.4 mF/F + 10 pF	
	(0.4 to 1.1) nF	5.3 mF/F + 10 pF	
	10 Hz to 3 kHz		
	(1.1 to 3.3) nF	5.1 mF/F + 10 pF	
Capacitance – Source	10 Hz to 1 kHz		Comparison to 5522A Multi Product Calibrator
	(3.3 to 11) nF	2.6 mF/F + 10 pF	
	(11 to 33) nF	2.6 mF/F + 100 pF	
	(33 to 110) nF	2.6 mF/F + 100 pF	
	(110 to 330) nF	2.6 mF/F + 300 pF	
	(10 to 600) Hz		
	(0.33 to 1.1) µF	2.6 mF/F + 1 nF	
	(10 to 300) Hz		
	(1.1 to 3.3) µF	2.6 mF/F + 3 nF	
	(10 to 150) Hz		
	(3.3 to 11) µF	2.6 mF/F + 10 nF	
	(10 to 120) Hz		
	(11 to 33) µF	4.1 mF/F + 30 nF	
	(10 to 80) Hz		
	(33 to 110) µF	4.7 mF/F + 0.1 µF	
	(0 to 50) Hz		
	(110 to 330) µF	4.6 mF/F + 0.3 µF	

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source	(0 to 20) Hz (0.33 to 1.1) mF (0 to 6) Hz (1.1 to 3.3) mF (0 to 2) Hz (3.3 to 11) mF (0 to 0.6) Hz (11 to 33) mF (0 to 0.2) Hz (33 to 110) mF	4.6 mF/F + 1 µF 4.5 mF/F + 3 µF 4.5 mF/F + 10 µF 7.5 mF/F + 30 µF 11 mF/F + 100 µF	Comparison to 5522A Multi Product Calibrator
Electrical Simulation of Thermocouple Indicators [1]	Type B (600 to 800) ºC (800 to 1 000) ºC (1 000 to 1 550) ºC (1 550 to 1 820) °C Type C (0 to 150) °C (150 to 650) °C (650 to 1 000) °C (1 000 to 1 800) °C (1 800 to 2 316) °C Type E (-250 to -100) °C (-100 to -25) °C (-25 to 350) °C (350 to 650) °C (650 to 1 000) °C Type J (-210 to -100) °C (-100 to - 30) °C (-30 to 150) °C (150 to 760) °C (760 to 1 200) °C Type K (-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 1 000) °C (1 000 to 1 372) °C	 0.44 °C 0.34 °C 0.3 °C 0.33 °C 0.3 °C 0.26 °C 0.31 °C 0.5 °C 0.84 °C 0.5 °C 0.16 °C 0.14 °C 0.16 °C 0.21 °C 0.27 °C 0.16 °C 0.14 °C 0.17 °C 0.23 °C 0.33 °C 0.18 °C 0.16 °C 0.26 °C 0.4 °C	Comparison to 5522A Multi Product Calibrator

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicators [1]	Type L		Comparison to 5522A Multi Product Calibrator
	(-200 to -100) ºC	0.37 ºC	
	(-100 to 800) ºC	0.26 ºC	
	(800 to 900) ºC	0.17 ºC	
	Type N		
	(-200 to -100) °C	0.4 °C	
	(-100 to - 25) °C	0.22 °C	
	(-25 to 120) °C	0.19 °C	
	(120 to 410) °C	0.18 °C	
	(410 to 1 300) °C	0.27 °C	
	Type R		
	(0 to 250) °C	0.57 °C	
	(250 to 400) °C	0.35 °C	
	(400 to 1 000) °C	0.33 °C	
	(1 000 to 1 767) °C	0.4 °C	
	Type S		
	(0 to 250) °C	0.47 °C	
	(250 to 400) °C	0.36 °C	
	(400 to 1 000) °C	0.37 °C	
	(1 000 to 1 767) °C	0.46 °C	
	Type T		
	(-250 to -150) °C	0.63 °C	
	(-150 to 0) °C	0.24 °C	
	(0 to 120) °C	0.16 °C	
	(120 to 400) °C	0.14 °C	
	Type U		
	(-200 to 0) °C	0.56 °C	
	(0 to 600) °C	0.27 °C	
Electrical Simulation of RTD Indicators [1]	Pt 385, 100 Ω		Comparison to 5522A Multi Product Calibrator
	(-200 to -80) ºC	0.05 ºC	
	(-80 to 0) ºC	0.05 ºC	
	(0 to 100) ºC	0.07 ºC	
	(100 to 300) ºC	0.09 ºC	
	(300 to 400) ºC	0.1 ºC	
	(400 to 630) ºC	0.12 ºC	
	(630 to 800) ºC	0.23 ºC	

