



# 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](http://www.anab.org).

Jason Stine, Vice President  
Expiry Date: 15 June 2025  
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
- 30447 Stacy Ponds Drive, Stacy, MN 55079
- 5245 27<sup>th</sup> Avenue, Rockford, IL 61109
- 3012 Old Charlotte Hwy., Monroe, NC 28110
- 1740 State Route 61, Crestline, OH 44827
- 2205 North Willow Avenue, Unit B, Broken Arrow, OK 74012

**CALIBRATION AND DIMENSIONAL MEASUREMENT**

Valid to: **June 15, 2025**

Certificate Number: **ACT-1272**

**CALIBRATION**

**Acoustics and Vibration**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Sound Level – Source <sup>1</sup> (100 Hz, 250 Hz, 500 Hz, 1 000 Hz, 2 000 Hz)	114 dB	0.6 dB	Gen Rad 1562-A Sound Level Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Accelerometers 1 g reference 1 g reference	10 Hz to 2 kHz (2 to 10) kHz	1.5 % of reading 1.4 % of reading	PCB 9150C Accelerometer Calibration Workstation  Oshkosh, WI

**Chemical Quantities**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
pH Meters <sup>1,6</sup>	4.01 pH 7 pH 10 pH	0.02 pH 0.02 pH 0.02 pH	Accredited pH Buffer Solutions  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Conductivity Meters <sup>1,6</sup>	12.85 mS/cm 1 408 µS/cm 10 µS/cm	0.18 mS/cm 14 µS/cm 0.18 µS/cm	Accredited Conductivity Solutions  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Refractometers <sup>1,6</sup>	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	Accredited Refractive Index Solutions  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Gas Detectors <sup>1,6</sup> O <sub>2</sub>	0 % Concentration 21.9 % Concentration 100 % Concentration	2.4 % Concentration 2.4 % Concentration 2.6 % Concentration	Accredited Gas Mixtures  Oshkosh, WI



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source <sup>1,6</sup> (Fixed Artifact)	10 V	0.8 $\mu$ V/V	Fluke 732B Voltage Standard  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC Voltage – Source <sup>1</sup>	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 $\mu$ V/V + 0.5 $\mu$ V 5.1 $\mu$ V/V + 0.77 $\mu$ V 3.6 $\mu$ V/V + 2.6 $\mu$ V 3.7 $\mu$ V/V + 4.2 $\mu$ V 5.2 $\mu$ V/V + 43 $\mu$ V 6.7 $\mu$ V/V + 0.4. mV	Fluke 5730A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC Voltage – Measure <sup>1</sup>	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 $\mu$ V/V + 0.26 $\mu$ V 2.9 $\mu$ V/V + 0.31 $\mu$ V 2.9 $\mu$ V/V + 0.94 $\mu$ V 4.4 $\mu$ V/V + 30 $\mu$ V 4.6 $\mu$ V/V + 0.58 mV	Fluke 8588A 8.5 Digit Multimeter  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC High Voltage – Measure <sup>1</sup>	(1 to 10) kV (10 to 100) kV	60 V 600 V	Hipotronics KVM-100 High Voltage Meter  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Source <sup>1</sup>	Up to 220 $\mu$ A 220 $\mu$ A to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mA to 2.2 A	39 $\mu$ A/A + 6.3 nA 36 $\mu$ A/A + 7.3 nA 36 $\mu$ A/A + 42 nA 47 $\mu$ A/A + 0.71 $\mu$ A 83 $\mu$ A/A + 12 $\mu$ A	Fluke 5730A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC Current – Source <sup>1</sup>	(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	Fluke 5560A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC Current – Source <sup>1</sup>	Up to 100 A	0.008 % of reading + 4 mA	Fluke 52120A Transconductance Amplifier  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC Current – Source <sup>1</sup> Clamp-on Meters	Up to 2 500 A	0.6 % of reading	Fluke 52120A Transconductance Amplifier with 25-turn coil  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Current – Measure <sup>1</sup>	Up to 20.2 $\mu$ A (20.2 to 202) $\mu$ A 202 $\mu$ 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 $\mu$ A/A + 0.89 nA 10 $\mu$ A/A + 0.42 nA 9.2 $\mu$ A/A + 4.3 nA 9.8 $\mu$ A/A + 48 nA 32 $\mu$ A/A + 1 $\mu$ A 100 $\mu$ A/A + 100 $\mu$ A 0.18 mA/A + 0.4 mA 0.49 mA/A + 4.4 mA	Fluke 8588A 8.5 Digit Multimeter  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Resistance – Measure <sup>1</sup> (Normal Mode)	Up to 2.02 $\Omega$ (2.02 to 20.2) $\Omega$ (20.2 to 202) $\Omega$ 202 $\Omega$ to 2.02 k $\Omega$ (2.02 to 20.2) k $\Omega$ (20.2 to 202) k $\Omega$ 202 k $\Omega$ to 2.02 M $\Omega$ (2.02 to 20.2) M $\Omega$ (20.2 to 202) M $\Omega$ 202 M $\Omega$ to 2.02 G $\Omega$	13 $\mu\Omega/\Omega$ + 4.1 $\mu\Omega$ 8 $\mu\Omega/\Omega$ + 17 $\mu\Omega$ 7.8 $\mu\Omega/\Omega$ + 58 $\mu\Omega$ 7.2 $\mu\Omega/\Omega$ + 0.58 m $\Omega$ 7.4 $\mu\Omega/\Omega$ + 5.8 m $\Omega$ 7.5 $\mu\Omega/\Omega$ + 58 m $\Omega$ 9.1 $\mu\Omega/\Omega$ + 1 $\Omega$ 13 $\mu\Omega/\Omega$ + 0.1 k $\Omega$ 43 $\mu\Omega/\Omega$ + 10 k $\Omega$ 0.52 m $\Omega/\Omega$ + 1 M $\Omega$	Fluke 8588A 8.5 Digit Multimeter  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Resistance – Measure <sup>1</sup> (High Voltage Mode)	Up to 20.2 M $\Omega$ (20.2 to 202) M $\Omega$ 202 M $\Omega$ to 2.02 G $\Omega$ (2.02 to 20.2) G $\Omega$	16 $\mu\Omega/\Omega$ + 10 $\Omega$ 68 $\mu\Omega/\Omega$ + 1 k $\Omega$ 0.16 m $\Omega/\Omega$ + 0.1 M $\Omega$ 0.54 m $\Omega/\Omega$ + 10 M $\Omega$	Fluke 8588A 8.5 Digit Multimeter  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Source <sup>1,6</sup> (Fixed Points)	0 Ω	40 μΩ	Fluke 5730A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	1 Ω	10 μΩ	
	1.9 Ω	0.18 mΩ	
	10 Ω	0.25 mΩ	
	19 Ω	0.46 mΩ	
	100 Ω	1 mΩ	
	190 Ω	1.9 mΩ	
	1 kΩ	6.8 mΩ	
	1.9 kΩ	12.8 mΩ	
	10 kΩ	67.5 mΩ	
	19 kΩ	0.13 Ω	
	100 kΩ	0.88 Ω	
	190 kΩ	1.7 Ω	
	1 MΩ	13.6 Ω	
	1.9 MΩ	35 Ω	
Resistance – Source <sup>1,6</sup> (Variable Artifact)	1 GΩ	1.9 MΩ	IET Labs HRRS Decade Box  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	10 GΩ	47 MΩ	
	100 GΩ	0.95 GΩ	
AC Voltage – Source <sup>1</sup>	Up to 2.2 mV		Fluke 5730A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	(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		



