



CERTIFICATE OF ACCREDITATION

The ANSI National Accreditation Board

Hereby attests that

Fox Valley Metrology, Ltd.
3114 Medalist Drive
Oshkosh, WI 54902
(and satellite locations as shown on the scope)

Fulfills the requirements of

ISO/IEC 17025:2017

and national standards

**ANSI/NCSL Z540-1-1994 (R2002) and
ANSI/NCSL Z540.3-2006 (R2013)**

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: 15 June 2027

Certificate Number: ACT-1272



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)

ANSI/NCSL Z540.3-2006 (R2013)

Fox Valley Metrology, Ltd.

3114 Medalist Drive

Oshkosh, WI 54902

Jacob Jurotich 815-205-4101 x7104

Services performed at satellite locations as indicated in far-right column

308 Axminister Drive
Fenton, MO 63026

1740 State Route 61
Crestline, OH 44827

30447 Stacy Ponds Drive
Stacy, MN 55079

2205 North Willow Avenue, Unit B
Broken Arrow, OK 74012

5245 27th Avenue
Rockford, IL 61109

600 North Steelhead Way
Boise, ID 83704

3012 Old Charlotte Hwy
Monroe, NC 28110

118 Seaboard Lane, Suite 109
Franklin, TN 37067

CALIBRATION AND DIMENSIONAL MEASUREMENT

ISO/IEC 17025 Accreditation Granted: **09 June 2025**

Certificate Number: **ACT-1272**

Certificate Expiry Date: **15 June 2027**



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CALIBRATION

Acoustics and Vibration

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sound Level – Source ¹ (100 Hz, 250 Hz, 500 Hz, 1 000 Hz, 2 000 Hz)	114 dB	0.62 dB	Comparison to Gen Rad 1562-A Sound Level Calibrator <u>Locations:</u> All
Accelerometers 1 g reference 1 g reference	10 Hz to 2 kHz (2 to 10) kHz	1.5 % of reading 1.4 % of reading	Comparison to PCB 9150C Accelerometer Calibration Workstation <u>Location:</u> Oshkosh, WI

Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters ^{1,6}	4.01 pH 7 pH 10 pH	0.032 pH 0.032 pH 0.032 pH	Comparison to Accredited pH Buffer Solutions <u>Locations:</u> All
Conductivity Meters ^{1,6}	12.85 mS/cm 1 408.5 µS/cm 25 µS/cm	4 µS/cm 11 µS/cm 10 µS/cm	Comparison to Accredited Conductivity Solutions <u>Locations:</u> All
Refractometers ^{1,6}	4.99 Brix 7.52 Brix 10.03 Brix 12.53 Brix 14.98 Brix 30.08 Brix	0.24 Brix 0.24 Brix 0.24 Brix 0.24 Brix 0.24 Brix 0.24 Brix	Comparison to Accredited Refractive Index Solutions <u>Locations:</u> All



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Chemical Quantities

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gas Detectors ^{1,6} O ₂	0 % Concentration 12.5 % Concentration 20.9 % Concentration 100 % Concentration	2.4 % Concentration 2.4 % Concentration 2.4 % Concentration 2.6 % Concentration	Comparison to Accredited Gas Mixtures <u>Location:</u> All

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source ^{1,6} (Fixed Artifact)	10 V	0.8 μ V/V	Comparison to Fluke 732B Voltage Standard <u>Locations:</u> All
DC Voltage – Source ¹	Up to 220 mV 220 mV to 2.2 V (2.2 to 11) V (11 to 22) V (22 to 220) V (220 to 1 100) V	7.5 μ V/V + 0.5 μ V 5.1 μ V/V + 0.77 μ V 3.6 μ V/V + 2.6 μ V 3.7 μ V/V + 4.2 μ V 5.2 μ V/V + 43 μ V 6.7 μ V/V + 0.4. mV	Comparison to Fluke 5730A Multiproduct Calibrator <u>Locations:</u> All
DC Voltage – Measure ¹	Up to 202 mV 202 mV to 2.02 V (2.02 to 20.2) V (20.2 to 202) V (202 to 1 050) V	5.7 μ V/V + 0.26 μ V 2.9 μ V/V + 0.31 μ V 2.9 μ V/V + 0.94 μ V 4.4 μ V/V + 30 μ V 4.6 μ V/V + 0.58 mV	Comparison to Fluke 8588A 8.5 Digit Multimeter <u>Locations:</u> All
DC High Voltage – Measure ¹	(1 to 10) kV (10 to 100) kV	60 V 600 V	Comparison to Hipotronics KVM-100 High Voltage Meter <u>Locations:</u> All
DC Current – Source ¹	Up to 220 μ A 220 μ A to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A	39 μ A/A + 6.3 nA 36 μ A/A + 7.3 nA 36 μ A/A + 42 nA 47 μ A/A + 0.71 μ A 83 μ A/A + 12 μ A	Comparison to Fluke 5730A Multiproduct Calibrator <u>Locations:</u> All



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source ¹	(1.2 to 3.1) A (3.1 to 12) A (12 to 30) A	0.3 mA/A + 0.15 mA 0.3 mA/A + 0.25 mA 1 mA/A + 0.78 mA	Comparison to Fluke 5560A Multiproduct Calibrator <u>Locations:</u> All
DC Current – Source ¹	Up to 100 A	0.008 % of reading + 4 mA	Comparison to Fluke 52120A Transconductance Amplifier <u>Locations:</u> All
DC Current – Measure ¹	Up to 20.2 μ A (20.2 to 202) μ A 202 μ A to 2.02 mA (2.02 to 20.2) mA (20.2 to 200.2) mA 200.2 mA to 2.02 A (2.02 to 20.2) A (20.2 to 30.2) A	6.2 μ A/A + 0.89 nA 10 μ A/A + 0.42 nA 9.2 μ A/A + 4.3 nA 9.8 μ A/A + 48 nA 32 μ A/A + 1 μ A 100 μ A/A + 100 μ A 0.18 mA/A + 0.4 mA 0.49 mA/A + 4.4 mA	Comparison to Fluke 8588A 8.5 Digit Multimeter <u>Locations:</u> All
Resistance – Measure ¹ (Normal Mode)	Up to 2.02 Ω (2.02 to 20.2) Ω (20.2 to 202) Ω 202 Ω to 2.02 k Ω (2.02 to 20.2) k Ω (20.2 to 202) k Ω 202 k Ω to 2.02 M Ω (2.02 to 20.2) M Ω (20.2 to 202) M Ω 202 M Ω to 2.02 G Ω	13 $\mu\Omega/\Omega$ + 4.1 $\mu\Omega$ 8 $\mu\Omega/\Omega$ + 17 $\mu\Omega$ 7.4 $\mu\Omega/\Omega$ + 58 $\mu\Omega$ 7.2 $\mu\Omega/\Omega$ + 0.58 m Ω 7.4 $\mu\Omega/\Omega$ + 5.8 m Ω 7.5 $\mu\Omega/\Omega$ + 58 m Ω 9.1 $\mu\Omega/\Omega$ + 1.1 Ω 13 $\mu\Omega/\Omega$ + 0.1 k Ω 43 $\mu\Omega/\Omega$ + 10 k Ω 0.52 m Ω/Ω + 1 M Ω	Comparison to Fluke 8588A 8.5 Digit Multimeter <u>Locations:</u> All
Resistance – Measure ¹ (High Voltage Mode)	Up to 20.2 M Ω (20.2 to 202) M Ω 202 M Ω to 2.02 G Ω (2.02 to 20.2) G Ω	16 $\mu\Omega/\Omega$ + 10 Ω 68 $\mu\Omega/\Omega$ + 1 k Ω 0.16 m Ω/Ω + 0.1 M Ω 0.54 m Ω/Ω + 10 M Ω	Comparison to Fluke 8588A 8.5 Digit Multimeter <u>Locations:</u> All



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Measure (High Resistance)	100 MΩ to 1 GΩ (1 to 10) GΩ (10 to 100) GΩ 100 GΩ to 1 TΩ	0.021 % of reading + 0.66 kΩ 0.021 % of reading + 0.61 kΩ 0.035 % of reading 0.12 % of reading	Comparison to IET Labs 1888 Ultra Precision Megohmmeter <u>Locations:</u> All
Resistance – Source ^{1,6} (Fixed Points)	0 Ω 1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 kΩ	40 μΩ 10 μΩ 0.18 mΩ 0.25 mΩ 0.46 mΩ 1 mΩ 1.9 mΩ 6.8 mΩ 12.8 mΩ	Comparison to Fluke 5730A Multiproduct Calibrator <u>Locations:</u> All
Resistance – Source ^{1,6} (Fixed Artifacts)	100 μΩ 1 mΩ 10 mΩ 100 mΩ 1 Ω 10 Ω 100 Ω 1 kΩ	0.13 μΩ 0.62 μΩ 3.6 μΩ 27 μΩ 0.25 mΩ 2.4 mΩ 24 mΩ 0.23 Ω	Comparison to IET DCCS Shunts <u>Locations:</u> All
Resistance – Source ^{1,6} (Fixed Points)	10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ 10 MΩ 19 MΩ 100 MΩ	67.5 mΩ 0.13 Ω 0.88 Ω 1.7 Ω 13.6 Ω 35 Ω 0.42 kΩ 0.94 kΩ 10.9 kΩ	Comparison to Fluke 5730A Multiproduct Calibrator <u>Locations:</u> All
Resistance – Source ^{1,6} (Variable Artifact)	100 mΩ to 1 MΩ (1 to 100) MΩ 100 MΩ to 1 GΩ (1 to 10) GΩ (10 to 100) GΩ	0.012 % of reading + 2.3 mΩ 0.081 % of reading + 0.39 Ω 0.16 % of reading + 28 mΩ 0.4 % of reading + 47 mΩ 0.83 % of reading + 0.55 Ω	Comparison to IET Labs Decade Boxes <u>Locations:</u> All



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source ¹	Up to 2.2 mV		<p>Comparison to Fluke 5730A Multiproduct Calibrator</p> <p><u>Locations:</u> All</p>
	(10 to 20) Hz	0.25 mV/V + 4 μV	
	(20 to 40) Hz	0.23 mV/V + 4 μV	
	40 Hz to 20 kHz	90 μV/V + 4 μV	
	(20 to 50) kHz	0.21 mV/V + 4 μV	
	(50 to 100) kHz	0.51 mV/V + 5 μV	
	(100 to 300) kHz	1.1 mV/V + 10 μV	
	(300 to 500) kHz	1.5 mV/V + 20 μV	
	500 kHz to 1 MHz	3 mV/V + 20 μV	
	(2.2 to 22) mV		
	(10 to 20) Hz	0.25 mV/V + 4 μV	
	(20 to 40) Hz	9.2 μV/V + 4.3 μV	
	40 Hz to 20 kHz	84 μV/V + 4 μV	
	(20 to 50) kHz	0.2 mV/V + 4 μV	
	(50 to 100) kHz	0.51 mV/V + 5 μV	
	(100 to 300) kHz	1.1 mV/V + 10 μV	
	(300 to 500) kHz	1.7 mV/V + 20 μV	
	500 kHz to 1 MHz	3 mV/V + 20 μV	
	(22 to 220) mV		
	(10 to 20) Hz	0.28 mV/V + 3.3 μV	
	(20 to 40) Hz	0.11 mV/V + 3.9 μV	
	40 Hz to 20 kHz	73 μV/V + 4.3 μV	
	(20 to 50) kHz	0.13 mV/V + 5.4 μV	
	(50 to 100) kHz	0.36 mV/V + 7.8 μV	
	(100 to 300) kHz	0.68 mV/V + 18 μV	
	(300 to 500) kHz	1.4 mV/V + 25 μV	
	500 kHz to 1 MHz	2.9 mV/V + 21 μV	
	220 mV to 2 V		
(10 to 20) Hz	0.26 mV/V + 8.9 μV		
(20 to 40) Hz	96 μV/V + 6.8 μV		
40 Hz to 20 kHz	42 μV/V + 10 μV		
(20 to 50) kHz	64 μV/V + 19 μV		
(50 to 100) kHz	68 μV/V + 67 μV		
(100 to 300) kHz	0.35 mV/V + 85 μV		
(300 to 500) kHz	1.1 mV/V + 95 μV		
500 kHz to 1 MHz	1.8 mV/V + 0.25 mV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source ¹	(2 to 22) V (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (22 to 220) V (10 to 20) Hz (20 to 40) Hz 40 Hz to 20 kHz (20 to 50) kHz (50 to 100) kHz (100 to 300) kHz (300 to 500) kHz 500 kHz to 1 MHz (220 to 1 100) V (15 to 50) Hz 50 Hz to 1 kHz	0.24 mV/V + 0.49 mV 90 μV/V + 0.19 mV 46 μV/V + 2.3 μV 73 μV/V + 1.9 μV 94 μV/V + 16 μV 0.29 mV/V + 0.2 mV 1.1 mV/V + 4.4 μV 1.9 mV/V + 92 μV 0.26 mV/V + 7.4 μV 61 μV/V + 7.9 mV 48 μV/V + 2.1 mV 75 μV/V + 2.5 mV 160 μV/V + 3 mV 0.9 mV/V + 16 mV 4.4 mV/V + 40 mV 8 mV/V + 80 mV 0.3 mV/V + 16 mV 70 μV/V + 11 mV	Comparison to Fluke 5730A Multiproduct Calibrator <u>Locations:</u> All
AC Voltage – Source ¹	(330 to 1 020) V (3 to 5) Hz (5 to 10) Hz 10 Hz to 10 kHz	2.5 mV/V + 75 mV 0.87 mV/V + 75 mV 0.14 mV/V + 80 mV	Comparison to Fluke 5560A Multiproduct Calibrator <u>Locations:</u> All
AC Voltage Harmonics – Source ¹	(2 nd to 50 th) (10 to 45) Hz (45 to 65) Hz (65 to 500) Hz 500 Hz to 5 kHz (5 to 10) kHz	32 mV to 33 V 33 mV to 1 000 V 33 mV to 1 000 V 330 mV to 1 000 V (3.3 to 1 000) V 0.35 mV/V + 16 μV 0.21 mV/V + 16 μV 0.21 mV/V + 16 μV 0.21 mV/V + 0.21 mV 0.21 mV/V + 1.2 mV	Comparison to Fluke 5522A Multiproduct Calibrator <u>Locations:</u> All
AC High Voltage – Measure ¹	(1 to 10) kV (50 to 60) Hz (10 to 100) kV (50 to 60) Hz	0.12 kV 1.2 kV	Comparison to Hipotronics KVM-100 High Voltage Meter <u>Locations:</u> All