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Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicators [1]	Pt 3926, 100 Ω		Comparison to 5522A Multi Product Calibrator
	(-200 to -80) ºC	0.05 ºC	
	(-80 to 0) ºC	0.05 ºC	
	(0 to 100) ºC	0.07 ºC	
	(100 to 300) ºC	0.09 ºC	
	(300 to 400) ºC	0.10 ºC	
	(400 to 630) ºC	0.12 ºC	
	Pt 3916, 100 Ω		
	(-200 to -190) ºC	0.25 ºC	
	(-190 to -80) ºC	0.04 ºC	
	(-80 to 0) ºC	0.05 ºC	
	(0 to 100) ºC	0.06 ºC	
	(100 to 260) ºC	0.07 ºC	
	(260 to 300) ºC	0.08 ºC	
	(300 to 400) ºC	0.09 ºC	
	(400 to 600) ºC	0.1 ºC	
	(600 to 630) ºC	0.23 ºC	
	Pt 385, 200 Ω		
	(-200 to -80) ºC	0.04 ºC	
	(-80 to 0) ºC	0.04 ºC	
	(0 to 100) ºC	0.04 ºC	
	(100 to 260) ºC	0.05 ºC	
	(260 to 300) ºC	0.12 ºC	
	(300 to 400) ºC	0.13 ºC	
	(400 to 600) ºC	0.14 ºC	
	(600 to 630) ºC	0.16 ºC	
	Pt 385, 500 Ω		
	(-200 to -80) ºC	0.04 ºC	
	(-80 to 0) ºC	0.05 ºC	
	(0 to 100) ºC	0.05 ºC	
	(100 to 260) ºC	0.06 ºC	
	(260 to 300) ºC	0.08 ºC	
	(300 to 400) ºC	0.08 ºC	
	(400 to 600) ºC	0.09 ºC	
	(600 to 630) ºC	0.11 ºC	

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Electrical – DC/Low Frequency **Eau Claire, WI**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicators [1]	Pt 385, 1 000 Ω (-200 to -80) ºC (-80 to 0) ºC (0 to 100) ºC (100 to 260) ºC (260 to 300) ºC (300 to 400) ºC (400 to 600) ºC (600 to 630) ºC PtNi 385, 120 Ω (Ni120) (-80 to 0) ºC (0 to 100) ºC (100 to 260) ºC Cu 427, 10 Ω (100 to 260) ºC	 0.03 ºC 0.03 ºC 0.04 ºC 0.05 ºC 0.06 ºC 0.07 ºC 0.07 ºC 0.23 ºC 0.08 ºC 0.08 ºC 0.14 ºC 0.3 ºC	Comparison to 5522A Multi Product Calibrator

Length – Dimensional Metrology **Eau Claire, WI**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Indicators [1,2]	(0.000 1 to 6) in	(8+3*L*) µin	Comparison to Horizontal Measuring Machine
Calipers [1,2]	Up to 60 in (60 to 80) in	(5+8*L*) µin (410 + 2*L*) µin	Comparison to Gage Blocks
Micrometers OD [1,2] Length Anvil Flatness	 Up to 12 in (12 to 24) in Up to 1 in*D* (0 to 84) µin	 (5+8*L*) µin (34 + 4.6*L*) µin 4 µin	 Comparison to Gage Blocks Optical Parallels
Height Measuring Devices [1,2]	Up to 36 in (36 to 48) in	(45 + 2*L*) µin (7 + 3L) µin	Comparison to Gage Blocks
External Diameter [1,2]	(0.000 1 to 6) in	(8+3L) µin	Comparison to Horizontal Measuring Machine
Internal Diameter [1,2]	(0.04 to 13) in	(8+3*L*) µin	Comparison to Horizontal Measuring Machine

