



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 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

Brian Gliszinski 920-426-5894

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 27th Avenue, Rockford, IL 61109

3012 Old Charlotte Hwy., Monroe, NC 28110

1740 State Route 61, Crestline, OH 44827

2810 Muskogee Avenue, Tahlequah, OK 74464

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 ¹ (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 ^{1,6}	(4.01, 7, 10) pH	0.02 pH	pH Buffer Solutions Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Conductivity Meters ^{1,6}	12.85 mS/cm 1 408 µS/cm 10 µS/cm	0.18 mS/cm 14 µS/cm 0.18 µS/cm	Conductivity Solutions Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Refractometers ^{1,6}	(4.99, 7.52, 10.03, 12.53, 14.98, 30.08) Brix	0.24 Brix	Refractive Index Solutions Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Gas Detectors ^{1,6} O ₂	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 ^{1,6} (Fixed Value)	10 V	0.8 μ V/V	Fluke 732B Voltage Standard Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
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	12 μ V/V + 0.4 μ V 5.8 μ V/V + 0.7 μ V 4.2 μ V/V + 2.5 μ V 4.1 μ V/V + 4 μ V 5.8 μ V/V + 40 μ V 7.6 μ V/V + 0.4 mV	Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC Voltage – Measure ¹	Up to 200 mV 200 mV to 2 V (2 to 20) V (20 to 200) V (200 to 1 050) V	5 μ V/V + 0.1 μ V 3.5 μ V/V + 0.4 μ V 3.5 μ V/V + 4 μ V 5.5 μ V/V + 40 μ V 5.5 μ V/V + 0.5 mV	Fluke 8508A 8.5 Digit Multimeter Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC High Voltage – Measure ¹	(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 ¹	Up to 220 μ A 220 μ A to 2.2 mA (2.2 to 22) mA (22 to 220) mA 220 mV to 2.2 A	0.12 mA/A + 6 nA 42 μ A/A + 7 nA 41 μ A/A + 40 nA 52 μ A/A + 0.7 μ A 93 μ A/A + 12 μ A	Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC Current – Source ¹	(2.2 to 11) A (11 to 20.5) A	0.5 mA/A + 0.5 mA 1 mA/A + 0.75 mA	Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC Current – Source ¹	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 ¹ 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 ¹	Up to 200 μ A 200 μ A to 2 mA (2 to 20) mA (20 to 200) mA 200 mA to 2 A (2 to 20) A	12 μ A/A + 0.4 nA 12 μ A/A + 4 nA 14 μ A/A + 40 nA 48 μ A/A + 0.8 μ A 0.19 mA/A + 16 μ A 4 mA/A + 0.4 mA	Fluke 8508A 8.5 Digit Multimeter Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Resistance – Measure ¹ (Normal Mode)	Up to 2 Ω (2 to 20) Ω (20 to 200) Ω 200 Ω to 2 k Ω (2 to 20) k Ω (20 to 200) k Ω 200 k Ω to 2 M Ω (2 to 20) M Ω (20 to 200) M Ω	17 $\mu\Omega/\Omega$ + 4 $\mu\Omega$ 9.5 $\mu\Omega/\Omega$ + 14 $\mu\Omega$ 8 $\mu\Omega/\Omega$ + 50 $\mu\Omega$ 8 $\mu\Omega/\Omega$ + 0.5 m Ω 8 $\mu\Omega/\Omega$ + 5 m Ω 8 $\mu\Omega/\Omega$ + 50 m Ω 9 $\mu\Omega/\Omega$ + 1 Ω 20 $\mu\Omega/\Omega$ + 0.1 k Ω 0.12 m Ω/Ω + 10 k Ω	Fluke 8508A 8.5 Digit Multimeter Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Resistance – Measure ¹ High Voltage Mode	(2 to 20) M Ω (20 to 200) M Ω 200 m Ω to 2 G Ω (2 to 20) G Ω	17 $\mu\Omega/\Omega$ + 10 Ω 65 $\mu\Omega/\Omega$ + 1 k Ω 0.18 m Ω/Ω + 0.1 M Ω 15 m Ω/Ω + 10 M Ω	Fluke 8508A 8.5 Digit Multimeter 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
Resistance – Source ^{1,6} (Simulation-Fixed)	0 Ω	0.11 mΩ	Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	1 Ω	0.11 mΩ	
	1.9 Ω	0.21 mΩ	
	10 Ω	0.27 mΩ	
	19 Ω	0.51 mΩ	
	100 Ω	1.4 mΩ	
	190 Ω	2.6 mΩ	
	1 kΩ	11 mΩ	
	1.9 kΩ	21 mΩ	
	10 kΩ	0.11 Ω	
	19 kΩ	0.21 Ω	
	100 kΩ	1.3 Ω	
	190 kΩ	2.7 Ω	
	1 MΩ	24 Ω	
1.9 MΩ	48 Ω		
Resistance – Source ^{1,6} (Simulation-Fixed)	10 MΩ	0.48 kΩ	Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	19 MΩ	1.1 kΩ	
	100 MΩ	23 kΩ	
Resistance – Source ^{1,6} (Artifact-Fixed)	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	