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure ¹	Up to 12.12 mV		Comparison to Fluke 8588A 8.5 Digit Multimeter <u>Locations:</u> All
	1 Hz to 2 kHz	0.22 mV/V + 1.9 μV	
	(2 to 10) kHz	0.29 mV/V + 1.9 μV	
	(10 to 30) kHz	0.3 mV/V + 1.9 μV	
	(30 to 100) kHz	2.9 mV/V + 1.9 μV	
	(100 to 300) kHz	10 mV/V + 4.3 μV	
	300 kHz to 1 MHz	20 mV/V + 4.3 μV	
	(12.12 to 121.2) mV		
	1 Hz to 2 kHz	39 μV/V + 3.8 μV	
	(2 to 10) kHz	77 μV/V + 4.1 μV	
	(10 to 30) kHz	0.19 mV/V + 3.1 μV	
	(30 to 100) kHz	0.29 mV/V + 28 μV	
	(100 to 300) kHz	1.5 mV/V + 89 μV	
	300 kHz to 1 MHz	10 mV/V + 0.1 mV	
	(1 to 2) MHz	15 mV/V + 0.5 mV	
	(2 to 4) MHz	40 mV/V + 1 mV	
	(4 to 8) MHz	81 mV/V + 1 mV	
	(8 to 10) MHz	0.15 V/V + 1 mV	
	121.2 mV to 12.12 V		
	1 Hz to 2 kHz	71 μV/V + 0.62 μV	
	(2 to 10) kHz	0.12 mV/V + 0.15 μV	
	(10 to 30) kHz	0.22 mV/V + 84 nV	
	(30 to 100) kHz	0.52 mV/V + 0.57 mV	
	(100 to 300) kHz	2.4 mV/V + 1.9 μV	
	300 kHz to 1 MHz	11 mV/V + 22 μV	
	(1 to 2) MHz	20 mV/V + 16 μV	
	(2 to 4) MHz	50 mV/V + 25 μV	
	(4 to 8) MHz	90 mV/V + 0.11 mV	
	(8 to 10) MHz	0.16 V/V + 0.11 mV	
	(12.12 to 121.2) V		
1 Hz to 2 kHz	73 μV/V + 0.48 mV		
(2 to 10) kHz	95 μV/V + 0.21 mV		
(10 to 30) kHz	0.23 mV/V + 0.81 mV		
(30 to 100) kHz	0.54 mV/V + 4.7 mV		
(100 to 300) kHz	3.5 mV/V + 50 mV		
300 kHz to 1 MHz	10 mV/V + 0.5 V		
(121.2 to 1 050) V			
1 Hz to 2 kHz	92 μV/V + 25 mV		
(2 to 10) kHz	95 μV/V + 0.21 mV		
(10 to 30) kHz	0.22 mV/V + 24 mV		
(30 to 100) kHz	0.53 mV/V + 98 mV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure	Up to 2.2 mV		Comparison to Fluke 5790B AC Measurement Standard <u>Location:</u> Oshkosh, WI
	Up to 20 Hz	0.011 % of reading + 1.4 μ V	
	(20 to 40) Hz	0.006 3 % of reading + 1.4 μ V	
	40 Hz to 20 kHz	0.005 7 % of reading + 1.4 μ V	
	(20 to 50) kHz	0.006 7 % of reading + 2 μ V	
	(50 to 100) kHz	0.008 8 % of reading + 2.5 μ V	
	(100 to 300) kHz	0.023 % of reading + 4 μ V	
	(300 to 500) kHz	0.072 % of reading + 8.1 μ V	
	500 kHz to 1 MHz	0.25 % of reading + 8.4 μ V	
	(2.2 to 7) mV		
	Up to 20 Hz	0.008 % of reading + 1.4 μ V	
	(20 to 40) Hz	0.003 8 % of reading + 1.4 μ V	
	40 Hz to 20 kHz	0.003 5 % of reading + 1.4 μ V	
	(20 to 50) kHz	0.004 3 % of reading + 2.1 μ V	
	(50 to 100) kHz	0.005 7 % of reading + 2.6 μ V	
	(100 to 300) kHz	0.013 % of reading + 4.2 μ V	
	(300 to 500) kHz	0.045 % of reading + 8.1 μ V	
	500 kHz to 1 MHz	0.17 % of reading + 13 μ V	
	(7 to 22) mV		
	Up to 20 Hz	0.006 1 % of reading + 1.9 μ V	
	(20 to 40) Hz	0.003 5 % of reading + 1.6 μ V	
	40 Hz to 20 kHz	0.003 3 % of reading + 1.5 μ V	
	(20 to 50) kHz	0.004 2 % of reading + 2.2 μ V	
	(50 to 100) kHz	0.005 1 % of reading + 3 μ V	
(100 to 300) kHz	0.008 9 % of reading + 5.6 μ V		
(300 to 500) kHz	0.035 % of reading + 9.5 μ V		
500 kHz to 1 MHz	0.14 % of reading + 10 μ V		
(22 to 70) mV			
Up to 20 Hz	0.005 1 % of reading + 2.8 μ V		
(20 to 40) Hz	0.002 4 % of reading + 2.5 μ V		
40 Hz to 20 kHz	0.002 1 % of reading + 2.3 μ V		
(20 to 50) kHz	0.002 9 % of reading + 3.2 μ V		
(50 to 100) kHz	0.003 8 % of reading + 5.5 μ V		
(100 to 300) kHz	0.008 1 % of reading + 10 μ V		
(300 to 500) kHz	0.024 % of reading + 16 μ V		
500 kHz to 1 MHz	0.09 % of reading + 15 μ V		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure	(70 to 220) mV		Comparison to Fluke 5790B AC Measurement Standard <u>Location:</u> Oshkosh, WI
	Up to 20 Hz	0.005 3 % of reading + 4.2 μ V	
	(20 to 40) Hz	0.002 6 % of reading + 2.7 μ V	
	40 Hz to 20 kHz	0.002 % of reading + 3 μ V	
	(20 to 50) kHz	0.001 8 % of reading + 4.8 μ V	
	(50 to 100) kHz	0.003 7 % of reading + 8.8 μ V	
	(100 to 300) kHz	0.009 2 % of reading + 15 μ V	
	(300 to 500) kHz	0.025 % of reading + 21 μ V	
	500 kHz to 1 MHz	0.09 % of reading + 25 μ V	
	(220 to 700) mV		
	Up to 20 Hz	0.005 4 % of reading + 8.9 μ V	
	(20 to 40) Hz	0.002 7 % of reading + 3.2 μ V	
	40 Hz to 20 kHz	0.002 2 % of reading + 3.9 μ V	
	(20 to 50) kHz	0.002 1 % of reading + 5.2 μ V	
	(50 to 100) kHz	0.004 5 % of reading + 11 μ V	
	(100 to 300) kHz	0.011 % of reading + 20 μ V	
	(300 to 500) kHz	0.026 % of reading + 14 μ V	
	500 kHz to 1 MHz	0.093 % of reading + 28 μ V	
	(0.7 to 2.2) V		
	Up to 20 Hz	0.005 6 % of reading + 15 μ V	
	(20 to 40) Hz	0.002 6 % of reading + 5.3 μ V	
	40 Hz to 20 kHz	0.002 % of reading + 4.9 μ V	
	(20 to 50) kHz	0.002 1 % of reading + 5.2 μ V	
	(50 to 100) kHz	0.004 6 % of reading + 14 μ V	
(100 to 300) kHz	0.01 % of reading + 24 μ V		
(300 to 500) kHz	0.022 % of reading + 26 μ V		
500 kHz to 1 MHz	0.082 % of reading + 0.21 mV		
(2.2 to 7) V			
Up to 20 Hz	0.005 6 % of reading + 45 μ V		
(20 to 40) Hz	0.002 8 % of reading + 14 μ V		
40 Hz to 20 kHz	0.002 % of reading + 18 μ V		
(20 to 50) kHz	0.002 4 % of reading + 19 μ V		
(50 to 100) kHz	0.006 3 % of reading + 10 μ V		
(100 to 300) kHz	0.015 % of reading + 46 μ V		
(300 to 500) kHz	0.038 % of reading + 28 μ V		
500 kHz to 1 MHz	0.12 % of reading + 0.48 mV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure	(7 to 22) V		Comparison to Fluke 5790B AC Measurement Standard <u>Location:</u> Oshkosh, WI
	Up to 20 Hz	0.005 5 % of reading + 0.17 mV	
	(20 to 40) Hz	0.002 8 % of reading + 60 μV	
	40 Hz to 20 kHz	0.001 9 % of reading + 80 μV	
	(20 to 50) kHz	0.002 3 % of reading + 87 μV	
	(50 to 100) kHz	0.006 1 % of reading + 91 μV	
	(100 to 300) kHz	0.015 % of reading + 0.13 mV	
	(300 to 500) kHz	0.038 % of reading + 81 μV	
	500 kHz to 1 MHz	0.11 % of reading + 1.7 mV	
	(22 to 70) V		
	Up to 20 Hz	0.005 7 % of reading + 0.44 mV	
	(20 to 40) Hz	0.002 9 % of reading + 0.16 mV	
	40 Hz to 20 kHz	0.002 3 % of reading + 0.21 mV	
	(20 to 50) kHz	0.002 4 % of reading + 0.3 mV	
	(50 to 100) kHz	0.006 6 % of reading + 0.21 mV	
	(100 to 300) kHz	0.005 1 % of reading + 18 mV	
	(300 to 500) kHz	0.026 % of reading + 15 mV	
	500 kHz to 1 MHz	0.11 % of reading + 8.1 mV	
	(70 to 220) V		
	Up to 20 Hz	0.005 7 % of reading + 1.5 mV	
	(20 to 40) Hz	0.002 9 % of reading + 0.95 mV	
	40 Hz to 20 kHz	0.002 2 % of reading + 1.1 mV	
	(20 to 50) kHz	0.003 % of reading + 1.3 mV	
	(50 to 100) kHz	0.006 4 % of reading + 1.7 mV	
	(100 to 300) kHz	0.017 % of reading + 0.77 mV	
	(300 to 500) kHz	0.048 % of reading + 0.28 mV	
	(220 to 700) V		
	Up to 20 Hz	0.006 % of reading + 3.1 mV	
(20 to 40) Hz	0.002 8 % of reading + 4.9 mV		
40 Hz to 20 kHz	0.001 9 % of reading + 7 mV		
(20 to 50) kHz	0.011 % of reading + 4 mV		
(50 to 100) kHz	0.05 % of reading + 4.5 mV		
(700 to 1 000) V			
Up to 20 Hz	0.006 % of reading + 4.7 mV		
(20 to 40) Hz	0.002 9 % of reading + 8.1 mV		
40 Hz to 20 kHz	0.002 % of reading + 9.7 mV		
(20 to 50) kHz	0.011 % of reading + 2.8 mV		
(50 to 100) kHz	0.05 % of reading + 0.63 mV		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure (Wideband)	Up to 2.2 mV		Comparison to Fluke 5790B AC Measurement Standard <u>Location:</u> Oshkosh, WI
	Up to 30 Hz	0.6 % of reading	
	(30 to 120) Hz	0.6 % of reading	
	120 Hz to 1.2 kHz	0.6 % of reading	
	(1.2 to 120) kHz	0.6 % of reading	
	(120 to 500) kHz	0.6 % of reading	
	500 kHz to 1.2 MHz	0.07 % of reading	
	(1.2 to 2) MHz	0.07 % of reading	
	(2 to 10) MHz	0.17 % of reading	
	(10 to 20) MHz	0.29 % of reading	
	(20 to 30) MHz	0.68 % of reading	
	(30 to 50) MHz	0.95 % of reading	
	(2.2 to 7) mV		
	Up to 30 Hz	0.51 % of reading	
	(30 to 120) Hz	0.5 % of reading	
	120 Hz to 1.2 kHz	0.5 % of reading	
	(1.2 to 120) kHz	0.5 % of reading	
	(120 to 500) kHz	0.5 % of reading	
	500 kHz 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	0.36 % of reading	
	(30 to 50) MHz	0.5 % of reading	
	(7 to 22) mV		
	Up to 30 Hz	0.51 % of reading	
	(30 to 120) Hz	0.5 % of reading	
	120 Hz to 1.2 kHz	0.5 % of reading	
	(1.2 to 120) kHz	0.5 % of reading	
	(120 to 500) kHz	0.5 % of reading	
500 kHz 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	0.16 % of reading		
(20 to 30) MHz	0.36 % of reading		
(30 to 50) MHz	0.58 % of reading		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure (Wideband)	(22 to 70) mV		Comparison to Fluke 5790B AC Measurement Standard <u>Location:</u> Oshkosh, WI
	Up to 30 Hz	0.51 % of reading	
	(30 to 120) Hz	0.5 % of reading	
	120 Hz to 1.2 kHz	0.5 % of reading	
	(1.2 to 120) kHz	0.5 % of reading	
	(120 to 500) kHz	0.5 % of reading	
	500 kHz 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	0.33 % of reading	
	(30 to 50) MHz	0.58 % of reading	
	(70 to 220) mV		
	Up to 30 Hz	0.41 % of reading	
	(30 to 120) Hz	0.4 % of reading	
	120 Hz to 1.2 kHz	0.4 % of reading	
	(1.2 to 120) kHz	0.4 % of reading	
	(120 to 500) kHz	0.4 % of reading	
	500 kHz 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	0.14 % of reading	
	(20 to 30) MHz	0.34 % of reading	
	(30 to 50) MHz	0.58 % of reading	
	(220 to 700) mV		
	Up to 30 Hz	0.41 % of reading	
	(30 to 120) Hz	0.4 % of reading	
120 Hz to 1.2 kHz	0.4 % of reading		
(1.2 to 120) kHz	0.4 % of reading		
(120 to 500) kHz	0.4 % of reading		
500 kHz 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	0.14 % of reading		
(20 to 30) MHz	0.34 % of reading		
(30 to 50) MHz	0.58 % of reading		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure (Wideband)	(0.7 to 2.2) V Up to 30 Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 120) kHz (120 to 500) kHz 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz (30 to 50) MHz	0.36 % of reading 0.35 % of reading 0.35 % of reading 0.35 % of reading 0.35 % of reading 0.05 % of reading 0.05 % of reading 0.09 % of reading 0.13 % of reading 0.31 % of reading 0.54 % of reading	Comparison to Fluke 5790B AC Measurement Standard <u>Location:</u> Oshkosh, WI
	(2.2 to 7) V Up to 30 Hz (30 to 120) Hz 120 Hz to 1.2 kHz (1.2 to 120) kHz (120 to 500) kHz 500 kHz to 1.2 MHz (1.2 to 2) MHz (2 to 10) MHz (10 to 20) MHz (20 to 30) MHz (30 to 50) MHz	0.36 % of reading 0.35 % of reading 0.35 % of reading 0.35 % of reading 0.35 % of reading 0.05 % of reading 0.05 % of reading 0.1 % of reading 0.14 % of reading 0.34 % of reading 0.58 % of reading	
AC Current – Source ¹	Up to 220 μ A (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz 220 μ A to 2.2 mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.25 mA/A + 16 nA 0.17 mA/A + 10 nA 0.11 mA/A + 8.2 nA 0.32 mA/A + 12 nA 1.1 mA/A + 65 nA 0.27 mA/A + 12 nA 0.18 mA/A + 7.5 nA 0.13 mA/A + 5.5 nA 0.25 mA/A + 25 nA 1.4 mA/A + 4.9 nA	Comparison to Fluke 5730A Multiproduct Calibrator <u>Locations:</u> All