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Length – Dimensional Metrology **Eau Claire, WI**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thread Plugs [1,2] Pitch Diameter Major Diameter	Up to 8 in Pitch (0.2 to 5) mm Pitch 90 – 4 TPI Up to 4 in	(87 + 1.9*L*) µin (8+3*L*) µin	Comparison to Horizontal Measuring Machine Thread Measuring Wires
Thread Rings (Adjustable) Pitch Diameter Tactile Fit (Set to Plug)	Up to 4 in	See footnote[5]	Comparison to Thread Setting Plug
Optical Comparators [1,2] Linear Accuracy Magnification	Up to 6 in 6 to 12 in 5X to 100X	(43 + 11*L*) µin (30 + 7.5*L*) µin 350 µin	Comparison to Glass Scale Glass Scale (Sphere)
Surface Plates [1,2] Overall Flatness Local Area Flatness	Up to 238 in*DL* Up to 238 in*DL*	(25 + 2.9*L*) µin 34 µin	Comparison to Laser System Repeat-O-Meter
CMMs [1,2]	(0 to 144) in	(25 + 2.4*L*) µin	Comparison to Laser Measuring System
VMMs [1,2]	Up to 6 in	(32 + 4.1*L*) µin	Comparison to Glass Scales
Horizontal Measuring Systems [1,2]	Up to 8 in of Travel (8 to 60) in	(6 + 1.7*L*) µin (3 + 2.5*L*) µin	Comparison to Gage Blocks
Feeler/Thickness Gages [2]	Up to 0.2 in	(4.3 + 3*L*) µin	Comparison to Horizontal Measuring System
Indicator Calibrator [2] Linearity	Up to 6 in	60 µin + 0.6*R*	Comparison to Horizontal Measuring System
Groove Micrometers [2]	Up to 12 in	(44 + 2.6*L*) µin+ 0.6*R*	Comparison to Gage Blocks
Microscopes, Stereo Reticle Linearity	Up to 2 in	870 µin	Comparison to Stage Micrometer
Microscopes – Toolmakers [2] Scale Linearity	Up to 4 in	(774 + 70*L*) µin + 0.6*R*	Comparison to Stage Micrometer
Length Standards [2]	(1 to 60) in	(3.4 + 3.5*L*) µin	Comparison to Horizontal Measuring System

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Length – Dimensional Metrology **Eau Claire, WI**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Micrometers – Inside [2]	Up to 8 in 8 to 60 in	(6 + 1.7*L*) µin (3 + 2.5*L*) µin	Comparison to Horizontal Measuring System
Parallels [2] Steel Granite	Up to 18 in	(96.3 + 1.8*L*) µin (48.6 + 0.7*L*) µin	Comparison to Electronic Amplifier with Probe, Surface Plate
Thickness Gages [2] Dial Digital	Up to 1 in	410 µin + 0.6*R* 44 µin+ 0.6*R*	Comparison to Gage Blocks
Thread Micrometers [2] (Screw Thread, Pitch Point) Linearity Anvil Wear	Up to 12 in	(44 + 2.6*L*) µin + 0.6*R* 690 µin	Comparison to Gage Blocks Thread Setting Plug