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source <sup>1</sup>	(2.2 to 22) mV		<p>Fluke 5730A Multiproduct Calibrator</p> <p>Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK</p>
	(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		
(2 to 22) V			
(10 to 20) Hz	0.24 mV/V + 0.49 mV		
(20 to 40) Hz	90 μV/V + 0.19 mV		
40 Hz to 20 kHz	46 μV/V + 2.3 μV		
(20 to 50) kHz	73 μV/V + 1.9 μV		
(50 to 100) kHz	94 μV/V + 16 μV		
(100 to 300) kHz	0.29 mV/V + 0.2 mV		
(300 to 500) kHz	1.1 mV/V + 4.4 μV		
500 kHz to 1 MHz	1.9 mV/V + 92 μV		



**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Source <sup>1</sup>	(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	0.26 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	Fluke 5730A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
AC Voltage – Source <sup>1</sup>	(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	Fluke 5560A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
AC Voltage Harmonics – Source <sup>1</sup> (2 <sup>nd</sup> to 50 <sup>th</sup> ) (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	Fluke 5522A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
AC High Voltage – Measure <sup>1</sup>	(1 to 10) kV (50 to 60) Hz (10 to 100) kV (50 to 60) Hz	0.12 kV 1.2 kV	Hipotronics KVM-100 High Voltage Meter  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Voltage – Measure <sup>1</sup>	Up to 12.12 mV		Fluke 8588A 8.5 Digit Multimeter  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	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 Current – Source <sup>1</sup>	Up to 220 $\mu$ A		Fluke 5730A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	(10 to 20) Hz	0.25 mA/A + 16 nA	
	(20 to 40) Hz	0.17 mA/A + 10 nA	
	40 Hz to 1 kHz	0.11 mA/A + 8.2 nA	
	(1 to 5) kHz	0.32 mA/A + 12 nA	
	(5 to 10) kHz	1.1 mA/A + 65 nA	
	220 $\mu$ A to 2.2 mA		
	(10 to 20) Hz	0.27 mA/A + 12 nA	
	(20 to 40) Hz	0.18 mA/A + 7.5 nA	
	40 Hz to 1 kHz	0.13 mA/A + 5.5 nA	
	(1 to 5) kHz	0.25 mA/A + 25 nA	
	(5 to 10) kHz	1.4 mA/A + 4.9 nA	
	(2.2 to 22) mA		
	(10 to 20) Hz	0.26 mA/A + 0.4 $\mu$ A	
	(20 to 40) Hz	0.17 mA/A + 0.35 $\mu$ A	
	40 Hz to 1 kHz	0.11 mA/A + 0.34 $\mu$ A	
	(1 to 5) kHz	0.21 mA/A + 0.54 $\mu$ A	
	(5 to 10) kHz	1.1 mA/A + 5 $\mu$ A	
	(22 to 220) mA		
	(10 to 20) Hz	0.26 mA/A + 3.9 $\mu$ A	
(20 to 40) Hz	0.17 mA/A + 3.4 $\mu$ A		
40 Hz to 1 kHz	0.12 mA/A + 2.2 $\mu$ A		
(1 to 5) kHz	0.21 mA/A + 3.4 $\mu$ A		
(5 to 10) kHz	1.1 mA/A + 9.7 $\mu$ A		
220 mA to 2.2 A			
40 Hz to 1 kHz	0.25 mA/A + 34 $\mu$ A		
(1 to 5) kHz	0.47 mA/A + 77 $\mu$ A		
(5 to 10) kHz	7.1 mA/A + 0.14 mA		
AC Current – Source <sup>1</sup>	(3 to 12) A		Fluke 5560A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	(3 to 45) Hz	0.37 mA/A + 1 mA	
	45 Hz to 1 kHz	0.3 mA/A + 0.5 mA	
	(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	
	(1 to 5) kHz	5 mA/A + 8 mA	