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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>Fluke 5720A Multiproduct Calibrator</p> <p>Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK</p>
	(10 to 20) Hz	0.24 mV/V + 4 μV	
	(20 to 40) Hz	0.09 mV/V + 4 μV	
	40 Hz to 20 kHz	0.08 mV/V + 4 μV	
	(20 to 50) kHz	0.2 mV/V + 4 μV	
	(50 to 100) kHz	0.5 mV/V + 5 μV	
	(100 to 300) kHz	1.05 mV/V + 10 μV	
	(300 to 500) kHz	1.4 mV/V + 20 μV	
	500 kHz to 1 MHz	2.7 mV/V + 20 μV	
	(2.2 to 22) mV		
	(10 to 20) Hz	0.24 mV/V + 4 μV	
	(20 to 40) Hz	0.09 mV/V + 4 μV	
	40 Hz to 20 kHz	0.08 mV/V + 4 μV	
	(20 to 50) kHz	0.2 mV/V + 4 μV	
	(50 to 100) kHz	0.5 mV/V + 5 μV	
	(100 to 300) kHz	1.05 mV/V + 10 μV	
	(300 to 500) kHz	1.4 mV/V + 20 μV	
	500 kHz to 1 MHz	2.7 mV/V + 20 μV	
	(22 to 220) mV		
	(10 to 20) Hz	0.24 mV/V + 12 μV	
	(20 to 40) Hz	0.09 mV/V + 7 μV	
	40 Hz to 20 kHz	0.08 mV/V + 7 μV	
	(20 to 50) kHz	0.2 mV/V + 7 μV	
	(50 to 100) kHz	0.46 mV/V + 17 μV	
(100 to 300) kHz	0.9 mV/V + 20 μV		
(300 to 500) kHz	1.4 mV/V + 25 μV		
500 kHz to 1 MHz	2.7 mV/V + 45 μV		
(0.22 to 2.2) V			
(10 to 20) Hz	0.2 mV/V + 40 μV		
(20 to 40) Hz	0.075 mV/V + 15 μV		
40 Hz to 20 kHz	0.025 mV/V + 8 μV		
(20 to 50) kHz	0.055 mV/V + 10 μV		
(50 to 100) kHz	0.080 mV/V + 30 μV		
(100 to 300) kHz	0.23 mV/V + 80 μV		
(300 to 500) kHz	0.7 mV/V + 0.2 mV		
500 kHz to 1 MHz	1 mV/V + 0.3 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	(2.2 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	0.2 mV/V + 0.4 mV 0.075 mV/V + 0.15 mV 0.025 mV/V + 50 μV 0.055 mV/V + 0.1 mV 0.08 mV/V + 0.2 mV 0.25 mV/V + 0.6 mV 0.7 mV/V + 2 mV 1.1 mV/V + 3.2 mV 0.24 mV/V + 4 mV 0.09 mV/V + 1.5 mV 0.052 mV/V + 0.6 mV 0.08 mV/V + 1 mV 0.15 mV/V + 2.5 mV 0.9 mV/V + 16 mV 4.4 mV/V + 40 mV 8 mV/V + 80 mV 0.3 mV/V + 16 mV 0.07 mV/V + 3.5 mV	Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
AC Voltage – Source ¹	(330 to 1 020) V 45 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.3 mV/V + 10 mV 0.25 mV/V + 10 mV 0.3 mV/V + 10 mV	Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
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	Fluke 5522A Multiproduct Calibrator 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 ¹	(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
AC Voltage – Measure ¹ Bandwidth < 1 MHz	Up to 200 mV (1 to 10) Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz 200 mV to 2 V (1 to 10) Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz (2 to 20) V (1 to 10) Hz (10 to 40) Hz (40 to 100) Hz 100 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (30 to 100) kHz (100 to 300) kHz 300 kHz to 1 MHz	0.17 mV/V + 14 μV 0.14 mV/V + 4 μV 0.12 mV/V + 4 μV 0.11 mV/V + 2 μV 0.14 mV/V + 4 μV 0.34 mV/V + 8 μV 0.77 mV/V + 20 μV 0.15 mV/V + 0.12 mV 0.12 mV/V + 20 μV 90 μV/V + 20 μV 75 μV/V + 20 μV 0.11 mV/V + 20 μV 0.22 mV/V + 0.84 mV 0.57 mV/V + 0.2 mV 3 mV/V + 2 mV 10 mV/V + 2 mV 0.15 mV/V + 1.2 mV 0.12 mV/V + 0.2 mV 90 μV/V + 0.2 mV 75 μV/V + 0.2 mV 0.11 mV/V + 0.2 mV 0.22 mV/V + 8.4 mV 0.57 mV/V + 2 mV 3 mV/V + 20 mV 10 mV/V + 20 mV	Fluke 8508A 8.5 Digit Multimeter 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 ¹ Bandwidth < 1 MHz	(20 to 200) V		Fluke 8508A 8.5 Digit Multimeter Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	(1 to 10) Hz	0.15 mV/V + 12 mV	
	(10 to 40) Hz	0.12 mV/V + 2 mV	
	(40 to 100) Hz	90 μV/V + 2 mV	
	100 Hz to 2 kHz	75 μV/V + 2 mV	
	(2 to 10) kHz	0.11 mV/V + 2 mV	
	(10 to 30) kHz	0.22 mV/V + 84 mV	
	(30 to 100) kHz	0.57 mV/V + 20 mV	
	(100 to 300) kHz	3 mV/V + 0.2 V	
	300 kHz to 1 MHz	10 mV/V + 0.2 V	
	(200 to 1 050) V		
	(1 to 10) Hz	0.15 mV/V + 70 mV	
	(10 to 40) Hz	0.12 mV/V + 20 mV	
	40 Hz to 10 kHz	0.12 mV/V + 20 mV	
(10 to 30) kHz	0.23 mV/V + 40 mV		
(30 to 100) kHz	0.58 mV/V + 0.2 V		
AC Current – Source ¹	Up to 220 μA		Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	(10 to 20) Hz	0.30 mA/A + 16 nA	
	(20 to 40) Hz	0.20 mA/A + 10 nA	
	40 Hz to 1 kHz	0.16 mA/A + 8 nA	
	(1 to 5) kHz	0.22 mA/A + 12 nA	
	(5 to 10) kHz	1.3 mA/A + 65 nA	
	220 μA to 2.2 mA		
	(10 to 20) Hz	0.31 mA/A + 40 nA	
	(20 to 40) Hz	0.22 mA/A + 35 nA	
	40 Hz to 1 kHz	0.15 mA/A + 35 nA	
	(1 to 5) kHz	0.24 mA/A + 0.11 μA	
	(5 to 10) kHz	1.3 mA/A + 0.65 μA	
	(2.2 to 22) mA		
	(10 to 20) Hz	0.32 mA/A + 0.4 μA	
	(20 to 40) Hz	0.23 mA/A + 0.35 μA	
	40 Hz to 1 kHz	0.15 mA/A + 0.35 μA	
	(1 to 5) kHz	0.24 mA/A + 0.55 μA	
	(5 to 10) kHz	1.3 mA/A + 5 μA	
(22 to 220) mA			
(10 to 20) Hz	0.3 mA/A + 4 μA		
(20 to 40) Hz	0.2 mA/A + 3.5 μA		
40 Hz to 1 kHz	0.15 mA/A + 2.5 μA		
(1 to 5) kHz	0.24 mA/A + 3.5 μA		
(5 to 10) kHz	1.3 mA/A + 10 μA		

