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.

R. Douglas Leonard Jr., VP, PILR SBU

Expiry Date: 15 June 2023
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, ANSI/NCSL Z540-1-1994 (R2002) AND 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
305 South Charlotte Avenue, Monroe, NC 28112

CALIBRATION AND DIMENSIONAL MEASUREMENT

Valid to: **June 15, 2023** 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
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]	(4.01, 7, 10) pH	0.02 pH	pH Buffer Solutions Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Conductivity Meters [1]	12.85 mS/cm 1408 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
Refractometers [1]	(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

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
DC Voltage – Source [1] (Fixed Value)	10 V	0.8 µV/V	Fluke 732B Voltage Standard Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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 µV/V + 0.4 µV 5.8 µV/V + 0.7 µV 4.2 µV/V + 2.5 µV 4.1 µV/V + 4 µV 5.8 µV/V + 40 µV 7.6 µV/V + 0.4 mV	Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
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 µV/V + 0.1 µV 3.5 µV/V + 0.4 µV 3.5 µV/V + 4 µV 5.5 µV/V + 40 µV 5.5 µV/V + 0.5 mV	Fluke 8508A 8.5 Digit Multimeter Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
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
DC Current – Source [1]	Up to 220 µA 220 µA 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 µA/A + 7 nA 41 µA/A + 40 nA 52 µA/A + 0.7 µA 93 µA/A + 12 µA	Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
DC Current – Source [1]	(2.2 to 11) A (11 to 20.5) A	0.58 mA/A + 0.5 mA 1.2 mA/A + 0.75 mA	Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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
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
DC Current – Measure [1]	Up to 200 µA 200 µA to 2 mA (2 to 20) mA (20 to 200) mA 200 mA to 2 A (2 to 20) A	12 µA/A + 0.4 nA 12 µA/A + 4 nA 14 µA/A + 40 nA 48 µA/A + 0.8 µA 0.19 mA/A + 16 µA 4 mA/A + 0.4 mA	Fluke 8508A 8.5 Digit Multimeter Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Resistance – Measure [1] (Normal Mode)	Up to 2 Ω (2 to 20) Ω (20 to 200) Ω 200 Ω to 2 kΩ (2 to 20) kΩ (20 to 200) kΩ 200 kΩ to 2 MΩ (2 to 20) MΩ (20 to 200) MΩ	17 µΩ/Ω + 4 µΩ 9.5 µΩ/Ω + 14 µΩ 8 µΩ/Ω + 50 µΩ 8 µΩ/Ω + 0.5 mΩ 8 µΩ/Ω + 5 mΩ 8 µΩ/Ω + 50 mΩ 9 µΩ/Ω + 1 Ω 20 µΩ/Ω + 0.1 kΩ 0.12 mΩ/Ω + 10 kΩ	Fluke 8508A 8.5 Digit Multimeter Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Resistance – Measure [1] High Voltage Mode	(2 to 20) MΩ (20 to 200) MΩ 200 mΩ to 2 GΩ (2 to 20) GΩ	17 μΩ/Ω + 10 Ω 65 μΩ/Ω + 1 kΩ 0.18 mΩ/Ω + 0.1 MΩ 15 mΩ/Ω + 10 MΩ	Fluke 8508A 8.5 Digit Multimeter Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Resistance – Source [1] (Simulation-Fixed)	0 Ω 1 Ω 1.9 Ω 10 Ω 19 Ω 100 Ω 190 Ω 1 kΩ 1.9 kΩ 10 kΩ 19 kΩ 100 kΩ 190 kΩ 1 MΩ 1.9 MΩ	0.11 mΩ 0.11 mΩ 0.21 mΩ 0.27 mΩ 0.51 mΩ 1.4 mΩ 2.6 mΩ 11 mΩ 21 mΩ 0.11 Ω 0.21 Ω 1.3 Ω 2.7 Ω 24 Ω 48 Ω	Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Resistance – Source [1] (Simulation-Fixed)	10 MΩ 19 MΩ 100 MΩ	0.48 kΩ 1.1 kΩ 23 kΩ	Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Resistance – Source [1] (Artifact-Fixed)	1 GΩ 10 GΩ 100 GΩ	1.9 MΩ 47 MΩ 0.95 GΩ	IET Labs HRRS Decade Box Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC

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		Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
	(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	