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source <sup>1</sup>	Up to 50 A (6 to 10) kHz	0.8 % of reading	Fluke 52120A Transconductance Amplifier with 25-turn Coil  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	Up to 100 A (3 to 6) kHz	0.75 % of reading	
	Up to 300 A (1 to 3) kHz	0.7 % of reading	
	Up to 1 000 A 300 Hz to 1 kHz	0.8 % of reading	
	Up to 2 500 A (10 to 300) Hz	0.6 % of reading	
AC Current – Source <sup>1</sup>	Up to 120 A (10 to 65) Hz	0.012 % of reading + 19 mA	Fluke 52120A Transconductance Amplifier  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	(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 <sup>1</sup> (2 <sup>nd</sup> to 50 <sup>th</sup> )	(10 to 45) Hz 3.3 mA to 3 A	1.1 mA/A + 4 μA	Fluke 5522A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	(45 to 65) Hz 3.3 mA to 20.5 A	0.5 mA/A + 4 μA	
	(65 to 500) Hz 33 mA to 20.5 A	1.2 mA/A + 0.1 mA	
	500 Hz to 5 kHz 33 mA to 20.5 A	2.3 mA/A + 0.2 mA	
	(5 to 10) kHz (33 to 330) mA	4.6 mA/A + 0.4 mA	



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Measure <sup>1</sup>	Up to 20.2 $\mu$ A		Fluke 8588A 8.5 Digit Multimeter  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	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 $\mu$ 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 $\mu$ 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 $\mu$ A	
	(10 to 30) kHz	0.76 mA/A + 0.19 $\mu$ 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		
Capacitance – Measure <sup>1</sup> 42 Hz to 5 MHz	0.32 pF to 370 mF	1.1 mF/F	Hioki 3532-50 LCR Meter  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Capacitance – Source <sup>1</sup> (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	Fluke 5560A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Phase – Measure <sup>1</sup>	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 °	Clark Hess 6000A Phase Meter  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC Power – Source <sup>1</sup>	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	Fluke 5560A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
AC Power – Source <sup>1</sup>	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	Fluke 5560A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes <sup>1</sup>			
DC Voltage (50 Ω)	(-6.6 to 6.6) V	0.25 % of reading + 40 μV	Fluke 5560A/SC2100 Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC Voltage (1 MΩ)	(-120 to 120) V	0.05 % of reading + 40 μV	
AC Voltage (50 Ω)	1 mVp-p to 6.6 Vp-p	0.25 % of reading + 40 μV	
AC Voltage (1 MΩ)	1 mVp-p to 130 Vp-p	0.1 % of reading + 40 μV	
Leveled Sine Wave			
50 kHz to 10 MHz	5 mVp-p to 5.5 Vp-p	1.5 % of reading + 0.1 mV	
(10 to 600) MHz	5 mVp-p to 5.5 Vp-p	3 % of reading + 0.1 mV	
600 MHz to 1.1 GHz	5 mVp-p to 3.5 Vp-p	4 % of reading + 0.1 mV	
(1.1 to 2.1) GHz	5 mVp-p to 3.5 Vp-p	5 % of reading + 0.1 mV	
Time Markers	500 ps to 5 s	0.000 25 % of reading	
Wave Generator (50 Ω)	1 mVp-p to 6.6 Vp-p	3 % of reading + 0.1 mV	
Wave Generator (1 MΩ)	1 mVp-p to 120 Vp-p	3 % of reading + 0.1 mV	
Pulse Generator – Width	4 ns to 0.5 μs	2 ns	
Pulse Generator – Period	0.2 μs to 22 ms	0.000 25 % of reading	
Input Impedance Measure	(40 to 60) Ω	0.1 % of reading	
	500 kΩ to 1.5 MΩ	0.1 % of reading	
Electrical Simulation of RTD Indicating Devices <sup>1</sup>	Pt 385, 100 Ω		Fluke 5560A Multiproduct Calibrator
	(-200 to -80) °C	0.05 °C	Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	(-80 to 0) °C	0.05 °C	
	(0 to 100) °C	0.07 °C	
	(100 to 300) °C	0.09 °C	
	(300 to 400) °C	0.1 °C	
	(500 to 630) °C	0.12 °C	
	(630 to 800) °C	0.23 °C	

**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Devices <sup>1</sup>	Pt 3926, 100 Ω		<p>Fluke 5560A Multiproduct Calibrator</p> <p>Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK</p>
	(-200 to -80) °C	0.05 °C	
	(-80 to 0) °C	0.05 °C	
	(0 to 100) °C	0.07 °C	
	(100 to 300) °C	0.09 °C	
	(300 to 400) °C	0.1 °C	
	(500 to 630) °C	0.12 °C	
	Pt 3916 (JIS), 100 Ω		
	(-200 to -190) °C	0.25 °C	
	(-190 to -80) °C	0.04 °C	
	(-80 to 0) °C	0.05 °C	
	(0 to 100) °C	0.06 °C	
	(100 to 260) °C	0.07 °C	
	(260 to 300) °C	0.08 °C	
	(300 to 400) °C	0.09 °C	
	(400 to 600) °C	0.1 °C	
	(600 to 630) °C	0.23 °C	
	Pt 385, 200 Ω		
	(-200 to -80) °C	0.04 °C	
	(-80 to 0) °C	0.04 °C	
	(0 to 100) °C	0.04 °C	
	(100 to 260) °C	0.05 °C	
	(260 to 300) °C	0.12 °C	
	(300 to 400) °C	0.13 °C	
(400 to 600) °C	0.14 °C		
(600 to 630) °C	0.16 °C		
Pt 385, 500 Ω			
(-200 to -80) °C	0.04 °C		
(-80 to 0) °C	0.05 °C		
(0 to 100) °C	0.05 °C		
(100 to 260) °C	0.06 °C		
(260 to 300) °C	0.08 °C		
(300 to 400) °C	0.08 °C		
(400 to 600) °C	0.09 °C		
(600 to 630) °C	0.11 °C		