Mass and Mass Related **Eau Claire, WI**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force [1] Source	(0.035 to 16) ozf (1 to 10) lbf (10 to 50) lbf (50 to 500) lbf	0.018 % of reading + 0.21 µozf 0.018 % of reading + 0.33 µlbf 0.018 % of reading + 9.3 mlbf 0.036 % of reading + 5.3 mlbf	Comparison to Dead Weight
Pressure [1]	(-15 to 30) psig (0 to 1) inH_2O (0.036 to 1) psig (0 to 100) psia (100 to 300) psig (300 to 1 000) psig (1 000 to 10 000) psig	19 mpsi 0.003 5 inH_2O 1.3 mpsi 0.07 psi 0.12 psi 0.4 psi 2.4 psi	Comparison to Pressure Calibrator
Torque Tools [1]	(5 to 50) lbf·in (50 to 400) lbf·in (400 to 1000) lbf·in (80 to 250) lbf·ft (250 to 600) lbf·ft (600 to 2 000) lbf·ft	0.33 % of reading 0.36 % of reading 0.4 % of reading 0.28 % of reading 0.51 % of reading 0.75 % of reading	Comparison to Torque Tester
Torque Transducers [1]	0.5 ozf·in to 1 000 lbf·ft	0.08 % of reading	Comparison to Dead Weight Torque Arms

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Mass and Mass Related **Eau Claire, WI**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Scales and Balances [1,6]	(0 to 500) mg 500 mg to 5 g (5 to 10) g (10 to 30) g (30 to 50) g (50 to 100) g (100 to 200) g (200 to 300) g 300 g to 1 kg (1 to 2) kg (2 to 3) kg	0.01 mg 0.034 mg 0.05 mg 0.074 mg 0.12 mg 0.25 mg 0.5 mg 0.75 mg 2.5 mg 5 mg 7.5 mg	Comparison to Class 1 Weights
Scales and Balances [1,6]	(3 to 5) kg (5 to 10) kg (10 to 20) kg (20 to 25) kg (25 to 30) kg	12 mg 25 mg 50 mg 62 mg 75 mg	Comparison to Class 1 Weights
Scales and Balances [1,6]	(0.5 to 1 000) lb	0.01 % of reading	Comparison to Class 6 Weights

Thermodynamic **Eau Claire, WI**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure [1]	(-20 to 100) ºC (100 to 425) ºC (425 to 500) ºC	0.058 ºC 0.069 ºC 0.086 ºC	Comparison to Digital Temperature Gage
Humidity- Measure [1]	(10 to 90) %RH (90 to 98) %RH	1.1 %RH 2 %RH	Comparison to Humidity Indicator

Time and Frequency **Eau Claire, WI**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Reference [4]	1 MHz	2.5×10^{-5} Hz	Comparison to 5522A Multi Product Calibrator

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DIMENSIONAL MEASUREMENT

2 Dimensional **Eau Claire, WI**

Specific Tests and / or Properties Measured	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Non-contact	(15.4 x 10.8) in	(126 + 12*L*) µin	Comparison to Vision System

3 Dimensional **Eau Claire, WI**

Specific Tests and / or Properties Measured	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Dimensional Inspection Contact	(16 x 18 x 14) in	(209+ 1.2*L*) µin	Comparison to Coordinate Measuring Machie

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Calibration and Measurement Capability (CMC) is expressed in terms of the measurement parameter, measurement range, expanded uncertainty of measurement and reference standard, method, and/or equipment. The expanded uncertainty of measurement is expressed as the standard uncertainty of the measurement multiplied by a coverage factor of 2 (k=2), corresponding to a confidence level of approximately 95%.

Notes:
1. On-site calibration service is available for this parameter, since on-site conditions are typically more variable than those in the laboratory, larger measurement uncertainties are expected on-site than what is reported on the accredited scope
2. The use of (R) signifies the Resolution of the unit under test, the use of (*L*) represents Length in inches, the use of (*D*) represents Diameter in inches.
3. Uncertainties listed for Electromagnetic - DC/Low Frequency and RF/Microwave does not include possible contributions from a “best available” unit under test
4. Derivatives of 10MHz will have different uncertainties due to resolution, noise, and gating errors.
5. The tactile fit of an adjustable thread ring to a thread-setting plug is not a measurement of pitch diameter. The uncertainty for this pitch diameter setting is based on the contributors associated with the thread setting plug and environmental contributors only.
6. The CMC for scales and balances are highly dependent upon the resolution of the unit under test. The uncertainties presented here does not include the resolution of the unit under test. The resolution will be included in the reported measurement uncertainty at the time of calibration.

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