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
AC Current – Source ¹	220 mA to 2.2 A 20 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (2 to 3) A (10 to 45) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	0.31 mA/A + 35 μ A 0.53 mA/A + 80 μ A 8.1 mA/A + 0.16 mA 2.1 mA/A + 0.1 mA 0.75 mA/A + 0.1 mA 6.9 mA/A + 1 mA 29 mA/A + 5 mA	Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
AC Current – Source ¹	(3 to 11) A (45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz (11 to 20.5) A (45 to 100) Hz (0.1 to 1) kHz (1 to 5) kHz	60 μ A/A + 2 mA 1 mA/A + 2 mA 30 mA/A + 2 mA 1.2 mA/A + 5 mA 1.5 mA/A + 5 mA 30 mA/A + 5 mA	Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
AC Current – Source ¹	Up to 50 A (6 to 10) kHz Up to 100 A (3 to 6) kHz Up to 300 A (1 to 3) kHz Up to 1 000 A 300 Hz to 1 kHz Up to 2 500 A (10 to 300) Hz	0.8 % of reading 0.75 % of reading 0.7 % of reading 0.8 % of reading 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
AC Current – Source ¹	Up to 120 A (10 to 65) Hz (65 to 300) Hz 300 Hz to 1 kHz	0.012 % of reading + 19.2 mA 0.023 % of reading + 27.6 mA 0.078 % of reading + 93.6 mA	Fluke 52120A Transconductance Amplifier 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 Current 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	3.3 mA to 3 A 3.3 mA to 20.5 A 33 mA to 20.5 A 33 mA to 20.5 A (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	Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
AC Current – Measure ¹	Up to 200 μA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz 200 μA to 2 mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz (2 to 20) mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz (20 to 200) mA (1 to 10) Hz 10 Hz to 10 kHz (10 to 30) kHz 200 mA to 2 A 10 Hz to 2 kHz (2 to 10) kHz (10 to 30) kHz (2 to 20) A 10 Hz to 2 kHz (2 to 10) kHz	0.31 mA/A + 20 nA 0.3 mA/A + 20 nA 0.71 mA/A + 20 nA 4 mA/A + 20 nA 0.31 mA/A + 0.2 μA 0.3 mA/A + 0.2 μA 0.71 mA/A + 0.2 μA 4 mA/A + 0.2 μA 0.31 mA/A + 2 μA 0.3 mA/A + 2 μA 0.71 mA/A + 2 μA 4 mA/A + 2 μA 0.31 mA/A + 20 μA 0.3 mA/A + 20 μA 0.63 mA/A + 20 μA 0.62 mA/A + 0.2 mA 0.73 mA/A + 0.2 mA 3 mA/A + 0.2 mA 0.82 mA/A + 2 mA 2.5 mA/A + 2 mA	Fluke 8508A 8.5 Digit Multimeter 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
Capacitance – Measure ¹ 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
Capacitance – Source ¹ (Simulation)	130 pF to 3.3 nF (3.3 to 11) nF (11 to 110) nF (110 to 330) nF 330 nF to 1.1 μF (1.1 to 3.3) μF (3.3 to 11) μF (11 to 33) μF (33 to 110) μF (110 to 330) μF 330 μF to 1.1 mF (1.1 to 3.3) mF (3.3 to 11) mF (11 to 33) mF (33 to 110) mF	0.5 % of reading + 10 pF 0.5 % of reading + 10 pF 0.5 % of reading + 0.1 nF 0.25 % of reading + 0.3 nF 0.25 % of reading + 1 nF 0.25 % of reading + 3 nF 0.25 % of reading + 10 nF 0.4 % of reading + 30 nF 0.45 % of reading + 0.1 μF 0.45 % of reading + 0.3 μF 0.45 % of reading + 1 μF 0.45 % of reading + 3 μF 0.45 % of reading + 10 μF 0.75 % of reading + 30 μF 1.1 % of reading + 0.1 mF	Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
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°	Clark Hess 6000A Phase 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
DC Power – Source ¹	10 mW to 330 W 330 W to 3 kW (3 to 20.5) kW	0.27 mW/W 0.26 mW/W 0.82 mW/W	Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
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 2.2 kW	1.7 mW/W 1.2 mW/W 1.7 mW/W 1.2 mW/W 11 mW/W 4.6 mW/W	Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Oscilloscopes ¹			
DC Voltage (50 Ω)	1 mV to 6.6 V	2.9 mV/V + 40 μV	Fluke 5522A SC1100 Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
DC Voltage (1 MΩ)	1 mV to 130 V	0.55 mV/V + 40 μV	
AC Voltage (50 Ω)	1 mVp-p to 6.6 Vp-p	2.9 mV/V + 40 μV	
AC Voltage (1 MΩ)	1 mVp-p to 130 Vp-p	1.1 mV/V + 40 μV	
Leveled Sine Wave 50 kHz to 1.1 GHz	5 mVp-p to 5.5 Vp-p	51 mV/V + 0.1 mV	
Time Markers	1 ns to 5 s	6.4 μs/s	