**Electrical – DC/Low Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Electrical Simulation of RTD Indicating Devices <sup>1</sup>	Pt 385, 1 000 Ω		<p style="text-align: center;">Fluke 5560A Multiproduct Calibrator</p> <p style="text-align: center;">Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK</p>
	(-200 to -80) °C	0.03 °C	
	(-80 to 0) °C	0.03 °C	
	(0 to 100) °C	0.04 °C	
	(100 to 260) °C	0.05 °C	
	(260 to 300) °C	0.06 °C	
	(300 to 400) °C	0.07 °C	
	(400 to 600) °C	0.07 °C	
	(600 to 630) °C	0.23 °C	
	PtNi 385, 120 Ω, Ni 120		
	(-80 to 0) °C	0.08 °C	
	(0 to 100) °C	0.08 °C	
	(100 to 260) °C	0.14 °C	
	Cu 427, 10 Ω		
(-80 to 260) °C	0.03 °C		
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 <sup>1</sup>	Type K		<p style="text-align: center;">Fluke 5560A Multiproduct Calibrator</p> <p style="text-align: center;">Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK</p>
	(-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 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 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		

**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 <sup>1</sup>	Type T		Fluke 5560A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	(-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 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 B		
	(600 to 800) °C	0.44 °C	
	(-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 L		
	(-200 to -100) °C	0.31 °C	
	(-100 to 800) °C	0.2 °C	
(800 to 900) °C	0.11 °C		
Type N			
(-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 U			
(-200 to 0) °C	0.4 °C		
(0 to 600) °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
Inductance – Source <sup>1</sup> (Simulation)	(13 to 120) $\mu$ H (0.12 to 1.2) mH (1.2 to 12) mH (12 to 120) mH (0.12 to 1.2) H (1.2 to 12) H (12 to 120) H	0.2 % of reading + 0.2 $\mu$ H 0.12 % of reading + 1 $\mu$ H 0.12 % of reading + 10 $\mu$ H 0.12 % of reading + 0.1 mH 0.15 % of reading + 1 mH 0.2 % of reading + 10 mH 0.25 % of reading + 0.1 H	Fluke 5560A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Inductance – Source <sup>1</sup> (Variable Artifact)	(1 to 10) mH (10 to 100) mH 100 mH to 1 H (1 to 10) H	22 mH/H 11 mH/H 6 mH/H 3 mH/H	General Radio 1490-D Decade Inductor  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Ionizers <sup>1</sup> Decay Time Float Voltage	(0.1 to 999.9) s (-1 100 to 1-100) V	0.2 s 3.1 V	Trek 156A Charged Plate Monitor  Oshkosh, WI
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  Oshkosh, WI



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Transient Generators Rise Time Open Circuit Closed Circuit  Duration/Pulse Width Open Circuit Closed Circuit  Peak Voltage  Peak Current  Frequency	75 ns to 10 $\mu$ s 75 ns to 10 $\mu$ s  (50 to 700) $\mu$ s (20 to 320) $\mu$ s  (0.5 to 6) kV  12.5 A to 3 kA  5 kHz to 1 MHz	1.5 % of reading + 0.12 $\mu$ s 0.69 % of reading + 79 ns  0.058 % of reading + 0.28 $\mu$ 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 per IEC 61000-4-5, IEC 61000-4-12, IEC 61000-4-18.  Oshkosh, WI
Defibrillators	Up to 360 J	0.41 % of reading + 0.77 J	Oscilloscope, Tektronix P6015 High Voltage Probe, Digital Multimeter, Power Resistor  Oshkosh, WI
Current Injection Probes	9 kHz to 400 MHz	0.22 dB	VNA, VNA Calibration Kit per IEC 61000-4-6.  Oshkosh, WI
EFT/Burst Generator Peak Voltage 50 $\Omega$ 1 k $\Omega$  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 $\Omega$ Attenuator, 1 k $\Omega$ Attenuator per IEC 61000-4-4.  Oshkosh, WI Stacy, MN



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Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure <sup>1,4</sup> Absolute Level	(20 to 30) dBm 100 kHz to 3 GHz (3 to 18) GHz (18 to 26.5) GHz (-20 to 20) dBm 100 kHz to 3 GHz (3 to 18) GHz (18 to 26.5) GHz	0.37 dB 0.39 dB 0.4 dB 0.15 dB 0.18 dB 0.21 dB	Agilent N5531S Measuring Receiver with N5532A Sensor Modules  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
RF Power – Measure <sup>1</sup> Relative Level	(3.05 to 6.6) GHz (-90 to +30) dBm (-113 to -90) dBm (6.6 to 13.2) GHz (-81 to +30) dBm (-104 to -81) dBm (13.2 to 19.2) GHz (-70 to +30) dBm (-93 to -70) dBm	0.026 dB + 0.005 dB/10 dB 0.067 dB + 0.12 dB/10 dB 0.026 dB + 0.005 dB/10 dB 0.062 dB + 0.12 dB/10 dB 0.026 dB + 0.005 dB/10 dB 0.056 dB + 0.12 dB/10 dB	Agilent N5531S Measuring Receiver with N5532A Sensor Modules  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
RF Power – Measure <sup>1</sup> Relative Level	(19.2 to 26.5) GHz (-62 to +30) dBm (-85 to -62) dBm	0.026 dB + 0.005 dB/10 dB 0.051 dB + 0.12 dB/10 dB	Agilent N5531S Measuring Receiver with N5532A Sensor Modules  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Electrical – RF/Microwave**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Amplitude Modulation – Source <sup>1,4</sup> 250 kHz to 40 GHz	Rate: DC to 100 kHz Depths: (0 to 100) %	7.1 % of reading	Agilent E8257D Signal Generator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Amplitude Modulation – Measure <sup>1,4</sup> 100 kHz to 10 MHz	Rate: 50 Hz to 10 kHz Depths: (5 to 99) %	2.2 % of reading	Agilent N5531S Measuring Receiver with N5532A Sensor Modules  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
10 MHz to 3 GHz	Rate: 50 Hz to 100 kHz Depths: (20 to 99) %	1.2 % of reading	
10 MHz to 3 GHz	Rate: 50 Hz to 100 kHz Depths: (5 to 20) %	4.2 % of reading	
(3 to 26.5) GHz	Rate: 50 Hz to 100 kHz Depths: (20 to 99) %	3.5 % of reading	
(3 to 26.5) GHz	Rate: 50 Hz to 100 kHz Depths: (5 to 20) %	6 % of reading	
Phase Modulation – Source <sup>1,4</sup> Rate: DC to 100 kHz	250 kHz to 40 GHz	5.9 % of reading + 0.1 rad	Agilent E8257D Signal Generator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK