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		Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
	(10 to 20) Hz	0.2 mV/V + 0.4 mV	
	(20 to 40) Hz	0.075 mV/V + 0.15 mV	
	40 Hz to 20 kHz	0.025 mV/V + 50 µV	
	(20 to 50) kHz	0.055 mV/V + 0.1 mV	
	(50 to 100) kHz	0.08 mV/V + 0.2 mV	
	(100 to 300) kHz	0.25 mV/V + 0.6 mV	
	(300 to 500) kHz	0.7 mV/V + 2 mV	
	500 kHz to 1 MHz	1.1 mV/V + 3.2 mV	
	(22 to 220) V		
	(10 to 20) Hz	0.24 mV/V + 4 mV	
	(20 to 40) Hz	0.09 mV/V + 1.5 mV	
	40 Hz to 20 kHz	0.052 mV/V + 0.6 mV	
	(20 to 50) kHz	0.08 mV/V + 1 mV	
	(50 to 100) kHz	0.15 mV/V + 2.5 mV	
	(100 to 300) kHz	0.9 mV/V + 16 mV	
	(300 to 500) kHz	4.4 mV/V + 40 mV	
	500 kHz to 1 MHz	8 mV/V + 80 mV	
	(220 to 1 100) V		
	(15 to 50) Hz	0.3 mV/V + 16 mV	
	50 Hz to 1 kHz	0.07 mV/V + 3.5 mV	
AC Voltage – Source [1]	(330 to 1 020) V		Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
	45 Hz to 1 kHz	0.23 mV/V + 10 mV	
	(1 to 5) kHz	0.19 mV/V + 10 mV	
	(5 to 10) kHz	0.23 mV/V + 10 mV	
AC Voltage Harmonics – Source [1]			Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
(2^{nd} to 50^{th})			
(10 to 45) Hz	32 mV to 33 V	0.35 mV/V + 16 µV	
(45 to 65) Hz	33 mV to 1 000 V	0.21 mV/V + 16 µV	
(65 to 500) Hz	33 mV to 1 000 V	0.21 mV/V + 16 µV	
500 Hz to 5 kHz	330 mV to 1 000 V	0.21 mV/V + 0.21 mV	
(5 to 10) kHz	(3.3 to 1 000) V	0.21 mV/V + 1.2 mV	

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
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

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 (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 (200 to 1 050) V (1 to 10) Hz (10 to 40) Hz 40 Hz to 10 kHz (10 to 30) kHz (30 to 100) kHz	 0.15 mV/V + 12 mV 0.12 mV/V + 2 mV 90 µV/V + 2 mV 75 µV/V + 2 mV 0.11 mV/V + 2 mV 0.22 mV/V + 84 mV 0.57 mV/V + 20 mV 3 mV/V + 0.2 V 10 mV/V + 0.2 V 0.15 mV/V + 70 mV 0.12 mV/V + 20 mV 0.12 mV/V + 20 mV 0.23 mV/V + 40 mV 0.58 mV/V + 0.2 V	Fluke 8508A 8.5 Digit Multimeter Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
AC Current – Source [1]	Up to 220 µA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz 220 µA to 2.2 mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (2.2 to 22) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz (22 to 220) mA (10 to 20) Hz (20 to 40) Hz 40 Hz to 1 kHz (1 to 5) kHz (5 to 10) kHz	 0.30 mA/A + 16 nA 0.20 mA/A + 10 nA 0.16 mA/A + 8 nA 0.22 mA/A + 12 nA 1.3 mA/A + 65 nA 0.31 mA/A + 40 nA 0.22 mA/A + 35 nA 0.15 mA/A + 35 nA 0.24 mA/A + 0.11 µA 1.3 mA/A + 0.65 µA 0.32 mA/A + 0.4 µA 0.23 mA/A + 0.35 µA 0.15 mA/A + 0.35 µA 0.24 mA/A + 0.55 µA 1.3 mA/A + 5 µA 0.3 mA/A + 4 µA 0.2 mA/A + 3.5 µA 0.15 mA/A + 2.5 µA 0.24 mA/A + 3.5 µA 1.3 mA/A + 10 µA	Fluke 5720A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC

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 µA 0.53 mA/A + 80 µA 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
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	 0.74 mA/A + 2 mA 1.2 mA/A + 2 mA 35 mA/A + 2 mA 1.4 mA/A + 5 mA 1.8 mA/A + 5 mA 35 mA/A + 5 mA	Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
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
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