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Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Oscilloscopes ¹			
Wave Generator (50 Ω)	1.8 mVp-p to 2.5 Vp-p	35 mV/V + 0.1 mV	Fluke 5522A SC1100 Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Wave Generator (1 MΩ)	1.8 mVp-p to 55 Vp-p	35 mV/V + 0.1 mV	
Pulse Generator – Width	(4 to 45) ns (45 to 500) ns	58 ms/s + 0.5 ns 58 ms/s + 4 ns	
Pulse Generator – Period	200 ns to 20 ms	58 ms/s + 0.2 μs	
Input Impedance Measure	(50 to 60) Ω 500 kΩ to 1 MΩ	1.2 mΩ/Ω 1.2 mΩ/Ω	
Electrical Simulation of RTD Indicating Devices ¹	Pt 385, 100 Ω (-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (500 to 630) °C (630 to 800) °C Pt 3926, 100 Ω (-200 to -80) °C (-80 to 0) °C (0 to 100) °C (100 to 300) °C (300 to 400) °C (500 to 630) °C Pt 3916 (JIS), 100 Ω (-200 to -190) °C (-190 to -80) °C (-80 to 0) °C (100 to 260) °C (260 to 300) °C (300 to 400) °C (400 to 600) °C (600 to 630) °C	0.05 °C 0.05 °C 0.07 °C 0.09 °C 0.1 °C 0.12 °C 0.23 °C 0.05 °C 0.05 °C 0.07 °C 0.09 °C 0.1 °C 0.12 °C 0.25 °C 0.04 °C 0.05 °C 0.06 °C 0.07 °C 0.09 °C 0.1 °C 0.23 °C	Fluke 5522A 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
Electrical Simulation of RTD Indicating Devices ¹	Pt 385, 200 Ω		<p>Fluke 5522A Multiproduct Calibrator</p> <p>Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK</p>
	(-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	
	Pt 385, 1 000 Ω		
	(-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			
(-100 to 260) °C	0.03 °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 ¹	Type K		Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	(-200 to -100) °C	0.33 °C	
	(-100 to -25) °C	0.18 °C	
	(-25 to 120) °C	0.16 °C	
	(120 to 1 000) °C	0.26 °C	
	(1 000 to 1 372) °C	0.4 °C	
	Type J		
	(-210 to -100) °C	0.27 °C	
	(-100 to -30) °C	0.16 °C	
	(-30 to 150) °C	0.14 °C	
	(150 to 760) °C	0.17 °C	
	(760 to 1 200) °C	0.23 °C	
	Type E		
	(-250 to -100) °C	0.5 °C	
	(-100 to -35) °C	0.16 °C	
	(-25 to 350) °C	0.14 °C	
	(350 to 650) °C	0.16 °C	
	(650 to 1 000) °C	0.21 °C	
	Type T		
	(-250 to -150) °C	0.63 °C	
	(-150 to 0) °C	0.24 °C	
	(0 to 120) °C	0.16 °C	
	(120 to 400) °C	0.14 °C	
	Type S		
(0 to 250) °C	0.47 °C		
(250 to 1 000) °C	0.36 °C		
(1 000 to 1400) °C	0.37 °C		
(1 400 to 1 767) °C	0.46 °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	0.3 °C		
(150 to 650) °C	0.26 °C		
(650 to 1 000) °C	0.31 °C		
(1 000 to 1 800) °C	0.5 °C		
(1 800 to 2 316) °C	0.84 °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 L (-200 to -100) °C (-100 to 800) °C (800 to 900) °C Type N (-200 to -100) °C (-100 to -25) °C (-25 to 120) °C (120 to 410) °C (410 to 1 300) °C Type R (0 to 250) °C (250 to 400) °C (400 to 1 000) °C (1 000 to 1767) °C Type U (-200 to 0) °C (0 to 600) °C	0.37 °C 0.26 °C 0.17 °C 0.4 °C 0.22 °C 0.19 °C 0.18 °C 0.27 °C 0.57 °C 0.35 °C 0.33 °C 0.4 °C 0.56 °C 0.27 °C	Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Inductance – Source ¹ (Artifact-Variable)	(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 ¹ 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 Burst/Surge 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 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 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