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source ¹	(2.2 to 22) mA		Comparison to Fluke 5730A Multiproduct Calibrator <u>Locations:</u> All
	(10 to 20) Hz	0.26 mA/A + 0.4 μA	
	(20 to 40) Hz	0.17 mA/A + 0.35 μA	
	40 Hz to 1 kHz	0.11 mA/A + 0.34 μA	
	(1 to 5) kHz	0.21 mA/A + 0.54 μA	
	(5 to 10) kHz	1.1 mA/A + 5 μA	
	(22 to 220) mA		
	(10 to 20) Hz	0.26 mA/A + 3.9 μA	
	(20 to 40) Hz	0.17 mA/A + 3.4 μA	
	40 Hz to 1 kHz	0.12 mA/A + 2.2 μA	
	(1 to 5) kHz	0.21 mA/A + 3.4 μA	
	(5 to 10) kHz	1.1 mA/A + 9.7 μA	
AC Current – Source ¹	220 mA to 2.2 A		Comparison to Fluke 5560A Multiproduct Calibrator <u>Locations:</u> All
	40 Hz to 1 kHz	0.25 mA/A + 34 μA	
	(1 to 5) kHz	0.47 mA/A + 77 μA	
	(5 to 10) kHz	7.1 mA/A + 0.14 mA	
	(3 to 12) A		
	(3 to 45) Hz	0.37 mA/A + 1 mA	
AC Current – Source ¹	45 Hz to 1 kHz	0.3 mA/A + 0.5 mA	Comparison to Fluke 52120A Transconductance Amplifier <u>Locations:</u> All
	(1 to 5) kHz	0.37 mA/A + 0.8 mA	
	(5 to 10) kHz	2.5 mA/A + 1 mA	
	(12 to 30) A		
	(3 to 45) Hz	1 mA/A + 10 mA	
	45 Hz to 1 kHz	0.7 mA/A + 8 mA	
AC Current – Source ¹	Up to 120 A		Comparison to Fluke 5522A Multiproduct Calibrator <u>Locations:</u> All
	(10 to 65) Hz	0.012 % of reading + 19 mA	
	(65 to 300) Hz	0.023 % of reading + 28 mA	
	300 Hz to 1 kHz	0.078 % of reading + 94 mA	
AC Current Harmonics – Source ¹	(2 nd to 50 th)		Comparison to Fluke 5522A Multiproduct Calibrator <u>Locations:</u> All
	(10 to 45) Hz	3.3 mA to 3 A	
	(45 to 65) Hz	3.3 mA to 20.5 A	
	(65 to 500) Hz	33 mA to 20.5 A	
	500 Hz to 5 kHz	33 mA to 20.5 A	
	(5 to 10) kHz	(33 to 330) mA	
		1.1 mA/A + 4 μA	
		0.5 mA/A + 4 μA	
		1.2 mA/A + 0.1 mA	
		2.3 mA/A + 0.2 mA	
		4.6 mA/A + 0.4 mA	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure ¹	Up to 20.2 μ A		<p style="text-align: center;">Comparison to Fluke 8588A 8.5 Digit Multimeter</p> <p style="text-align: center;"><u>Locations:</u> All</p>
	10 Hz to 2 kHz	2 mA/A + 2.8 nA	
	(2 to 10) kHz	2 mA/A + 2.8 nA	
	(10 to 30) kHz	2 mA/A + 2.8 nA	
	20.2 μ A to 20.2 mA		
	10 Hz to 2 kHz	0.32 mA/A + 20 nA	
	(2 to 10) kHz	0.56 mA/A + 17 nA	
	(10 to 30) kHz	0.77 mA/A + 15 nA	
	(30 to 100) kHz	4 mA/A + 1 μ A	
	(20.2 to 202) mA		
	10 Hz to 2 kHz	0.32 mA/A	
	(2 to 10) kHz	0.55 mA/A + 0.11 μ A	
	(10 to 30) kHz	0.76 mA/A + 0.19 μ A	
	202 mA to 2.02 A		
10 Hz to 2 kHz	0.27 mA/A + 0.1 mA		
(2 to 10) kHz	0.52 mA/A + 0.1 mA		
(10 to 30) kHz	0.71 mA/A + 0.1 mA		
(2.02 to 20.2) A			
10 Hz to 2 kHz	0.8 mA/A + 0.52 mA		
(2 to 10) kHz	0.8 mA/A + 0.51 mA		
(20.2 to 30.2) A			
10 Hz to 2 kHz	0.8 mA/A + 12 mA		
(2 to 10) kHz	1.2 mA/A + 12 mA		
AC Current – Measure	Up to 1 mA		<p style="text-align: center;">Comparison to Fluke 5790B AC Measurement Standard, Fluke A40B Series Current Shunt</p> <p style="text-align: center;"><u>Location:</u> Oshkosh, WI</p>
	Up to 10 Hz	0.005 2 % of reading	
	10 Hz to 1 kHz	0.005 8 % of reading	
	(1 to 10) kHz	0.007 8 % of reading	
	(10 to 30) kHz	0.007 8 % of reading	
	(30 to 100) kHz	0.016 % of reading	
	(1 to 10) mA		
	Up to 10 Hz	0.005 2 % of reading	
	10 Hz to 1 kHz	0.003 3 % of reading	
	(1 to 10) kHz	0.003 3 % of reading	
	(10 to 30) kHz	0.003 3 % of reading	
	(30 to 100) kHz	0.004 8 % of reading	
	(10 to 20) mA		
	Up to 10 Hz	0.005 2 % of reading	
10 Hz to 1 kHz	0.003 2 % of reading		
(1 to 10) kHz	0.003 3 % of reading		
(10 to 30) kHz	0.003 2 % of reading		
(30 to 100) kHz	0.004 7 % of reading		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure	(20 to 200) mA		Comparison to Fluke 5790B AC Measurement Standard, Fluke A40B Series Current Shunt <u>Location:</u> Oshkosh, WI
	Up to 10 Hz	0.005 3 % of reading	
	10 Hz to 1 kHz	0.003 4 % of reading	
	(1 to 10) kHz	0.003 4 % of reading	
	(10 to 30) kHz	0.003 4 % of reading	
	(30 to 100) kHz	0.004 8 % of reading	
	(0.2 to 2) A		
	Up to 10 Hz	0.005 4 % of reading	
	10 Hz to 1 kHz	0.003 5 % of reading + 0.17 μ A	
	(1 to 10) kHz	0.003 7 % of reading + 0.16 μ A	
	(10 to 30) kHz	0.003 8 % of reading	
	(30 to 100) kHz	0.006 3 % of reading + 0.21 μ A	
	(2 to 20) A		
	Up to 10 Hz	0.005 5 % of reading	
	10 Hz to 1 kHz	0.004 8 % of reading + 1.3 μ A	
(1 to 10) kHz	0.005 6 % of reading + 1.1 μ A		
(10 to 30) kHz	0.007 3 % of reading + 0.43 μ A		
(30 to 100) kHz	0.012 % of reading + 1.1 μ A		
(20 to 50) A			
Up to 10 Hz	0.005 8 % of reading		
10 Hz to 1kHz	0.005 8 % of reading + 16 μ A		
(1 to 10) kHz	0.008 2 % of reading + 11 μ A		
(10 to 30) kHz	0.008 4 % of reading + 5.6 μ A		
(30 to 100) kHz	0.015 % of reading + 14 μ A		
Capacitance – Measure ¹	0.32 pF to 370 mF	0.058 % of reading	Comparison to Hioki IM3533 LCR Meter <u>Locations:</u> Oshkosh, WI
Capacitance – Measure ¹	Up to 1.9 nF (1.9 to 19) nF (19 to 190) nF (0.19 to 1.9) μ F (1.9 to 19) μ F (19 to 190) μ F (0.19 to 1.9) mF (1.9 to 19) mF (19 to 190) mF	1.3 mF/F + 1.2 pF 0.76 mF/F + 2.3 pF 0.51 mF/F + 11 pF 0.54 mF/F + 0.11 nF 0.53 mF/F + 1.1 nF 0.74 mF/F + 11 nF 0.74 mF/F + 0.12 μ F 0.85 mF/F + 1.2 μ F 0.85 mF/F + 11 μ F	Comparison to Fluke 8588A 8.5 Digit Multimeter <u>Locations:</u> All