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Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Tuned RF Level – Measure <sup>1,4</sup> 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	Agilent N5531S Measuring Receiver with N5532A Sensor Modules  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Tuned RF Level – Measure <sup>1,4</sup> 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	Agilent N5531S Measuring Receiver with N5532A Sensor Modules  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
RF Power – Source <sup>1</sup>	> -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	Agilent E8257D Signal Generator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK



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Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power Sensors – Calibration Factor <sup>1,4</sup>	(-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	Tegam 1827 Power Sensor Calibrator, Agilent 3458A 8.5 Digit Multimeter, Agilent E8257D Signal Generator, Agilent E4419B Power Meter, Agilent 3325B Function Generator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Frequency Modulation – Measure <sup>1,4</sup> 250 kHz to 10 MHz  10 MHz to 3 GHz  (3 to 26.5) GHz	Rate: 20 Hz to 10 kHz Dev.: ≤ 40 kHz peak  Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak  Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak	3.1 % of reading  3.1 % of reading  7.7 % of reading	Agilent N5531S Measuring Receiver with N5532A Sensor Modules  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Frequency Modulation – Source <sup>1,4</sup> 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	Agilent E8257D Signal Generator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK



**Electrical – RF/Microwave**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Pulse Generation – Measure <sup>1,4</sup> 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	Agilent 53132A Counter  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Pulse Generation – Source <sup>1,4</sup> Repetition Frequency: 24 mHz to 14.28 MHz Period: 70 ns to 42 s	10 ns to 42 s	1.7 ns	Agilent E8257D Signal Generator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
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	Schwarzbeck IGUU 2918 Pulse Generator, Keysight E8257D Signal Generator  Oshkosh, WI Stacy, MN
Line Impedance Stabilization Network <sup>1,4</sup> 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  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Electrical – RF/Microwave**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Coupling/De-coupling Network <sup>1,4</sup> Insertion Loss	(-20 to 0) dB 9 kHz to 230 MHz	0.25 dB	Vector Network Analyzer, Attenuators, VNA Cal Kit, IEC 61000-4-6, CISPR 16-1-2  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Impedance – Magnitude	100 mΩ to 1 kΩ 9 kHz to 230 MHz	5.6 % of reading	

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gage Blocks <sup>2</sup>	Up to 30 in	$(3.8 + 0.93L) \mu\text{in}$	Mahr 828 Measuring Machine, Per ASME B89.1.9  Oshkosh, WI
Gage Blocks <sup>2</sup>	Up to 11 in	$(1.2 + 5.7L) \mu\text{in}$	P & W Universal Labmaster®, Per ASME B89.1.9  Oshkosh, WI Rockford, IL
Gage Blocks <sup>2</sup>	Up to 20 in	$(8.5 + 1L) \mu\text{in}$	ULM 600 Measuring Machine, Per ASME B89.1.9  Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Length Standards <sup>2</sup>	Up to 24 in	$(12 + 1L) \mu\text{in}$	ULM 600 Measuring Machine, Per ASME B89.1.1  Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Length Standards <sup>2</sup>	Up to 39 in	$(12 + 1L) \mu\text{in}$	Mahr 828 Measuring Machine, Per ASME B89.1.1  Oshkosh, WI
Length Standards <sup>2</sup>	(39 to 70) in	$(390 + 2.6L) \mu\text{in}$	CMM  Oshkosh, WI Stacy, MN
Length Standards <sup>2</sup>	Up to 4 in	$(53 + 0.4L) \mu\text{in}$	Plug Gage Comparator  Crestline, OH Tahlequah, OK
Cylindrical Rings <sup>2</sup>	(0.02 to 18) in	$(8 + 1.8D) \mu\text{in}$	Mahr 828 Measuring Machine, ASME B89.1.6  Oshkosh, WI
Cylindrical Rings <sup>1,2</sup>	(0.25 to 8) in	$(12 + 3D) \mu\text{in}$	Fowler Lab Concept Measuring Machine, ASME B89.1.6  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Cylindrical Plugs <sup>2</sup>	Up to 30 in	$(2.7 + 6D) \mu\text{in}$	Mahr 828 Measuring Machine  Oshkosh, WI