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 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 ¹ 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 ¹ 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 ^{1,4} 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 ^{1,4} 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 ^{1,4} 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 ^{1,4} Absolute Level	500 kHz to 3.05 GHz (16 to 30) dBm (-106 to 16) dBm (-129 to -106) 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	Agilent N5531S Measuring Receiver with N5532A Sensor Modules Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	(3.05 to 6.6) GHz (20 to 30) dBm (-90 to 20) dBm (-114 to -90) dBm	0.39 dB + 0.005 dB/10 dB 0.18 dB + 0.005 dB/10 dB 0.23 dB + 0.12 dB/10 dB	
	(6.6 to 13.2) GHz (20 to 30) dBm (-81 to 20) dBm (-104 to -81) dBm	0.39 dB + 0.005 dB/10 dB 0.18 dB + 0.005 dB/10 dB 0.23 dB + 0.12 dB/10 dB	
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	0.4 dB + 0.005 dB/10 dB 0.21 dB + 0.005 dB/10 dB 0.25 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
	(19.2 to 26.5) GHz (+20 to +30) dBm (-62 to +20) dBm (-85 to -62) dBm	0.4 dB + 0.005 dB/10 dB 0.21 dB + 0.005 dB/10 dB 0.24 dB + 0.12 dB/10 dB	
	500 kHz to 3.05 GHz (-90 to +30) dBm (-106 to -90) dBm (-129 to -106) dBm	0.026 dB + 0.005 dB/10 dB 0.067 dB + 0.12 dB/10 dB 0.076 dB + 0.12 dB/10 dB	
RF Power – Source ¹	> -10 dBm		Agilent E8257D Signal Generator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz	0.72 dB 0.96 dB 1.1 dB	
	(-10 to -70) dBm		
	250 kHz to 2 GHz (2 to 20) GHz (20 to 40) GHz	0.89 dB 1.1 dB 1.2 dB	
	(-70 to -90) dBm		
	250 kHz to 2 GHz (2 to 20) GHz	0.95 dB 1.2 dB	
	(20 to 40) GHz	1.21 dB	