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source ¹ (Simulation)	(0.2 to 1.2) nF (1.2 to 12) nF (12 to 120) nF (0.12 to 1.2) μF (1.2 to 12) μF (12 to 120) μF (0.12 to 1.2) mF (1.2 to 12) mF (12 to 120) mF	0.12 % of reading + 2 pF 0.12 % of reading + 5 pF 0.13 % of reading + 30 pF 0.13 % of reading + 0.3 nF 0.13 % of reading + 3 nF 0.15 % of reading + 25 nF 0.25 % of reading + 0.25 μF 0.25 % of reading + 3 μF 0.5 % of reading + 30 μF	Comparison to Fluke 5560A Multiproduct Calibrator <u>Locations:</u> All
Capacitance – Source ¹ (Variable Artifact)	1 pF to 11 111 μF	0.07 % of reading	Comparison to IET HACS Capacitance Substitutor <u>Locations:</u> All
Phase – Measure ¹	Up to 360° 10 Hz to 2 kHz (2 to 5) kHz (5 to 10) kHz (10 to 50) kHz (50 to 60) kHz (60 to 70) kHz (70 to 80) kHz (80 to 90) kHz (90 to 100) kHz (100 to 500) kHz 500 kHz to 1 MHz	0.026° 0.036° 0.048° 0.059° 0.07° 0.082° 0.093° 0.1° 0.12° 0.58° 1.2°	Comparison to Clark Hess 6000A Phase Meter <u>Locations:</u> All
DC Power – Source ¹	10 mW to 330 W 330 W to 3 kW (3 to 30) kW	0.005 4 % of reading 0.035 % of reading 0.1 % of reading	Comparison to Fluke 5560A Multiproduct Calibrator <u>Locations:</u> All
AC Power – Source ¹	100 μW to 9 W (9 to 33) W (33 to 90) W (90 to 330) W (330 to 900) W 900 W to 3 kW (3 to 30) kW	0.027 % of reading 0.043 % of reading 0.035 % of reading 0.05 % of reading 0.039 % of reading 0.052 % of reading 0.099 % of reading	Comparison to Fluke 5560A Multiproduct Calibrator <u>Locations:</u> All



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Clamp-on Meters ¹ (Current Measuring Equipment)	Up to 1 500 A	0.25 % of reading + 0.5 A	Comparison to Multiproduct Calibrator, 50-turn Current Coil <u>Locations:</u> All
DC Clamp-on Meters ¹ (Current Measuring Equipment)	Up to 2 500 A	0.54 % of reading + 0.65 A	Comparison to Fluke 52120A Transconductance Amplifier, 25-turn Current Coil <u>Locations:</u> All
AC Clamp-on Meters ¹ (Current Measuring Equipment)	Up to 1 500 A	0.25 % of reading + 0.5 A	Comparison to Multiproduct Calibrator, 50-turn Current Coil <u>Locations:</u> All
AC Clamp-on Meters ¹ (Current Measuring Equipment)	Up to 3 000 A Up to 1 kHz (1 to 3) kHz (3 to 6) kHz (6 to 10) kHz	0.7 % of reading + 0.93 A 0.9 % of reading + 0.93 A 1.8 % of reading + 0.93 A 3.9 % of reading + 0.93 A	Comparison to Fluke 52120A Transconductance Amplifier, 25-turn Current Coil <u>Locations:</u> All
Oscilloscopes ¹			
DC Voltage (50 Ω load)	(-6.6 to 6.6) V	0.25 % of reading + 40 μV	Comparison to Fluke 5560A/SC2100 Multiproduct Calibrator <u>Locations:</u> All
DC Voltage (1 MΩ load)	(-120 to 120) V	0.05 % of reading + 40 μV	
AC Voltage (50 Ω load)	1 mVp-p to 6.6 Vp-p	0.25 % of reading + 40 μV	
AC Voltage (1 MΩ load)	1 mVp-p to 130 Vp-p	0.1 % of reading + 40 μV	



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Devices ¹	Pt 3916 (JIS), 100 Ω		Comparison to Fluke 5560A Multiproduct Calibrator <u>Locations:</u> All
	(-200 to -190) °C	0.25 °C	
	(-190 to -80) °C	0.04 °C	
	(0 to 100) °C	0.05 °C	
	(100 to 260) °C	0.06 °C	
	(260 to 300) °C	0.07 °C	
	(300 to 400) °C	0.08 °C	
	(400 to 600) °C	0.09 °C	
	(600 to 630) °C	0.1 °C	
	Pt 385, 200 Ω		
	(-200 to -80) °C	0.04 °C	
	(0 to 100) °C	0.04 °C	
	(100 to 260) °C	0.04 °C	
	(260 to 300) °C	0.05 °C	
	(300 to 400) °C	0.12 °C	
	(400 to 600) °C	0.13 °C	
	(600 to 630) °C	0.14 °C	
	Pt 385, 500 Ω		
	(-200 to -80) °C	0.04 °C	
	(0 to 100) °C	0.05 °C	
	(100 to 260) °C	0.05 °C	
	(260 to 300) °C	0.06 °C	
	(300 to 400) °C	0.08 °C	
	(400 to 600) °C	0.08 °C	
	(600 to 630) °C	0.09 °C	
	Pt 385, 1 000 Ω		
	(-200 to -80) °C	0.03 °C	
	(0 to 100) °C	0.03 °C	
	(100 to 260) °C	0.04 °C	
	(260 to 300) °C	0.05 °C	
	(300 to 400) °C	0.06 °C	
	(400 to 600) °C	0.07 °C	
	(600 to 630) °C	0.07 °C	
PtNi 385, 120 Ω, Ni 120			
(-80 to 0) °C	0.23 °C		
(0 to 100) °C	0.08 °C		
(100 to 260) °C	0.08 °C		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Devices ¹	Cu 427, 10 Ω (-80 to 260) °C	0.03 °C	Comparison to Fluke 5560A Multiproduct Calibrator <u>Locations:</u> All
	Cu 428, 50 Ω (-180 to 200) °C	0.4 °C	
	Cu 428, 100 Ω (-180 to 40) °C	0.4 °C	
	(40 to 200) °C	0.65 °C	
Electrical Simulation of Thermocouple Indicating Devices – Source/Measure ¹	Type B (600 to 800) °C	0.44 °C	Comparison to Fluke 5560A Multiproduct Calibrator <u>Locations:</u> All
	(-100 to -25) °C	0.34 °C	
	(-25 to 120) °C	0.3 °C	
	(120 to 1 000) °C	0.33 °C	
	Type C (0 to 150) °C	0.25 °C	
	(150 to 650) °C	0.21 °C	
	(650 to 1 000) °C	0.26 °C	
	(1 000 to 1 800) °C	0.45 °C	
	(1 800 to 2 316) °C	0.79 °C	
	Type E (-250 to -100) °C	0.4 °C	
	(-100 to -35) °C	0.14 °C	
	(-25 to 350) °C	0.11 °C	
	(350 to 650) °C	0.16 °C	
	(650 to 1 000) °C	0.21 °C	
	Type J (-210 to -100) °C	0.24 °C	
	(-100 to -30) °C	0.13 °C	
	(-30 to 150) °C	0.11 °C	
	(150 to 760) °C	0.14 °C	
	(760 to 1 200) °C	0.2 °C	
	Type K (-200 to -100) °C	0.28 °C	
	(-100 to -25) °C	0.13 °C	
	(-25 to 120) °C	0.11 °C	
	(120 to 1 000) °C	0.21 °C	
	(1 000 to 1 372) °C	0.35 °C	
Type L (-200 to -100) °C	0.31 °C		
(-100 to 800) °C	0.2 °C		
(800 to 900) °C	0.11 °C		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of Thermocouple Indicating Devices – Source/Measure ¹	Type N		Comparison to Fluke 5560A Multiproduct Calibrator <u>Locations:</u> All
	(-200 to -100) °C	0.33 °C	
	(-100 to -25) °C	0.15 °C	
	(-25 to 120) °C	0.12 °C	
	(120 to 410) °C	0.11 °C	
	(410 to 1 300) °C	0.2 °C	
	Type R		
	(0 to 250) °C	0.51 °C	
	(250 to 400) °C	0.29 °C	
	(400 to 1 000) °C	0.27 °C	
	(1 000 to 1767) °C	0.34 °C	
	Type S		
	(0 to 250) °C	0.42 °C	
	(250 to 1 000) °C	0.31 °C	
(1 000 to 1400) °C	0.32 °C		
(1 400 to 1 767) °C	0.41 °C		
Type T			
(-250 to -150) °C	0.6 °C		
(-150 to 0) °C	0.21 °C		
(0 to 120) °C	0.13 °C		
(120 to 400) °C	0.11 °C		
Type U			
(-200 to 0) °C	0.4 °C		
(0 to 600) °C	0.11 °C		
Inductance – Source ¹ (Simulation)	(13 to 120) μH	0.2 % of reading + 0.2 μH	Comparison to Fluke 5560A Multiproduct Calibrator <u>Locations:</u> All
	(0.12 to 1.2) mH	0.12 % of reading + 1 μH	
	(1.2 to 12) mH	0.12 % of reading + 10 μH	
	(12 to 120) mH	0.12 % of reading + 0.1 mH	
	(0.12 to 1.2) H	0.15 % of reading + 1 mH	
	(1.2 to 12) H	0.2 % of reading + 10 mH	
(12 to 120) H	0.25 % of reading + 0.1 H		
Inductance – Source ¹ (Variable Artifact)	1 μH to 10 H	1.2 % of reading + 1.2 μH	Comparison to IET 1492 Inductance Substituter <u>Locations:</u> All



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Inductance – Measure	80 nH to 100 H	0.24 % of reading + 2.4 μ H	Comparison to Hioki IM3533 LCR Meter <u>Locations:</u> All
Ionizers ¹ Decay Time Float Voltage	(0.1 to 999.9) s (-1 100 to 1 100) V	0.2 s 3.1 V	Comparison to Trek 156A Charged Plate Monitor <u>Locations:</u> All
ESD Simulators Rise Time Peak Current 30 ns Current 60 ns Current RC Time Constant	700 ps to 1 ns (7.5 to 30) A (4 to 16) A (2 to 8) A 600 ns 300 ns	0.14 ns 50 mA/A 0.1 A/A 0.12 A/A 20 ns 15 ns	Tektronix TDS684B Oscilloscope with EM Test CTR2 ESD Target; IEC 61000-4-2, SAE J1113-13 <u>Locations:</u> Oshkosh, WI
Transient Generators Rise Time Open Circuit Closed Circuit Duration/Pulse Width Open Circuit Closed Circuit Peak Voltage Peak Current Frequency	75 ns to 10 μ s 75 ns to 10 μ s (50 to 700) μ s (20 to 320) μ s (0.5 to 6) kV 12.5 A to 3 kA 5 kHz to 1 MHz	1.5 % of reading + 0.12 μ s 0.69 % of reading + 79 ns 0.058 % of reading + 0.28 μ s 0.12 % of reading + 34 ns 1.6 % of reading + 9.5 V 2.2 % of reading + 0.2 A 0.12 % of reading + 1.6 Hz	Oscilloscope, High Voltage Differential Probe, Current Probe; IEC 61000-4-5, IEC 61000-4-12, IEC 61000-4-18. <u>Locations:</u> All