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Cylindrical Plugs <sup>1,2</sup>	Up to 4 in	$(53 + 0.4D) \mu\text{in}$	Plug Gage Comparator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Thread Rings <sup>2</sup> Pitch Diameter  Minor Diameter	Up to Setting plug size Up to 16 in  Up to 9 in	$(240 + 0.3D) \mu\text{in}$  120 $\mu\text{in}$	Setting Plug Gages, Measuring Machine, ID Bore Gages, ASME B1.2  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Non-Standard Thread Rings <sup>2</sup>  Pitch Diameter  Minor Diameter	Up to 14 in  Up to 9 in	$(120 + 2.5D) \mu\text{in}$  120 $\mu\text{in}$	Mahr ULM 600 Measuring Machine, ID Bore Gages, ASME B1.2  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
NPT Rings (Standoff and Basic Length)	(0.062 5 to 8) in	250 μin	NPT Plugs, P&W Labmaster <sup>®</sup> , P&W Laser Ruler ASME B1.20.5 ASME B1.20.1  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH
NPT Plugs (Standoff and Basic Length)	(0.062 5 to 6) in	490 μin	NPT Rings, P&W Labmaster <sup>®</sup> , P&W Laser Ruler ASME B1.20.5 ASME B1.20.1  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH
Thread Plugs <sup>2</sup> Pitch Diameter  Major Diameter	Up to 24 in  Up to 24 in	(73 + 0.9D) μin  (40 + 1.2D) μin	P&W Supermicrometer <sup>®</sup> , Thread Measuring Wires, ASME B1.2  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Thread Plugs <sup>1,2</sup> Pitch Diameter  Major Diameter	Up to 4 in  Up to 4 in	(73 + 3.2D) μin  (53 + 4.1D) μin	Plug Gage Comparator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Thread Wires <sup>2</sup>	Up to 0.5 in	$(11 + 1.5D) \mu\text{in}$	Mahr ULM 600 Measuring Machine, ASME B89.1.17  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Calipers <sup>1,2</sup>	Up to 80 in	$(380 + 15L) \mu\text{in}$	Gage Blocks  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Indicators <sup>1,2</sup>	Up to 4 in	$(36 + 10L) \mu\text{in}$	Indicator Checker  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Test Indicators <sup>1</sup>	Up to 0.06 in	39 $\mu\text{in}$	Indicator Checker  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
OD Micrometers <sup>1,2</sup>	Up to 60 in	$(72 + 12L) \mu\text{in}$	Gage Blocks  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
ID Micrometer <sup>1,2</sup>	(1.5 to 40) in	$(370 + 7L) \mu\text{in}$	Gage Blocks  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Height Gages <sup>1,2</sup>	Up to 40 in	$(96 + 14L) \mu\text{in}$	Gage Blocks, Surface Plate  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Bore Gages <sup>1</sup>	(0.25 to 12) in	45 $\mu\text{in}$	Cylindrical Rings  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Crimpers <sup>1</sup> Die Check Crimp Height	(0.011 to 0.5) in (0.01 to 0.5) in	230 μin 0.001 2 in	Pin Gages, Micrometer  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Profilometers <sup>1</sup>	(2 to 300) μin Ra	2.2 μin	Roughness Specimen  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Surface Plates <sup>1,2</sup> 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  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Pi Tapes Diameter	Up to 204 in	0.000 14 % of reading + 260 μin	Renishaw Laser Measuring System w/Microscope  Oshkosh, WI
Profilometer Reference Specimens	(0.01 to 9 500) μin Ra	1.3 μin	Mahr VD280 Profilometer  Oshkosh, WI



**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
CMM Calibration <sup>1,2</sup> Volumetric  Linearity	(5 to 40) in  (1 to 60) in > 60 in	(12 + 14L) μin  (7 + 14L) μin (20 + 0.4L) μin	Ball Bars, Step Gage, Renishaw Laser System, B89.4.10  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Linear Measurements	Up to 1 560 in	(38 + 0.5L) μin	Renishaw Laser System  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Optical Comparators <sup>1,2</sup> Linearity of Table Travel  Magnification	Up to 30 in  10x, 20x, 31.25x, 50x, 62.5x, 100x, 200x	(97 + 12L) μin  460 μin	Glass Scale, Precision Balls, Calibration Sphere  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Roundness Testers <sup>1</sup> Axial Error  Radial Error	(-1 000 to 1 000) μm  (-1 000 to 1 000) μm	0.15 μm  0.15 μm	Test Sphere  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Length – Dimensional Metrology**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
ULMs <sup>1</sup> (Length)	Up to 100 mm	0.19 μm	Gage Blocks  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Thickness Gages <sup>1</sup>	Up to 0.06 in Up to 6 in	380 μin 380 μin	Film Thickness Standards Gage Blocks  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Brinell Scopes <sup>1</sup>	(1 to 6) mm	11 μm	Stage Micrometer  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Angle Measuring Devices <sup>2</sup> Protractors  Inclinometers	Up to 90°  Up to 1°	0.000 73 % of reading + 0.000 12°  0.009 8 % of reading + 0.000 16°	Gage Blocks, Sine Bar, Granite Square  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Analytical Balances <sup>1,5</sup>	Up to 12 kg	0.000 31 % of reading + 12 µg	ASTM E617 Class 1 Weights and NIST Handbook 44 utilized in the calibration of the weighing system.  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Bench and Floor Scales <sup>1,5</sup>	Up to 1 000 lb	0.001 6 % of reading + 0.000 4 lb	NIST 105 Class F Weights and NIST Handbook 44 utilized in the calibration of the weighing system.  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Mass – 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  Oshkosh, WI (Class 4 and below) Fenton, MO (Class F Only) Stacy, MN (Class F Only) Monroe, NC (Class 4 and below)

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Mass – 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 500 mg 200 mg 100 mg 50 mg 20 mg 10 mg 5 mg 3 mg 2 mg 1 mg	0.29 g 0.29 g 5.9 mg 5.8 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 2 µg 1.6 µg 1.6 µg 1.6 µg 1.7 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  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 <sup>1</sup>	Up to 854 inH <sub>2</sub> O	0.03 % of reading + 0.000 044 inH <sub>2</sub> O	Ametek PK2 Deadweight Tester  Oshkosh, WI
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	Ruska 2465 Deadweight Tester  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gauge Pressure Devices	(500 to 3 000) psig	0.003 % of reading + 0.000 9 psi	Ruska 2470 Deadweight Tester  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Gauge Pressure Devices	Up to 600 psig (600 to 40 000) psig	0.005 3 % of reading + 0.002 1 psi 0.008 % of reading	Budenberg BGH2600 Deadweight Tester  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Gauge Pressure Devices	(40 000 to 60 000) psig	36 psi	Additel Hydraulic Pump, Digital Pressure Test Gauge  Oshkosh, WI
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  Oshkosh, WI