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	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 ^{1,4} 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 ^{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	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 ^{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	Agilent 53132A Counter Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
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	Agilent E8257D Signal Generator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
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 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 ^{1,4} 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 ²	Up to 30 in	$(3.8 + 0.93L) \mu\text{in}$	Mahr 828 Measuring Machine, Per ASME B89.1.9 Oshkosh, WI
Gage Blocks ²	Up to 10 in	$(3.9 + 1.3L) \mu\text{in}$	P & W Universal Labmaster, Per ASME B89.1.9 Oshkosh, WI Rockford, IL
Gage Blocks ²	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 ²	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 ²	Up to 39 in	$(12 + 1L) \mu\text{in}$	Mahr 828 Measuring Machine, Per ASME B89.1.1 Oshkosh, WI
Length Standards ²	(39 to 70) in	$(390 + 2.6L) \mu\text{in}$	CMM Oshkosh, WI Stacy, MN
Length Standards ²	Up to 4 in	$(53 + 0.4L) \mu\text{in}$	Plug Gage Comparator Crestline, OH Tahlequah, OK
Cylindrical Rings ²	(0.02 to 18) in	$(8 + 1.8D) \mu\text{in}$	Mahr 828 Measuring Machine, ASME B89.1.6 Oshkosh, WI
Cylindrical Rings ^{1,2}	(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 ²	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 ^{1,2}	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 ² Pitch Diameter Minor Diameter	Up to Setting plug size Up to 16 in Up to 9 in	$(240 + 0.3D) \mu\text{in}$ 120 μin	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 ² Pitch Diameter Minor Diameter	Up to 14 in Up to 9 in	$(120 + 2.5D) \mu\text{in}$ 120 μin	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 μ in	NPT Plugs, P&W LabMaster, 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 μ in	NPT Rings, P&W LabMaster, 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 ² Pitch Diameter Major Diameter	Up to 24 in Up to 24 in	(73 + 0.9D) μ in (40 + 1.2D) μ in	P&W Supermicrometer, Thread Measuring Wires, ASME B1.2 Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Thread Plugs ^{1,2} Pitch Diameter Major Diameter	Up to 4 in Up to 4 in	(73 + 3.2D) μ in (53 + 4.1D) μ in	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 ²	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 ^{1,2}	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 ^{1,2}	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 ¹	Up to 0.06 in	39 μin	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 ^{1,2}	Up to 60 in	(72 + 12L) μin	Gage Blocks Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
ID Micrometer ^{1,2}	(1.5 to 40) in	(370 + 7L) μin	Gage Blocks Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Height Gages ^{1,2}	Up to 40 in	(96 + 14L) μin	Gage Blocks Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Bore Gages ¹	(0.25 to 12) in	45 μin	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 ¹ 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 ¹	(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 ^{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 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 600) μin Ra	2.4 μin	Profilometer Oshkosh, WI