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Defibrillators	Up to 360 J	0.41 % of reading + 0.77 J	Comparison to Oscilloscope, Tektronix P6015 High Voltage Probe, Digital Multimeter, Power Resistor <u>Locations:</u> All
Current Injection Probes	9 kHz to 400 MHz	0.22 dB	VNA, VNA Calibration Kit; IEC 61000-4-6. <u>Locations:</u> All
EFT/Burst Generator Peak Voltage 50 Ω 1 kΩ Rise Time Pulse Width	Up to 4 kV Up to 4 kV (5 to 5.5) ns (45 to 50) ns	5.7 % of reading + 1.2 V 3.9 % of reading + 1.7 V 1.4 % of reading + 77 ps 0.21 % of reading + 65 ps	Oscilloscope, 50 Ω Attenuator, 1 kΩ Attenuator; IEC 61000-4-4. <u>Locations:</u> All
Multiproduct/Multifunction Calibrators DC Voltage	(10 to 100) V (30 to 1 000) V	0.33 μV/V + 1.7 μV 32 nV/V + 3.5 μV	Comparison to Fluke 8588A 8.5 Digit Multimeter, Fluke 752A DC Voltage Reference <u>Location:</u> Oshkosh, WI
Multiproduct/Multifunction Calibrators DC Current	(0 to 120) μA (0.12 to 1.2) mA (1.2 to 12) mA (12 to 120) mA (0.12 to 1.2) A (1.2 to 20) A (20 to 100) A	4.5 μA/A + 0.29 nA 5 μA/A + 28 nA 4.6 μA/A + 28 nA 4.6 μA/A + 0.28 μA 8 μA/A + 2.5 μA 57 μA/A + 7.7 μA 56 μA/A + 81 μA	Comparison to Fluke 8588A 8.5 Digit Multimeter, Current Shunts <u>Location:</u> Oshkosh, WI



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Multiproduct/Multifunction Calibrators Resistance	(0 to 1.9) Ω (0 to 19) Ω (0 to 190) Ω (0 to 1.9) k Ω (0 to 19) k Ω (0 to 190) k Ω (0 to 1.9) M Ω (0 to 19) M Ω (0 to 190) M Ω (0 to 1.09) G Ω	7.4 $\mu\Omega/\Omega$ + 0.91 $\mu\Omega$ 2.8 $\mu\Omega/\Omega$ + 9.2 $\mu\Omega$ 2 $\mu\Omega/\Omega$ + 38 $\mu\Omega$ 1.5 $\mu\Omega/\Omega$ + 0.39 m Ω 2.4 $\mu\Omega/\Omega$ + 3.2 m Ω 2.6 $\mu\Omega/\Omega$ + 41 m Ω 4.3 $\mu\Omega/\Omega$ + 0.48 Ω 8.6 $\mu\Omega/\Omega$ + 7.4 Ω 26 $\mu\Omega/\Omega$ + 0.22 k Ω 0.16 m Ω/Ω + 8.6 k Ω	Comparison to Fluke 8588A 8.5 Digit Multimeter, 9330 Series Standard Resistors; 4-wire Configuration, Ranges Locked <u>Location:</u> Oshkosh, WI
Multiproduct/Multifunction Calibrators Phase AC Voltage/Current AC Voltage/Voltage	10 mV to 630 V Up to 20.5 A 5 Hz to 2 kHz (0 to 180) $^\circ$ 10 mV to 630 V 10 mV to 5 V 5 Hz to 30 kHz (0 to 180) $^\circ$	 0.02 $^\circ$ -0.03 $^\circ$	Comparison to Clark Hess 6000A Phase Meter <u>Location:</u> Oshkosh, WI
Multiproduct/Multifunction Calibrators – Scope Options Input Impedance Resistance Measure Input Impedance Capacitance Measure	(40 to 60) Ω 600 k Ω to 1.5 M Ω (10 to 47) pF	0.1 % of reading + 0.32 m Ω 0.012 % of reading + 90 m Ω 1.2 % of reading + 5.4 fF	Comparisons to IET Labs 1433 Series Decade Resistor Standard Capacitors with Hioki IM3533 LCR Meter <u>Location:</u> Oshkosh, WI



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Multiproduct/Multifunction Calibrators Thermocouple Simulation Measurements 10 $\mu\text{V}/^\circ\text{C}$	(-3 000 to 3 000) $^\circ\text{C}$	0.000 57 % of reading + 0.032 $^\circ\text{C}$	Comparison to Fluke 8588A 8.5 Digit Multimeter, Fluke 7526A Precision Process Calibrator <u>Location:</u> Oshkosh, WI
Multiproduct/Multifunction Calibrators Amplitude – Sine Wave	1 Vp-p to 70 Vp-p Up to 45 Hz 45 Hz to 1 kHz (1 to 20) kHz (20 to 100) kHz	0.1 % of reading + 0.59 μV 0.1 % of reading + 0.59 μV 0.17 % of reading + 0.4 μV 0.5 % of reading + 0.14 μV	Comparison to Fluke 5790B AC Measurement Standard <u>Location:</u> Oshkosh, WI
Amplitude – Square Wave	1 Vp-p to 70 Vp-p Up to 45 Hz 45 Hz to 1 kHz (1 to 20) kHz (20 to 100) kHz	0.1 % of reading + 0.33 μV 0.1 % of reading + 0.33 μV 0.17 % of reading + 0.21 μV 0.5 % of reading + 72 nV	
Amplitude – Triangle Wave	1 Vp-p to 70 Vp-p Up to 45 Hz 45 Hz to 1 kHz (1 to 20) kHz (20 to 100) kHz	0.1 % of reading + 0.81 μV 0.1 % of reading + 0.81 μV 0.17 % of reading + 0.57 μV 0.5 % of reading + 0.22 μV	
Multiproduct/Multifunction Calibrators Leveled Sine Wave Flatness	Up to 5.5 Vp-p < 100 MHz 0 % 100 MHz to 1 GHz 0 %	0.79 % 1 %	Comparison to Rohde & Schwarz NRP Power Sensor <u>Location:</u> Oshkosh, WI



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Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure ^{1,4} Absolute Level	(-20 to 20) dBm		Comparison to Power Meter, Power Sensors <u>Locations:</u> All
	DC to 100 MHz	0.06 dB	
	100 MHz to 2.4 GHz	0.09 dB	
	(2.4 to 8) GHz	0.16 dB	
	(8 to 12.4) GHz	0.17 dB	
	(12.4 to 18) GHz	0.2 dB	
	(18 to 26.5) GHz	0.26 dB	
	(26.5 to 33) GHz	0.32 dB	
	(33 to 40) GHz	0.33 dB	
	(40 to 50) GHz	0.35 dB	
	(-25 to 20) dBm		
	DC to 100 MHz	0.09 dB	
	100 MHz to 2.4 GHz	0.11 dB	
	(2.4 to 12.4) GHz	0.18 dB	
	(12.4 to 18) GHz	0.21 dB	
	(18 to 26.5) GHz	0.27 dB	
	(26.5 to 40) GHz	0.33 dB	
	(40 to 50) GHz	0.36 dB	
	(-30 to 25) dBm		
	DC to 100 MHz	0.23 dB	
	100 MHz to 2.4 GHz	0.24 dB	
(2.4 to 12.4) GHz	0.28 dB		
(12.4 to 18) GHz	0.3 dB		
(18 to 26.5) GHz	0.34 dB		
(26.5 to 40) GHz	0.39 dB		
(40 to 50) GHz	0.42 dB		

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure ^{1,4} Absolute Level	(-20 to 20) dBm		Comparison to Power Meter, Power Sensors <u>Locations:</u> All
	DC to 100 MHz	0.06 dB	
	100 MHz to 2.4 GHz	0.09 dB	
	(2.4 to 8) GHz	0.16 dB	
	(8 to 12.4) GHz	0.17 dB	
	(12.4 to 18) GHz	0.2 dB	
	(18 to 26.5) GHz	0.26 dB	
	(26.5 to 33) GHz	0.32 dB	
	(33 to 40) GHz	0.33 dB	
	(40 to 50) GHz	0.35 dB	
	(-25 to 20) dBm		
	DC to 100 MHz	0.09 dB	
	100 MHz to 2.4 GHz	0.11 dB	
	(2.4 to 12.4) GHz	0.18 dB	
	(12.4 to 18) GHz	0.21 dB	
	(18 to 26.5) GHz	0.27 dB	
	(26.5 to 40) GHz	0.33 dB	
	(40 to 50) GHz	0.36 dB	
	(-30 to 25) dBm		
	DC to 100 MHz	0.23 dB	
100 MHz to 2.4 GHz	0.24 dB		
(2.4 to 12.4) GHz	0.28 dB		
(12.4 to 18) GHz	0.3 dB		
(18 to 26.5) GHz	0.34 dB		
(26.5 to 40) GHz	0.39 dB		
(40 to 50) GHz	0.42 dB		
(-35 to 25) dBm			
DC to 2.4 GHz	0.73 dB		
(2.4 to 12.4) GHz	0.74 dB		
(12.4 to 18) GHz	0.75 dB		
(18 to 26.5) GHz	0.77 dB		
(26.5 to 40) GHz	0.79 dB		
(40 to 50) GHz	0.81 dB		
RF Power – Measure ¹ Relative Level	(-80 to 20) dB		Comparison to Rohde & Schwarz FSMR3050 Measuring Receiver <u>Locations:</u> All
	100 kHz to 18 GHz	0.03 % of reading + 0.000 6 dB	
	(18 to 40) GHz	0.05 % of reading + 0.000 6 dB	
	(40 to 50) GHz	0.06 % of reading + 0.058 dB	
	(-110 to 80) dB		
	100 kHz to 18 GHz	0.03 % of reading + 0.003 9 dB	
(18 to 40) GHz	0.03 % of reading + 0.015 dB		
(40 to 50) GHz	0.03 % of reading + 0.033 dB		



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Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure ¹ Relative Level	(-130 to 110) dB 100 kHz to 18 GHz (18 to 40) GHz (40 to 50) GHz (-140 to 130) dB 100 kHz to 18 GHz (18 to 40) GHz (40 to 50) GHz	0.03 % of reading + 0.005 8 dB 0.03 % of reading + 0.017 dB 0.03 % of reading + 0.035 dB 0.03 % of reading + 0.004 9 dB 0.03 % of reading + 0.012 dB 0.03 % of reading + 0.032 dB	Comparison to Rohde & Schwarz FSMR3050 Measuring Receiver <u>Locations:</u> All
Amplitude Modulation – Source ^{1,4} 250 kHz to 40 GHz	Rate: DC to 100 kHz Depths: (0 to 100) %	7.1 % of reading	Comparison to Agilent E8257D Signal Generator <u>Locations:</u> All
Amplitude Modulation – Measure ^{1,4}	100 kHz to 10 MHz (1 to 5) % Depth (5.001 to 99) % Depth 10 MHz to 8 GHz (1 to 5) % Depth (5.001 to 50) % Depth (50 to 99) % Depth (8 to 50) GHz (1 to 5) % Depth (5.001 to 50) % Depth (50 to 99) % Depth	0.02 % of reading + 0.024 % Depth 0.1 % of reading + 0.005 6 % Depth 0.05 % of reading + 0.047 % Depth 0.21 % of reading + 0.006 4 % Depth 0.18 % of reading + 0.019 % Depth 0.03 % of reading + 0.074 % Depth 0.14 % of reading + 0.053 % Depth 0.17 % of reading + 0.039 % Depth	Comparison to Rohde & Schwarz FSMR3050 Measuring Receiver <u>Locations:</u> All
Phase Modulation – Source ^{1,4} Rate: DC to 100 kHz	250 kHz to 40 GHz	5.9 % of reading + 0.1 rad	Comparison to Agilent E8257D Signal Generator <u>Locations:</u> All
Phase Modulation – Measure ^{1,4}	100 kHz to 50 GHz (1 to 10 000) rad	0.59 % of reading + 0.002 3 rad	Comparison to Rohde & Schwarz FSMR3050 Measuring Receiver <u>Locations:</u> All