**Mass and Mass Related**

<b>Parameter/Equipment</b>	<b>Range</b>	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Durometers			Full 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
			Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Durometer Test Blocks Types A, D	Up to 100 Duro	1.2 Duro	Rex Reference Durometer, Rex Operating Stand  Oshkosh, WI
Durometer Calibrator Type A	Up to 822 g	0.034 % of reading + 20 mg	Dead Weights
Type B	Up to 10 lb	0.005 9 g	Oshkosh, WI

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Brinell Hardness Testers <sup>1</sup>  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  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Brinell Hardness Testers <sup>1</sup>	(50 to 650) HBW	1.2 % of reading + 3.2 HBW	Indirect Verification per ASTM E10 using Brinell Test Blocks and Brinell Scope  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Knoop and Vickers Hardness Testers <sup>1</sup>	HK0.05 (250 to 650) HK > 650 HK	11 HK 27 HK	Indirect Verification per ASTM E384 using Knoop and Vickers Test Blocks  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	HK0.1 (250 to 650) HK > 650 HK	11 HK 25 HK	
	HK0.3 (250 to 650) HK > 650 HK	11 HK 18 HK	
	HK0.5 (250 to 650) HK > 650 HK	14 HK 17 HK	
	HK1.0 (250 to 650) HK > 650 HK	11 HK 16 HK	
Knoop and Vickers Hardness Testers <sup>1</sup>	HV0.05 (250 to 650) HV > 650 HV	10 HK 39 HK	Indirect Verification per ASTM E384 using Knoop and Vickers Test Blocks  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	HV0.1 (250 to 650) HV > 650 HV	9 HK 30 HK	
	HV0.3 (250 to 650) HV > 650 HV	10 HK 18 HK	
	HV0.5 (250 to 650) HV > 650 HV	7 HK 17 HK	
	HV1.0 (250 to 650) HV > 650 HV	7 HK 14 HK	
Leeb Hardness Tester <sup>1</sup>	(300 to 900) LD	7.3 LD	Indirect Verification per ASTM A596 using Leeb Test Blocks  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK



**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Rockwell Hardness Testers <sup>1</sup>	HRBW Low	0.77 HRBW	Indirect Verification per ASTM E18 using Rockwell Test Blocks  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	HRBW Med	0.79 HRBW	
	HRBW High	0.71 HRBW	
	HRA Low	0.56 HRA	
	HRA Med	0.49 HRA	
	HRA High	0.47 HRA	
	HRC Low	0.52 HRC	
	HRC Med	0.53 HRC	
	HRC High	0.54 HRC	
	HREW Low	0.72 HREW	
	HREW Med	0.7 HREW	
	HREW High	0.64 HREW	
	HRFW Low	0.71 HRFW	
	HRFW Med	0.59 HRFW	
	HRFW High	0.57 HRFW	
	HRHW Low	0.72 HRH	
	HRHW Med	0.58 HRH	
	HRHW High	0.6 HRH	
	HR15N Low	0.72 HR15N	
	HR15N Med	0.7 HR15N	
	HR15N High	0.55 HR15N	
	HR30N Low	0.67 HR30N	
	HR30N Med	0.66 HR30N	
	HR30N High	0.64 HR30N	
HR45N Low	0.58 HR45N		
HR45N Med	0.65 HR45N		
HR45N High	0.62 HR45N		
HR15TW Low	0.72 HR15TW		
HR15TW Med	0.74 HR15TW		
HR15TW High	0.52 HR15TW		

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Rockwell Hardness Testers <sup>1</sup>	HR30TW Low HR30TW Med HR30T High  HR45TW Low HR45TW Med HR45TW High	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  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Force Devices <sup>1</sup>	Up 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 8 lbf 0.12 lbf 0.47 lbf 0.6 lbf 1.2 lbf 3.5 lbf 12 lbf 0.1 % of reading	Load Cells  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Force Devices <sup>1</sup>	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	Dead Weight  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Wedge Tester <sup>1</sup>	Up to 40 000 N	32 N	Load Cell  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Torque Transducers <sup>1</sup>	(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	0.048 % of reading 0.014 % of reading 0.002 6 % of reading 0.000 5 % of reading + 0.000 04 lbf·in 0.047 % of reading + 0.034 lbf·in	Torque Arms, Dead Weight  Oshkosh, WI Fenton, MO Stacy, MN
Torque Tools <sup>1</sup>	(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	0.1 % 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	AKO Low Torque System, CDI Torque System  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Viscosity Rotational Viscometers	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 0.012 cP/cP 0.012 cP/cP 0.013 cP/cP 0.012 cP/cP	Viscosity Solutions, Temperature Bath  Oshkosh, WI Stacy, MN
Viscosity Cups	17.82 cP 65.28 cP 231 cP	0.03 cP/cP	Viscosity Solutions, Temperature Bath, Stopwatch Per ASTM D4212  Oshkosh, WI Stacy, MN
Pipettes <sup>1</sup>	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 Per ISO 8655-6  Oshkosh, WI

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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	Balances  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Foundry Sand Test Equipment / Measurement <sup>1</sup> Ultrasonic Cleaner/Scrubber	18 °F 30 m	1.7 °F 1.2 s	Temperature Calibrator Stopwatch
Wet Tensile Tester	0.449 N/cm <sup>2</sup> (300 to 320) °F	0.003 1 N/cm <sup>2</sup> 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
Permmeter	Up to 500 perm	0.43 perm	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  Oshkosh, WI