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})			Fluke 5522A Multiproduct Calibrator
(10 to 45) Hz	3.3 mA to 3 A	1.1 mA/A + 4 µA	Oshkosh, WI
(45 to 65) Hz	3.3 mA to 20.5 A	0.5 mA/A + 4 µA	Fenton, MO
(65 to 500) Hz	33 mA to 20.5 A	1.2 mA/A + 0.1 mA	Stacy, MN
500 Hz to 5 kHz	33 mA to 20.5 A	2.3 mA/A + 0.2 mA	Rockford, IL
(5 to 10) kHz	(33 to 330) mA	4.6 mA/A + 0.4 mA	Monroe, NC
AC Current – Measure [1]	Up to 200 µA		Fluke 8508A 8.5 Digit Multimeter
	(1 to 10) Hz	0.31 mA/A + 20 nA	Oshkosh, WI
	10 Hz to 10 kHz	0.3 mA/A + 20 nA	Fenton, MO
	(10 to 30) kHz	0.71 mA/A + 20 nA	Stacy, MN
	(30 to 100) kHz	4 mA/A + 20 nA	Rockford, IL
	200 µA to 2 mA		Monroe, NC
	(1 to 10) Hz	0.31 mA/A + 0.2 µA	
	10 Hz to 10 kHz	0.3 mA/A + 0.2 µA	
	(10 to 30) kHz	0.71 mA/A + 0.2 µA	
	(30 to 100) kHz	4 mA/A + 0.2 µA	
	(2 to 20) mA		
	(1 to 10) Hz	0.31 mA/A + 2 µA	
	10 Hz to 10 kHz	0.3 mA/A + 2 µA	
	(10 to 30) kHz	0.71 mA/A + 2 µA	
	(30 to 100) kHz	4 mA/A + 2 µA	
	(20 to 200) mA		
	(1 to 10) Hz	0.31 mA/A + 20 µA	
	10 Hz to 10 kHz	0.3 mA/A + 20 µA	
	(10 to 30) kHz	0.63 mA/A + 20 µA	
	200 mA to 2 A		
	10 Hz to 2 kHz	0.62 mA/A + 0.2 mA	
	(2 to 10) kHz	0.73 mA/A + 0.2 mA	
	(10 to 30) kHz	3 mA/A + 0.2 mA	
	(2 to 20) A		
	10 Hz to 2 kHz	0.82 mA/A + 2 mA	
	(2 to 10) kHz	2.5 mA/A + 2 mA	
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

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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	5.8 mF/F + 10 pF 2.9 mF/F + 10 pF 2.9 mF/F + 0.1 nF 2.9 mF/F + 0.3 nF 2.9 mF/F + 1 nF 2.9 mF/F + 3 nF 2.9 mF/F + 10 nF 4.7 mF/F + 30 nF 5.3 mF/F + 0.1 µF 1 mF/F + 0.3 µF 6 mF/F + 1 µF 5.3 mF/F + 3 µF 5.3 mF/F + 10 µF 8.9 mF/F + 30 µF 13 mF/F + 0.1 mF	Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
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
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

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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
Oscilloscopes [1]			
DC Voltage (50 Ω)	1 mV to 6.6 V	2.9 mV/V + 40 µV	
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	Fluke 5522A SC1100 Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Time Markers	1 ns to 5 s	6.4 µs/s	
Wave Generator (50 Ω)	1.8 mVp-p to 2.5 Vp-p	35 mV/V + 0.1 mV	
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 – 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, 100 Ω		Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
	(-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	
	(630 to 800) °C	0.23 °C	
	Pt 3926, 100 Ω		
	(-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	
	(100 to 260) °C	0.06 °C	
	(260 to 300) °C	0.07 °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	

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, 500 Ω		Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
	(-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 Simulation of Thermocouple Indicating Devices – Source/Measure [1]	Type K		Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
	(-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	

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 T		Fluke 5522A Multiproduct Calibrator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
	(-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	
	Type L		
	(-200 to -100) °C	0.37 °C	
	(-100 to 800) °C	0.26 °C	
	(800 to 900) °C	0.17 °C	
	Type N		
	(-200 to -100) °C	0.4 °C	
	(-100 to -25) °C	0.22 °C	
	(-25 to 120) °C	0.19 °C	
	(120 to 410) °C	0.18 °C	
	(410 to 1 300) °C	0.27 °C	
	Type R		
	(0 to 250) °C	0.57 °C	
	(250 to 400) °C	0.35 °C	
	(400 to 1 000) °C	0.33 °C	
	(1 000 to 1767) °C	0.4 °C	
	Type U		
	(-200 to 0) °C	0.56 °C	
	(0 to 600) °C	0.27 °C	

Electrical – DC/Low Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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
Ionizers [1] Decay Time Float Voltage	 (0.1to 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

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Measure [1,4] Absolute Level 100 kHz to 3 GHz (3 to 18) GHz (18 to 26.5) GHz 100 kHz to 3 GHz (3 to 18) GHz (18 to 26.5) GHz	 (+20 to +30) dBm (-20 to +20) dBm	 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