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Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Tuned RF Level – Measure ^{1,4} Absolute Level	500 kHz to 3.05 GHz (16 to 30) dBm (-106 to 16) dBm (-129 to -106) dBm (3.05 to 6.6) GHz (20 to 30) dBm (-90 to 20) dBm (-114 to -90) dBm (6.6 to 13.2) GHz (20 to 30) dBm (-81 to 20) dBm (-104 to -81) dBm	0.37 dB + 0.005 dB/10 dB 0.15 dB + 0.005 dB/10 dB 0.15 dB + 0.12 dB/10 dB 0.39 dB + 0.005 dB/10 dB 0.18 dB + 0.005 dB/10 dB 0.23 dB + 0.12 dB/10 dB 0.39 dB + 0.005 dB/10 dB 0.18 dB + 0.005 dB/10 dB 0.23 dB + 0.12 dB/10 dB	Comparison to Agilent N5531S Measuring Receiver with N5532A Sensor Modules <u>Locations:</u> All
Tuned RF Level – Measure ^{1,4} Absolute Level	(13.2 to 19.2) GHz (+20 to +30) dBm (-70 to +20) dBm (-93 to -70) dBm (19.2 to 26.5) GHz (+20 to +30) dBm (-62 to +20) dBm (-85 to -62) dBm 500 kHz to 3.05 GHz (-90 to +30) dBm (-106 to -90) dBm (-129 to -106) dBm	0.4 dB + 0.005 dB/10 dB 0.21 dB + 0.005 dB/10 dB 0.25 dB + 0.12 dB/10 dB 0.4 dB + 0.005 dB/10 dB 0.21 dB + 0.005 dB/10 dB 0.24 dB + 0.12 dB/10 dB 0.026 dB + 0.005 dB/10 dB 0.067 dB + 0.12 dB/10 dB 0.076 dB + 0.12 dB/10 dB	Comparison to Agilent N5531S Measuring Receiver with N5532A Sensor Modules <u>Locations:</u> All
RF Power – Source ¹	> -10 dBm 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz (-10 to -70) dBm 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz (-70 to -90) dBm 250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz	0.72 dB 0.96 dB 1.1 dB 0.89 dB 1.1 dB 1.2 dB 0.95 dB 1.2 dB 1.21 dB	Comparison to Agilent E8257D Signal Generator <u>Locations:</u> All

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Sensors – Calibration Factor ^{1,4}	(-20 to +14) dBm 100 kHz to 10 MHz 10 MHz to 10 GHz (10 to 18) GHz	1.5 % of reading 1.5 % of reading 1.7 % of reading	Comparison to Tegam 1827 Power Sensor Calibrator, Agilent 3458A 8.5 Digit Multimeter, Agilent E8257D Signal Generator, Agilent E4419B Power Meter, Agilent 3325B Function Generator <u>Locations:</u> All
Frequency Modulation – Measure ^{1,4}	100 kHz to 50 GHz Rate: 100 Hz to 3 MHz	0.5 % of reading + 75 mHz	Comparison to Rohde & Schwarz FSMR3050 Measuring Receiver <u>Locations:</u> All
Frequency Modulation – Source ^{1,4} 250 kHz to 40 GHz	1 dB Rate: DC to 100 kHz 3 dB Rate: DC to 10 MHz	4.2 % of reading + 20 Hz	Comparison to Agilent E8257D Signal Generator <u>Locations:</u> All
Pulse Generation – Measure ^{1,4} DC to 225 MHz Pulse Width Rise/Fall Time	5 ns to 1 000 000 s 5 ns to 1 000 000 s	1.1 ns 1.1 ns	Comparison to Agilent 53132A Counter <u>Locations:</u> All
Pulse Generation – Source ^{1,4} Repetition Frequency: 24 mHz to 14.28 MHz Period: 70 ns to 42 s	10 ns to 42 s	1.7 ns	Comparison to Agilent E8257D Signal Generator <u>Locations:</u> All



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Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Impulse Spectral Amplitude Source CISPR Band A CISPR Band B CISPR Band C and Band D CISPR Band E Sine Wave Output Accuracy CISPR	(10 to 150) kHz > 150 kHz to 30 MHz > 30 MHz to 1 GHz (> 1 to 40) GHz 60 dB/μV 10 kHz to 40 GHz	0.81 dB 0.74 dB 0.78 dB 1.1 dB 0.32 dB	Comparison to Schwarzbeck IGUU 2918 Pulse Generator, Keysight E8257D Signal Generator; CISPR 16-1-1 <u>Locations:</u> All
Line Impedance Stabilization Network ^{1,4} Insertion Loss Impedance – Magnitude Impedance – Phase Isolation (De-coupling Factor)	(-20 to 0) dB 9 kHz to 400 MHz 100 mΩ to 1 kΩ 9 kHz to 400 MHz (-180 to 180)° 9 kHz to 400 MHz (-90 to 0) dB 9 kHz to 400 MHz	0.25 dB 5.6 % of reading 5.3° 0.37 dB	Vector Network Analyzer, Attenuators, VNA Cal Kit; ANSI C63.4, CISPR 25, CISPR 16-1-2, DO-160G, MIL-STD 461G <u>Locations:</u> All
Coupling/De-coupling Network ^{1,4} Insertion Loss Impedance – Magnitude	(-20 to 0) dB 9 kHz to 230 MHz 100 mΩ to 1 kΩ 9 kHz to 230 MHz	0.25 dB 5.6 % of reading	Vector Network Analyzer, Attenuators, VNA Cal Kit; IEC 61000-4-6, CISPR 16-1-2 <u>Locations:</u> All



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Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gage Blocks ²	Up to 30 in	$(3.4 + 1.8L) \mu\text{in}$	Mahr 828 Measuring Machine; ASME B89.1.9 <u>Location:</u> Oshkosh, WI
Gage Blocks ²	Up to 11 in	$(5.7 + 1.2L) \mu\text{in}$	P & W Universal Labmaster®; ASME B89.1.9 <u>Locations:</u> Oshkosh, WI Rockford, IL
Gage Blocks ²	Up to 20 in	$(8.5 + 1L) \mu\text{in}$	ULM Measuring Machine; ASME B89.1.9 <u>Locations:</u> Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH
Length Standards ²	Up to 24 in	$(12 + 1L) \mu\text{in}$	ULM Measuring Machine; ASME B89.1.1 <u>Locations:</u> Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH
Length Standards ²	Up to 39 in	$(12 + 1L) \mu\text{in}$	Mahr 828 Measuring Machine; ASME B89.1.1 <u>Location:</u> Oshkosh, WI



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Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length Standards ²	(39 to 70) in	$(390 + 2.6L) \mu\text{in}$	Comparison to CMM <u>Locations:</u> Oshkosh, WI Stacy, MN
Length Standards ²	Up to 4 in	$(37 + 1.5L) \mu\text{in}$	Comparison to Plug Gage Comparator <u>Locations:</u> All
Cylindrical Rings ²	(0.02 to 18) in	$(8 + 1.8D) \mu\text{in}$	Mahr 828 Measuring Machine; ASME B89.1.6 <u>Location:</u> Oshkosh, WI
Cylindrical Rings ²	Up to 12 in	$(9.8 + 1.8D) \mu\text{in}$	ULM Measuring Machine; ASME B89.1.6 <u>Locations:</u> All
Cylindrical Rings ^{1,2}	(0.25 to 8) in	$(12 + 3D) \mu\text{in}$	Fowler Lab Concept Measuring Machine; ASME B89.1.6 <u>Locations:</u> All
Cylindrical Plugs ²	Up to 30 in	$(2.7 + 6D) \mu\text{in}$	Comparison to Mahr 828 Measuring Machine <u>Location:</u> Oshkosh, WI
Cylindrical Plugs ²	Up to 20 in	$(7.8 + 1.4D) \mu\text{in}$	Comparison to ULM <u>Location:</u> All

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Cylindrical Plugs ^{1,2}	Up to 4 in	$(37 + 1.5D) \mu\text{in}$	Comparison to Plug Gage Comparator <u>Locations:</u> All
Thread Rings ² Pitch Diameter Minor Diameter	Up to Setting plug size Up to 16 in Up to 1 in (> 1 to 9) in	$(190 + 0.75D) \mu\text{in}$ 260 μin $(150 + 0.09D) \mu\text{in}$	Setting Plug Gages, Measuring Machine, Pin Gages, ID Bore Gages; ASME B1.2 <u>Locations:</u> All
Non-Standard Thread Rings ² Pitch Diameter Minor Diameter	Up to 14 in Up to 1 in (> 1 to 9) in	$(120 + 2.5D) \mu\text{in}$ 260 μin $(150 + 0.09D) \mu\text{in}$	ULM Measuring Machine, Pin Gages, ID Bore Gages; ASME B1.2 <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH
NPT Rings (Standoff and Basic Length)	(0.062 5 to 8) in	250 μin	NPT Plugs, P&W Labmaster [®] , P&W Laser Ruler; ASME B1.20.5, ASME B1.20.1 <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Boise, ID



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Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
NPT Plugs (Standoff and Basic Length)	(0.062 5 to 6) in	490 μ in	NPT Rings, P&W Labmaster [®] , P&W Laser Ruler; ASME B1.20.5, ASME B1.20.1 <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Boise, ID
Thread Plugs ² Pitch Diameter Major Diameter	Up to 24 in Up to 24 in	(54 + 0.29D) μ in (40 + 1.9D) μ in	P&W Supermicrometer [®] , Thread Measuring Wires; ASME B1.2 <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Boise, ID Crestline, OH Broken Arrow, OK
Thread Plugs ^{1,2} Pitch Diameter Major Diameter	Up to 4 in Up to 4 in	(63 + 1.9D) μ in (53 + 4.1D) μ in	Comparison to Plug Gage Comparator <u>Locations:</u> All

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thread Wires ²	Up to 0.5 in	$(11 + 1.5D) \mu\text{in}$	ULM Measuring Machine; ASME B89.1.17 <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH
Calipers ^{1,2}	Up to 120 in	$(8.4 + 3.6L) \mu\text{in}$	Comparison to Gage Blocks <u>Locations:</u> All
Indicators, Test Indicators ^{1,2}	Up to 4 in	$(8.5 + 2.3L) \mu\text{in}$	Comparison to Gage Blocks <u>Locations:</u> All
Indicators, Test Indicators ^{1,2}	Up to 4 in	$(140 + 0.34L) \mu\text{in}$	Comparison to Indicator Checker <u>Locations:</u> All
OD Micrometers ^{1,2}	Up to 60 in	$(27 + 3.2L) \mu\text{in}$	Comparison to Gage Blocks <u>Locations:</u> All
ID Micrometer ^{1,2}	(1.5 to 40) in	$(370 + 7L) \mu\text{in}$	Comparison to Gage Blocks <u>Locations:</u> All
Depth Micrometers ^{1,2}	Up to 24 in	$(8.6 + 0.47L) \mu\text{in}$	Comparison to Gage Blocks, Surface Plate <u>Locations:</u> All

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Laser Micrometers ¹	Up to 4 in	$(23 + 11L) \mu\text{in}$	Comparison to Master Pin Gages <u>Locations:</u> All
Height Gages ^{1,2}	Up to 40 in	$(180 + 1.2L) \mu\text{in}$	Comparison to Gage Blocks, Surface Plate <u>Locations:</u> All
Bore Gages ^{1,2}	(0.25 to 12) in	$(180 + 1.2L) \mu\text{in}$	Comparison to Cylindrical Rings <u>Locations:</u> All
Crimpers ¹ Die Check Crimp Height	(0.011 to 0.5) in (0.01 to 0.5) in	230 μin 0.001 2 in	Comparison to Pin Gages, Micrometer <u>Locations:</u> All
Profilometers ¹	(2 to 300) $\mu\text{in Ra}$	2.3 μin	Comparison to Roughness Specimen <u>Locations:</u> All
Chamfer Gage ² Diameter Edge Detection	Up to 6 in Up to 6 in	$(220 + 0.033D) \mu\text{in}$ $(200 + 0.84D) \mu\text{in}$	Comparison to Chamfer Ring Plate Laser Ruler, Master Sphere <u>Locations:</u> All

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Surface Plates ^{1,2} Repeat Reading Overall Flatness	 (4 to 34) inDL (34 to 175) inDL	 35 μin (92 + 0.14DL) μin	In accordance with ASME B89.3.7 using Repeat-O-Meter Electronic Levels <u>Locations:</u> All
Pi Tapes Diameter	 Up to 240 in	 0.000 14 % of reading + 260 μin	Comparison to Renishaw Laser Measuring System w/Microscope <u>Location:</u> Oshkosh, WI
Profilometer Reference Specimens	(0.01 to 9 500) μin Ra	1.6 μin	Comparison to Mahr VD280 Profilometer <u>Location:</u> Oshkosh, WI
Linear Measurements	Up to 1 560 in	(38 + 0.5L) μin	Comparison to Renishaw Laser System <u>Locations:</u> All
Optical Comparators ^{1,2} Linearity of Table Travel Magnification	 Up to 30 in 10x, 20x, 31.25x, 50x, 62.5x, 100x, 200x	 (97 + 12L) μin 460 μin	Comparison to Glass Scale, Precision Balls, Calibration Sphere <u>Locations:</u> All
Vision Systems ^{1,2} X-Y Axis Linearity Z Axis Linearity Magnification (variable)	 Up to 6 in (> 6 to 12) in Up to 6 in Up to 6 in length	 (130 + 2.2L) μin (390 + 0.027L) μin (4.1 + 4.4L) μin 14 μin	Comparison to Glass Scales, Gage Blocks <u>Locations:</u> All