**Mass and Mass Related**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gas Flow	50 sccm to 100 slpm	0.38 % of reading + 0.000 22 slpm	Fluke molBox/molBloc Calibration System, Mass Flow Controller  Stacy, MN
Liquid Flowmeters	(0.4 to 2) lpm	0.16 % of reading + 0.027 lpm	Comparison to Omega FLR1000 Flowmeter  Oshkosh, WI
Liquid Flow – Syringe	(1 to 1 500) ml/h	0.074 % of reading + 20 µl/h	Syringe Pump, Master Syringe  Oshkosh, WI

**Photometry and Radiometry**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Optical Power – Measure <sup>1</sup> (800 to 1 650) nm	(-70 to 20) dBm	0.03 dB/dBm	Agilent 81533B Interface, 81525A Optical Head  Oshkosh, WI Fenton, MO Stacy, MN
Optical Power – Source <sup>1</sup> (820, 1 310, 1 550) nm	(-60 to 0) dB	0.05 dB/dB+ 0.05 dB	Agilent 81554SM Laser Source Module, 81533B Interface, 81525A Optical Head, 81655A Laser Module, 81570A Optical Attenuator, 81578A Optical Attenuator  Oshkosh, WI Fenton, MO Stacy, MN



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**Photometry and Radiometry**

<b>Parameter/Equipment</b>	<b>Range</b>	<b>Expanded Uncertainty of Measurement (+/-)</b>	<b>Reference Standard, Method, and/or Equipment</b>
Optical Attenuation – Source <sup>1</sup> (700 to 1 650) nm	(-60 to 0) dB	0.04 dB/dB+ 0.04 dB	Agilent 81570A and 81578A Optical Attenuators  Oshkosh, WI Fenton, MO Stacy, MN
Optical Wavelength – Measure <sup>1</sup>	(700 to 1 650) nm	0.05 nm	Agilent 86120B Multi-Wavelength Meter  Oshkosh, WI Fenton, MO Stacy, MN
Gloss Meters <sup>2</sup> 20°, 60°, 85°	(0 to 100) GU	0.73 GU	Standard Gloss Tiles  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
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	Illuminance Projector, Photometric Calibration System  Oshkosh, WI

**Thermodynamic**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Source	(-95 to 600) °C (600 to 1200) °C	0.03 °C 2.3 °C	Fluke 9011, 9190A Drywell, PRT, Type S Probe  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Infrared Thermometers <sup>1,6</sup>	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	Hart Scientific 9132 Blackbody $\lambda = (8 \text{ to } 14) \mu\text{m}, \epsilon = 0.95$  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Surface Probes <sup>1</sup>	(35 to 400) °C	1.3 °C	Hart Scientific 2200 Temperature Controller, Hot-plate  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**Thermodynamic**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature – Measure <sup>1</sup>	(-30 to 600) °C (600 to 1 200) °C	0.03 °C 1.7 °C	Hart Scientific 1502 Indicator, PRT, Type S Probe  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Thermo-Hygrometers Temperature  Humidity	(0 to 70) °C  (10 to 98) %RH	0.2 °C  0.9 %RH	Thunder Scientific 2500 Humidity Chamber  Oshkosh, WI Fenton, MO Stacy, MN Monroe, NC
System Accuracy Test <sup>1</sup> (SAT)	(0 to 2 200) °F	2.6 °F	Certified Thermocouple  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Temperature Uniformity Survey (TUS) <sup>1</sup>	(0 to 2 200) °F	4.9 °F	MV 1000 Data Logger or Equivalent  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK



**Time and Frequency**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Time Interval <sup>1</sup>	(1 to 86 400) s	450 μs	Agilent 53132A Universal Counter, Spectracom 8197B GPS Oscillator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Frequency – Measure <sup>1</sup>	0.1 Hz to 26.5 GHz	7.6 % of reading	Agilent N5531S Measuring Receiver, Spectracom 8197B GPS Oscillator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Frequency – Source <sup>1</sup>	10 MHz	24 pHz	Spectracom 8197B GPS Oscillator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Frequency – Source <sup>1</sup>	0.1 mHz to 40 GHz	4.1 % of reading	Agilent 3325B Function Generator, Agilent E8257D Signal Generator, SRS FS725 Frequency Standard  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
Tachometers <sup>1,2</sup> Contact  Non-Contact	(1 to 6 500) rpm  (500 to 40 000) rpm	0.08 % of reading  0.08 % of reading	King Nutronics 3711-B Tachometer Test Set  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Tachometers <sup>1,2</sup> Non-Contact	(0.01 to 100 000) rpm	0.005 % of reading	Fluke 5560A Multiproduct Calibrator  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK

**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	Video Measuring Machine  Oshkosh, WI Fenton, MO Stacy, MN



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**2 Dimensional**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Surface Finish (Ra)	(0.01 to 600) $\mu\text{in}$	2.1 $\mu\text{in}$	Profilometer  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Angular	Up to 180°	0.002 5°	Starrett AVR300  Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC

**3 Dimensional**

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Dimensional Inspection <sup>2</sup> Volumetric	Up to (28 x 40 x 24) in	320 $\mu\text{in}$	Coordinate Measuring Machine
Linear	Up to (28 x 40 x 24) in	(38 + 5.2L) $\mu\text{in}$	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:

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.  $L$  = length in inches,  $D$  = diameter in inches,  $DL$  = diagonal length in inches, ' = arc-minute, " = arc-second, GU = Gloss Unit; rpm = revolutions per minute, ® = Registered Trademark.
3. Where ranges overlap, the uncertainty associated with the higher range begins above the overlapping value.
4. RF/Microwave uncertainties do not include inaccuracies due to sensor mismatch.
5. 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.
6. The fixed values presented here are approximate values. Actual calibration values will be used at the time of calibration, along with the actual uncertainties.
7. This scope is formatted as part of a single document including Certificate of Accreditation No. ACT-1272.



Jason Stine, Vice President