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
CMM Calibration ^{1,2} 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 ^{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	Glass Scale, Precision Balls, Calibration Sphere Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Roundness Testers ¹ 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 ¹ (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 ¹	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 ¹	(1 to 6) mm	11 μm	Stage Micrometer 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 ^{1,5}	Up to 20 g Up to 100 g Up to 10 kg	0.038 % of reading + 1.6 µg 0.077 % of reading + 1.6 µg 0.009 4 % of reading + 69 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 ^{1,5}	Up to 10 lb (>10 to 5 000) lb	1.3 mg 0.001 3 % of reading	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	0.29 g 0.12 g 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 Fenton, MO (Class F Only) Stacy, MN (Class F Only)



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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	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	Class 1 Weights and Analytical Balance, Modified Substitution Oshkosh, WI Fenton, MO (Class F Only) Stacy, MN (Class F Only)
Mass – 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 Oshkosh, WI Fenton, MO (Class F Only) Stacy, MN (Class F Only)
Gauge Pressure ¹	Up to 854 inH ₂ O	0.03 % of reading + 0.000 044 inH ₂ O	Ametek PK2 Deadweight Tester Oshkosh, WI
Absolute Pressure	(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	(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	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	(40 000 to 60 000) psig	36 psi	Additel Hydraulic Pump, Digital Pressure Test Gauge Oshkosh, WI
Durometers			Full Direct Verification per ASTM D2240 using Durometer Calibrator, Triple Beam Balance
Spring Force	Up to 100 duro	0.1 duro	
Indenter Dimensions			Video Measuring Machine
Indenter Angle	(20 to 40)°	0.11°	
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

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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 Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
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 Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
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 HK1.0 (250 to 650) HK > 650 HK	11 HK 27 HK 11 HK 25 HK 11 HK 18 HK 14 HK 17 HK 11 HK 16 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

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Knoop and Vickers Hardness Testers ¹	HV0.05 (250 to 650) HV > 650 HV HV0.1 (250 to 650) HV > 650 HV HV0.3 (250 to 650) HV > 650 HV HV0.5 (250 to 650) HV > 650 HV HV1.0 (250 to 650) HV > 650 HV	10 HK 39 HK 9 HK 30 HK 10 HK 18 HK 7 HK 17 HK 7 HK 14 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
Leeb Hardness Tester ¹	(300 to 900) LD	12 LD	Indirect Verification per ASTM A596 using Leeb Test Blocks Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Rockwell Hardness Testers ¹	HRBW Low HRBW Med HRBW High HRA Low HRA Med HRA High HRC Low HRC Med HRC 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	Indirect Verification per ASTM E18 using Rockwell Test Blocks Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK