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Roundness Testers ¹ Axial Error	(-1 000 to 1 000) μm	0.15 μm	Comparison to Test Sphere
Radial Error	(-1 000 to 1 000) μm	0.15 μm	<u>Locations:</u> All
Universal Length Measuring Machines ^{1,2} Length	Up to 300 mm	(0.11 + 0.02L) μm	Comparison to Gage Blocks
Force	Up to 5 lbf	0.009 8 lbf	Load Cell
			<u>Locations:</u> All
Thickness Gages ^{1,2}	Up to 0.06 in Up to 6 in	(66 + 65L) μin (8.5 + 2.3L) μin	Comparison to Film Thickness Standards, Gage Blocks
			<u>Locations:</u> All
Brinell Scopes ¹	(1 to 6) mm	11 μm	Comparison to Stage Micrometer
			<u>Locations:</u> All
Angle Measuring Devices ² Protractors	Up to 90°	0.000 73 % of reading + 0.000 12°	Comparison to Gage Blocks, Sine Bar, Granite Square
Inclinometers	Up to 1°	0.009 8 % of reading + 0.000 16°	
			<u>Locations:</u> All
Radius Gages ²	Up to 300 mm	(2.8 + 0.005 7X) μm	Comparison to Vision System
			<u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH



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Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Optical Flats ² Height Flatness	Up to 4 in Up to 4 in	$(6.7 + 3.4t) \mu\text{in}$ 5.4 μin	Comparison to Laser Ruler, Master Optical Flat, Monochromatic Light <u>Locations:</u> All
Glass Grids, Stage Micrometers ²	Up to 20 in	$(0.55 + 0.000 28L) \mu\text{m}$	Comparison to ULM, Camera <u>Locations:</u> All
Concentricity Gages	Up to 8 in	11 μin	Compared to P&W Laser Ruler <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Crestline, OH

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Analytical Balances ^{1,5}	Up to 12 kg	0.000 31 % of reading + 12 μg	ASTM E617 Class 1 weights and internal procedure MC-009B utilized in the calibration of the weighing system. <u>Locations:</u> All



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Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Bench and Floor Scales ^{1,5}	Up to 5 000 lb	0.001 6 % of reading + 0.000 4 lb	ASTM E617 Class 6, ASTM E617 Class 7 weights and internal procedure MC-009A utilized in the calibration of the weighing system. <u>Locations:</u> All
Moisture Balances ¹ Weighing System	Up to 12 kg	0.003 1 % of reading + 12 µg	Comparison to ASTM E617 Class 1 Weights
Temperature	Up to 300 °C	0.04 % of reading + 0.26 °C	RTD Probe with Indicator <u>Locations:</u> All
Mass Determination (Avoirdupois)	50 lb 20 lb 5 lb 2 lb 1 lb 0.5 lb 1 oz	59 mg 58 mg 5.8 mg 5.8 mg 5.8 mg 5.8 mg 9.5 µg	Class 1 Weights and Analytical Balance; Modified Substitution <u>Locations:</u> Oshkosh, WI (Class 4 and below) Fenton, MO (Class F Only) Stacy, MN (Class F Only) Monroe, NC (Class 4 and below)



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Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Mass Determination (SI)	25 000 g 20 000 g 5 000 g 3 000 g 2 000 g 1 000 g 500 g 300 g 200 g 100 g 50 g 30 g 20 g 10 g 5 g 3 g 2 g 1 g	0.29 g 0.29 g 5.9 mg 5.8 mg 5.8 mg 5.8 mg 5.8 mg 5.8 mg 0.11 mg 97 µg 95 µg 94 µg 11 µg 9.3 µg 3.8 µg 2.8 µg 2.4 µg 2.4 µg	Class 1 Weights and Analytical Balance; Modified Substitution <u>Locations:</u> Oshkosh, WI (Class 4 and below) Fenton, MO (Class F Only) Stacy, MN (Class F Only) Monroe, NC (Class 4 and below)
Mass Determination (SI)	500 mg 200 mg 100 mg 50 mg 20 mg 10 mg 5 mg 3 mg 2 mg 1 mg	2 µg 1.6 µg 1.6 µg 1.6 µg 1.7 µg 1.7 µg 1.7 µg 1.8 µg 1.7 µg 1.6 µg	Class 1 Weights and Analytical Balance; Modified Substitution <u>Locations:</u> Oshkosh, WI (Class 4 and below) Fenton, MO (Class F Only) Stacy, MN (Class F Only) Monroe, NC (Class 4 and below)
Gauge Pressure Devices ¹	Up to 854 inH ₂ O	0.03 % of reading + 0.000 044 inH ₂ O	Comparison to Ametek PK2 Deadweight Tester <u>Location:</u> Oshkosh, WI

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Absolute Pressure Devices	(0.2 to 25) psia (25 to 500) psia	0.001 2 % of reading 0.002 7 % of reading + 0.000 4 psi	Comparison to Ruska 2465 Deadweight Tester <u>Locations:</u> All
Gauge Pressure Devices	(500 to 3 000) psig	0.003 % of reading + 0.000 9 psi	Comparison to Ruska 2470 Deadweight Tester <u>Locations:</u> All
Gauge Pressure Devices	Up to 600 psig (600 to 40 000) psig	0.007 8 % of reading + 0.001 2 psi 0.008 % of reading	Comparison to Budenberg BGH2600 Deadweight Tester <u>Locations:</u> All
Gauge Pressure Devices	(40 000 to 60 000) psig	36 psi	Comparison to Additel Hydraulic Pump, Digital Pressure Test Gauge <u>Locations:</u> Oshkosh, WI
Gauge Pressure Devices ¹	Up to 1 inH ₂ O (1 to 2) inH ₂ O (2 to 10) inH ₂ O (10 to 30) inH ₂ O (-14 to 30) psig (30 to 100) psig (100 to 300) psig (300 to 500) psig (500 to 1 000) psig (1 000 to 3 000) psig (3 000 to 5 000) psig (5 000 to 10 000) psig	0.001 3 inH ₂ O 0.002 4 inH ₂ O 0.012 inH ₂ O 0.035 inH ₂ O 0.01 psi 0.059 psi 0.071 psi 0.18 psi 0.23 psi 0.7 psi 1.2 psi 2.5 psi	Comparison to Additel Digital Test Gauge <u>Locations:</u> All



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Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Vacuum Devices	(> 0 to 0.1) Torr (> 0.1 to 1) Torr	0.56 % of reading + 0.022 mTorr 0.26 % of reading + 0.55 mTorr	Comparison to MKS Capacitance Manometers <u>Location:</u> Oshkosh, WI
Vacuum Devices ¹	(> 0 to 10) Torr (> 0 to 1 000) Torr	5 % of reading + 0.085 Torr 0.11 % of reading + 0.37 Torr	Comparison to Hastings HVG-2020B Vacuum Gage <u>Location:</u> All
Durometers			Direct Verification per ASTM D2240 using Durometer Calibrator, Triple Beam Balance
Spring Force	Up to 100 Duro	0.1 Duro	
Indenter Dimensions			
Indenter Angle	(20 to 40)°	0.11°	Video Measuring Machine
Indenter Radius	Up to 0.1 in	160 μin	Video Measuring Machine
Indenter Length	Up to 0.198 in	22 μin	Gage Blocks
			<u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH
Durometer Test Blocks Shore A, D	Up to 100 Duro	1.2 Duro	Comparison to Rex Reference Durometer, Rex Operating Stand <u>Location:</u> Oshkosh, WI



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Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Durometer Calibrator Shore A Shore D	Up to 822 g Up to 10 lb	0.034 % of reading + 20 mg 0.005 9 g	Comparison to Dead Weights <u>Location:</u> Oshkosh, WI
Brinell Hardness Testers ¹ Verification of Test Force	(500, 750, 1 500, 2 000, 3 000) kgf	0.072 % of reading + 4.2 kgf	Partial Direct Verification per ASTM E10 using Morehouse Proving Ring, Video Measuring Machine <u>Locations:</u> All
Brinell Hardness Testers ¹	(50 to 650) HBW	1.2 % of reading + 3.2 HBW	Indirect Verification per ASTM E10 using Brinell Test Blocks and Brinell Scope <u>Locations:</u> All
Knoop and Vickers Hardness Testers ¹	HK0.05 (250 to 650) HK > 650 HK HK0.1 (250 to 650) HK > 650 HK HK0.3 (250 to 650) HK > 650 HK HK0.5 (250 to 650) HK > 650 HK	11 HK 27 HK 11 HK 25 HK 11 HK 18 HK 14 HK 17 HK	Indirect Verification per ASTM E384 using Knoop and Vickers Test Blocks <u>Locations:</u> All
Knoop and Vickers Hardness Testers ¹	HK1 (250 to 650) HK > 650 HK	11 HK 16 HK	Indirect Verification per ASTM E384 using Knoop and Vickers Test Blocks <u>Locations:</u> All



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Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Leeb Hardness Tester ¹	(300 to 900) LD	7.3 LD	Indirect Verification per ASTM A596 using Leeb Test Blocks <u>Locations:</u> All
Rockwell Hardness Testers ¹	HRBW Low HRBW Med HRBW High HRA Low HRA Med HRA High HRC Low HRC Med HRC High HREW Low HREW Med HREW High HRFW Low HRFW Med HRFW High HRHW Low HRHW Med HRHW High HR15N Low HR15N Med HR15N High	0.77 HRBW 0.79 HRBW 0.71 HRBW 0.56 HRA 0.49 HRA 0.47 HRA 0.52 HRC 0.53 HRC 0.54 HRC 0.72 HREW 0.7 HREW 0.64 HREW 0.71 HRFW 0.59 HRFW 0.57 HRFW 0.72 HRH 0.58 HRH 0.6 HRH 0.72 HR15N 0.7 HR15N 0.55 HR15N	Indirect Verification per ASTM E18 using Rockwell Test Blocks <u>Locations:</u> All



ANSI National Accreditation Board

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Rockwell Hardness Testers ¹	HR30N Low HR30N Med HR30N High HR45N Low HR45N Med HR45N High HR15TW Low HR15TW Med HR15TW High HR30TW Low HR30TW Med HR30T High HR45TW Low HR45TW Med HR45TW High	0.67 HR30N 0.66 HR30N 0.64 HR30N 0.58 HR45N 0.65 HR45N 0.62 HR45N 0.72 HR15TW 0.74 HR15TW 0.52 HR15TW 0.64 HR30TW 0.65 HR30TW 0.54 HR30TW 0.67 HR45TW 0.69 HR45TW 0.69 HR45TW	Indirect Verification per ASTM E18 using Rockwell Test Blocks <u>Locations:</u> All
Force Devices ¹	(1 to 5) lbf (5 to 1 000) lbf (1 000 to 2 000) lbf (2 000 to 5 000) lbf (5 000 to 10 000) lbf (10 000 to 30 000) lbf (30 000 to 100 000) lbf (100 000 to 500 000) lbf	0.009 5 lbf 0.13 lbf 0.21 lbf 0.36 lbf 1.5 lbf 2.4 lbf 5.9 lbf 0.015 % of reading + 490 lbf	Comparison to Load Cells <u>Locations:</u> All
Force Devices ¹	Up to 121.5 lbf (121.5 to 500) lbf	0.000 9 % of reading + 0.000 4 lbf 0.003 % of reading + 0.007 lbf	Comparison to Dead Weight <u>Locations:</u> All
Cable Tension Meters	Up to 300 lbf	0.26 lbf	Comparison to Dead Weight, Cable <u>Locations:</u> Oshkosh, WI Fenton, MO