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Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Rockwell Hardness Testers ¹	HREW Low	0.72 HREW	Indirect Verification per ASTM E18 using Rockwell Test Blocks Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
	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	
	HR30TW Low	0.64 HR30TW	
	HR30TW Med	0.65 HR30TW	
	HR30T High	0.54 HR30TW	
HR45TW Low	0.67 HR45TW		
HR45TW Med	0.69 HR45TW		
HR45TW High	0.69 HR45TW		

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Force Devices ¹	Up to 100 lb	0.05 % of reading	Dead Weight Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Force Devices ¹	Up to 500 lb (500 to 2 000) lb (2 000 to 12 500) lb (12 500 to 50 000) lb (50 000 to 500 000) lb	0.05 % of reading 0.07 % of reading 0.1 % of reading 0.1 % of reading 0.1 % of reading	Load Cells Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Force Devices	Up to 200 lb	0.05 % reading	Dead Weight Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Force Devices	Up to 1 000 lb (1 000 to 10 000) lb (10 000 to 100 000) lb	0.03 % reading 0.03 % reading 0.04 % reading	Load Cells 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
Wedge Tester ¹	Up to 40 000 N	32 N	Load Cell Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Torque Transducers ¹	0.000 04 in oz to 250 lbf·ft (250 to 2 000) lbf·ft	0.05 % of reading 0.06 % of reading	Torque Arms, Dead Weight Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Torque Tools ¹	(10 to 200) ozf·in 4 lbf·in to 2 000 lbf·ft	0.5 % of reading 0.3 % of reading	CDI Torque System Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Viscosity Rotational Viscometers	500 cP 5 000 cP	0.02 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

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	0.064 μL 0.6 μL 1.8 μL 8.9 μL 18 μL	Analytical Balance Per ISO 8655-6 Oshkosh, WI
Liquid Volume Measuring Devices	Up to 200 mL (200 to 6 000) mL (6 000 to 34 000) mL	0.003 mL 0.46 mL 2.8 mL	Balances Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Foundry Sand Test Equipment / Measurement ¹ Ultrasonic Cleaner/Scrubber	18 °F 30 m	1.7 °F 1.2 s	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 Oshkosh, WI

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Foundry Sand Test Equipment / Measurement ¹			
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
Gas Flow	50 sccm to 100 slm	0.38 % of reading + 0.000 22 slm	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 ¹ (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 ¹ (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
Optical Attenuation – Source ¹ (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 ¹	(700 to 1 650) nm	0.05 nm	Agilent 86120B Multi-Wavelength Meter Oshkosh, WI Fenton, MO Stacy, MN
Gloss Meters ² 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

Photometry and Radiometry

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Illuminance – Lux Meters	(180 to 18 000) lux	6.9% of reading + 0.66 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 ^{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	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

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Surface Probes ¹	(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
Temperature – Measure ¹	(-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 ¹ (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

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Temperature Uniformity Survey (TUS) ¹	(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 ¹	(1 to 86 400) s	450 μs	Agilent 53132A Counter and Spectracom 8197B GPS Oscillator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC Crestline, OH Tahlequah, OK
Frequency – Measure ¹	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

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency – Source ¹	10 MHz	24 pHz	Spectracom 8197B GPS Oscillator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Frequency – Source ¹	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
Tachometers ¹ 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 ¹ Non-Contact	(0.01 to 100 000) rpm	0.005 % of reading	Fluke 5522A 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
Linear	Up to 24 in	0.000 9 in	Video Measuring Machine Oshkosh, WI Fenton, MO Stacy, MN

2 Dimensional

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Surface Finish (Ra)	(0.01 to 600) μin	2.1 μin	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 ² Volumetric	Up to (28 x 40 x 24) in	320 μin	Coordinate Measuring Machine
Linear	Up to (28 x 40 x 24) in	(38 + 5.2L) μin	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, GU = Gloss Unit.
 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 may be used at the time of calibration.
 7. This scope is formatted as part of a single document including Certificate of Accreditation No. ACT-1272.



Jason Stine, Vice President