ANSI National Accreditation Board

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Torque Transducers ¹	(0.007 to 40) ozf·in (2.5 to 10) lbf·in (10 to 150) lbf·in (150 to 3 000) lbf·in (3 000 to 24 000) lbf·in	0.016 % of reading + 0.000 4 lbf·in 0.002 5 % of reading + 0.000 8 lbf·in 0.000 92 % of reading + 0.005 lbf·in 0.001 6 % of reading + 0.025 lbf·in 0.000 56 % of reading + 1 lbf·in	Comparison to Torque Arms, Dead Weight <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Crestline, OH
Torque Tools ¹	Up to 5 ozf·in (2 to 20) ozf·in (15 to 200) ozf·in (4 to 50) lbf·in (50 to 400) lbf·in (400 to 1 000) lbf·in (1 000 to 3 000) lbf·in (3 000 to 7 200) lbf·in (7 200 to 24 000) lbf·in	0.21 % of reading + 0.001 ozf·in 0.1 % of reading + 0.005 7 ozf·in 0.17 % of reading + 0.000 38 ozf·in 0.29 % of reading + 0.001 1 lbf·in 0.29 % of reading + 0.006 8 lbf·in 0.28 % of reading + 0.028 lbf·in 0.29 % of reading + 0.036 lbf·in 0.28 % of reading + 0.36 lbf·in 0.24 % of reading + 4.9 lbf·in	Comparison to Transducer Techniques Torque Sensor, AKO Low Torque System, CDI Torque System <u>Locations:</u> All
Viscosity Rotational Viscometers ⁶	10 cP 100 cP 500 cP 1 000 cP 5 000 cP 12 500 cP 100 000 cP	0.014 cP/cP 0.014 cP/cP 0.014 cP/cP 0.014 cP/cP 0.014 cP/cP 0.014 cP/cP 0.014 cP/cP	Comparison to Viscosity Solutions, Temperature Bath <u>Locations:</u> Oshkosh, WI Stacy, MN Monroe, NC Crestline, OH
Viscosity Cups ⁶	Up to 1 800 cP	0.009 1 % of reading + 0.61 cP	Viscosity Solutions, Temperature Bath, Stopwatch; ASTM D4212 <u>Locations:</u> Oshkosh, WI Stacy, MN Monroe, NC Crestline, OH



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Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pipettes ¹	Up to 20 µL (20 to 200) µL (200 to 1 000) µL (1 000 to 5 000) µL (5 000 to 10 000) µL	64 nL 0.6 µL 1.8 µL 8.9 µL 18 µL	Analytical Balance; ISO 8655-6 <u>Location:</u> Oshkosh, WI Stacy, MN Rockford, IL
Liquid Volume Measuring Devices	Up to 200 mL (200 to 6 200) mL (6 200 to 61 000) mL	0.39 mL 1.4 mL 6.5 mL	Comparison to Balances <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Broken Arrow, OK
Foundry Sand Test Equipment / Measurement ¹ Ultrasonic Cleaner/Scrubber	18 °F 30 m	1.7 °F 1.2 s	Comparison to Temperature Calibrator Stopwatch
Wet Tensile Tester	0.449 N/cm ² (300 to 320) °F	0.003 1 N/cm ² 2 °F	Dead Weight Temperature Calibrator
Sand Squeezer	Up to 200 psi	3.8 psi	Proving Ring
Tensile Testers	Up to 10 000 lb	7.2 lb	Load Cell
AFS Clay Tester	Up to 10 min	1.2 s	Stopwatch
Friability Tester	60 s	1.2 s	Stopwatch
Sand Rammer	Up to 2 in	0.01 in	Impact Rings
Moisture Teller	(0 to 300) °F	1.9 °F	Temperature Calibrator <u>Location:</u> All



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Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Foundry Sand Test Equipment / Measurement ¹			
Permmeter	Up to 500 perm	0.43 perm	Comparison to Perm Standards
Sand Strength Tester	Up to 500 psi Up to 1 000 lb	1.1 psi 4.2 lb	Proving Ring
Core Scratch Tester	Up to 0.1 in	0.006 in	Flatness Block
Green Sand Hardness Tester (B&C)	Up to 0.1 in	0.006 in	Flatness Block
			<u>Location:</u> All
Gas Flow	50 sccm to 100 slpm	0.38 % of reading + 0.000 22 slpm	Comparison to Fluke molBox/molBloc Calibration System, Mass Flow Controller
			<u>Location:</u> Stacy, MN
Liquid Flowmeters	(0.4 to 2) lpm	0.16 % of reading + 0.027 lpm	Comparison to Omega FLR1000 Flowmeter
			<u>Location:</u> All
Liquid Flow – Syringe	(1 to 1 500) ml/h	0.074 % of reading + 20 µl/h	Comparison to Syringe Pump, Master Syringe
			<u>Location:</u> All
Deadweight Testers			
Masses	Up to 210 g (> 210 to 6 200) g	0.000 24 % of reading + 340 µg 0.000 41 % of reading + 17 mg	Direct Measure using Digital Scale
Pressure	Up to 2 000 psi (> 2 000 to 10 000) psi	0.005 9 % of reading + 0.021 psi 0.008 1 % of reading + 0.17 psi	Reference Pressure Meter
			<u>Location:</u> Oshkosh, WI

Photometry and Radiometry

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gloss Meters ² 20°, 60°, 85°	(0 to 100) GU	0.73 GU	Comparison to Standard Gloss Tiles <u>Locations:</u> All
Tint Meters	27 % 58 %	0.1 % 0.1 %	Comparison to Tint Film <u>Location:</u> Oshkosh, W
Illuminance – Lux Meters	(180 to 1 000) lux (1 000 to 18 000) lux	2.7 % of reading + 1.3 lux 2.1 % of reading + 7.6 lux	Comparison to Illuminance Projector, Photometric Calibration System <u>Location:</u> Oshkosh, WI

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Source (Temperature Measuring Devices)	(-95 to 600) °C	0.03 °C	Comparison to Fluke 9011, 9190A Drywells, PRT
	(600 to 1200) °C	2.3 °C	Fluke 9011, 9190A Drywells, Type S Probe <u>Locations:</u> All
Surface Probes ¹	(35 to 400) °C	1.3 °C	Comparison to Hart Scientific 2200 Temperature Controller, Hot-plate <u>Locations:</u> All

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure ¹	(-30 to 600) °C	0.03 °C	Comparison to Hart Scientific 1502 Indicator, PRT
	(600 to 1 200) °C	1.7 °C	Temperature Indicator, Type S Probe <u>Locations:</u> All
Humidity Measuring Devices	(10 to 98) %RH	0.21 %RH	Comparison to Thunder Scientific 2500 Two Pressure Chamber <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Monroe, NC
Humidity Measuring Devices ¹	(10 to 95) %RH	1.1 %RH	Comparison to Portable Hygromatic II Chamber <u>Locations:</u> All
Humidity – Measure ¹	(10 to 98) %RH (15 to 25) °C (-20 to 40) °C (-40 to 180) °C	0.96 % of reading + 1.1 %RH 0.93 % of reading + 1.2 %RH 1.7 % of reading + 1.7 %RH	Comparison to Vaisala Humidity Probe <u>Locations:</u> All
System Accuracy Test ¹ (SAT)	(0 to 2 200) °F	2.6 °F	Comparison to Certified Thermocouple <u>Locations:</u> All
Temperature Uniformity Survey (TUS) ¹	(0 to 2 200) °F	4.9 °F	Comparison to MV 1000 Data Logger or Equivalent <u>Locations:</u> All

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Infrared Thermometers ^{1,6}	125 °F 200 °F 400 °F 500 °F 900 °F 932 °F	2.3 °F 2.9 °F 4.4 °F 5.2 °F 8.2 °F 8.5 °F	Comparison to Blackbody Sources (flat-plate) $\lambda = (8 \text{ to } 14) \mu\text{m}, \epsilon = 0.95$ <u>Locations:</u> All
Infrared Calibrators (Black Body Sources)	(86 to 212) °F (212 to 932) °F	0.046 % of reading + 0.42 °F 0.22 % of reading + 0.042 °F	Comparison to Heitronics KT19.82-II Infrared Thermometer <u>Locations:</u> All

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Time Interval ¹	1 ns to 100 000 s	0.000 15 % of reading + 0.6 ns	Comparison to Agilent 53132A Universal Counter, Spectracom 8197B GPS Oscillator <u>Locations:</u> All
Frequency – Measure ¹	1 mHz to 350 MHz	23 pHz/Hz + 45 μ Hz	Comparison to Agilent N5531S Measuring Receiver, Spectracom 8197B GPS Oscillator <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Measure ¹	100 kHz to 50 GHz	1.5 pHz/Hz + 0.58 mHz	Comparison to Rohde & Schwarz FSMR3050 Measuring Receiver, Spectracom 8197B External Reference <u>Locations:</u> All
Frequency – Reference ¹	10 MHz	24 pHz	Comparison to Spectracom 8197B GPS Oscillator <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Frequency – Source ¹	1 μHz to 80 MHz	0.000 12 % of reading + 0.58 μHz	Comparison to Agilent 3325B Function Generator, Agilent E8257D Signal Generator, SRS FS725 Frequency Standard <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Source ¹	> 8 kHz to 50 GHz	33 zHz/Hz + 0.64 pHz	Rohde & Schwarz SMA100B RF and Microwave Signal Generator, Spectracom 8197B GPS Ageless Master Oscillator <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Tachometers ^{1,2} Contact Non-Contact	(1 to 6 500) rpm (500 to 40 000) rpm	0.08 % of reading 0.08 % of reading	Comparison to King Nutronics 3711-B Tachometer Test Set <u>Locations:</u> All
Tachometers ^{1,2} Non-Contact	(0.01 to 100 000) rpm	0.005 % of reading	Comparison to Fluke 5560A Multiproduct Calibrator <u>Locations:</u> All
Fluke 55xxA Series Calibrators Normal Output Frequency AC Voltage Frequency	3 V 119 Hz 120 Hz 1 kHz 100 kHz 2.1 Vp-p 10 Hz 100 Hz 1 kHz 10 kHz	30 μHz 30 μHz 0.1 mHz 10 mHz 1.2 μHz 10 μHz 0.1 mHz 1 mHz	Comparison to Keysight 53220A Universal Counter <u>Location:</u> Oshkosh, WI



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Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Fluke 55xxA Series Calibrators Leveled Sine Wave Frequency	5.5 Vp-p 50 kHz 500 kHz 5 MHz 50 MHz 500 MHz 3 Vp-p 1.1 GHz	5 mHz 50 mHz 0.5 Hz 5 Hz 50 Hz 0.11 kHz	Comparison to Keysight 53220A Universal Counter <u>Location:</u> Oshkosh, WI
Fluke 55xxA Series Scope Options Edge Frequency	2.5 Vp-p 1 kHz 10 kHz 100 kHz 1 MHz 10 MHz	0.1 mHz 1 mHz 10 mHz 0.1 Hz 1 Hz	Comparison to Keysight 53220A Universal Counter <u>Location:</u> Oshkosh, WI
Edge Duty Cycle	2.5 Vp-p 1 MHz 50 %	0.011 %	
Period (Time Markers)	1 ns to 5 s	0.000 01 % of reading	
Pulse Width	2 μs Period 4 ns 20 μs Period 4 ns 200 μs Period 4 ns 2 ms Period 40 ns	0.21 ns 0.21 ns 0.21 ns 0.21 ns 21 ps	

DIMENSIONAL MEASUREMENT

1 Dimensional

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
1D Linear Measure	Up to 24 in	0.000 9 in	Direct Measure using Video Measuring Machine <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Crestline, OH

2 Dimensional

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Surface Finish Measure (Ra)	(0.01 to 600) μin	2.1 μin	Direct Measure using Profilometer <u>Locations:</u> Oshkosh, WI
2D Angular Measure	Up to 180°	0.002 5°	Direct Measure using Starrett AVR300 Vision System <u>Locations:</u> Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH

3 Dimensional

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
3D Dimensional Inspection ² Volumetric	Up to (28 x 40 x 24) in	320 μin	Direct Measure using Coordinate Measuring Machine
Linear	Up to (28 x 40 x 24) in	(38 + 5.2L) μin	<u>Locations:</u> Oshkosh, WI Stacy, MN

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:

- 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.
- L = length in inches or mm, D = diameter in inches, DL = diagonal length in inches, ' = arc-minute, " = arc-second, GU = Gloss Unit; rpm = revolutions per minute, ® = Registered Trademark; X = radius in mm; t = thickness in inches.
- Where ranges overlap, the uncertainty associated with the higher range begins above the overlapping value.
- RF/Microwave uncertainties do not include inaccuracies due to sensor mismatch.
- The CMC for scales and balances is highly dependent upon the resolution of the unit under test. The CMC 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.
- The fixed values presented here are approximate values. Actual calibration values will be used at the time of calibration, along with the actual uncertainties.
- Unless otherwise specified in the far-right column, the calibration procedure or method was written and validated internally.



Jason Stine, Vice President