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Relative Level (3.05 to 6.6) GHz (6.6 to 13.2) GHz (13.2 to 19.2) GHz	(-90 to +30) dBm (-113 to -90) dBm (-81 to +30) dBm (-104 to -81) dBm (-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
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
Amplitude Modulation – Source [1,4] Rate: DC to 100 kHz Depths: 0 % to 100 %	250 kHz to 40 GHz	7.1 % of reading	Agilent E8257D Signal Generator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Amplitude Modulation – Measure [1,4] 100 kHz to 10 MHz 10 MHz to 3 GHz 10 MHz to 3 GHz (3 to 26.5) GHz (3 to 26.5) GHz	 Rate: 50 Hz to 10 kHz Depths: 5 % to 99 % Rate: 50 Hz to 100 kHz Depths: 20 % to 99 % Rate: 50 Hz to 100 kHz Depths: 5 % to 20 % Rate: 50 Hz to 100 kHz Depths: 20 % to 99 % Rate: 50 Hz to 100 kHz Depths: 5 % to 20 %	 2.2 % of reading 1.2 % of reading 4.2 % of reading 3.5 % of reading 6 % of reading	 Agilent N5531S Measuring Receiver with N5532A Sensor Modules Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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
Tuned RF Level – Measure [1,4] Absolute Level 500 kHz to 3.05 GHz (3.05 to 6.6) GHz (6.6 to 13.2) GHz	 (+16 to +30) dBm (-106 to +16) dBm (-129 to –106) dBm (+20 to +30) dBm (-90 to +20) dBm (-114 to -90) dBm (+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
Tuned RF Level – Measure [1,4] Absolute Level (13.2 to 19.2) GHz (19.2 to 26.5) GHz 500 kHz to 3.05 GHz	 (+20 to +30) dBm (-70 to +20) dBm (-93 to -70) dBm (+20 to +30) dBm (-62 to +20) dBm (-85 to -62) dBm (-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

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
RF Power – Source [1]			
250 kHz to 2 GHz	> -10 dBm	0.72 dB	
(2 to 20) GHz		0.96 dB	Agilent E8257D Signal Generator
(20 to 40) GHz		1.1 dB	
250 kHz to 2 GHz	(-10 to -70) dBm	0.89 dB	Oshkosh, WI
(2 to 20) GHz		1.1 dB	Fenton, MO
(20 to 40) GHz		1.2 dB	Stacy, MN
			Rockford, IL
250 kHz to 2 GHz	(-70 to -90) dBm	0.95 dB	Monroe, NC
(2 to 20) GHz		1.2 dB	
(20 to 40) GHz		1.21 dB	
RF Power Sensors – Calibration Factor [1,4]			Tegam 1827 Power Sensor Calibrator, Agilent 3458[a] Multimeter, Agilent E8257D Signal Generator, Agilent E4419B Power Meter, Agilent 3325B Function Generator
100 kHz to 10 MHz	(-20 to +14) dBm	1.5 % of reading	
10 MHz to 10 GHz	(-20 to +14) dBm	1.5 % of reading	
(10 to 18) GHz	(-20 to +14) dBm	1.7 % of reading	Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Frequency Modulation – Measure [1,4]			Agilent N5531S Measuring Receiver with N5532A Sensor Modules
250 kHz to 10 MHz	Rate: 20 Hz to 10 kHz Dev.: ≤ 40 kHz peak	3.1 % of reading	
10 MHz to 3 GHz	Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak	3.1 % of reading	Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
(3 to 26.5) GHz	Rate: 20 Hz to 200 kHz Dev.: ≤ 400 kHz peak	7.7 % of reading	

Electrical – RF/Microwave

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Frequency Modulation – Source [1,4] 250 kHz to 40 GHz	1 dB Rate: DC to 100 kHz 3 dB Rate: DC to 10 MHz Dev: ≤ (N X 800 kHz)	4.2 % of reading + 20 Hz	Agilent E8257D Signal Generator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
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
Pulse Generation – Source [1,4] Repetition Frequency: 0.024 Hz 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

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 + 0.93*L*) µin	Mahr 828 Measuring Machine, Per ASME B89.1.9 Oshkosh, WI

Length – Dimensional Metrology

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Gage Blocks [2]	Up to 20 in	(8.5 + 1*L*) µin	ULM 600 Measuring Machine, Per ASME B89.1.9 Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Length Standards [2]	Up to 39 in	(12 + 1*L*) µin	Mahr 828 Measuring Machine, Per ASME B89.1.1 Oshkosh, WI
Length Standards [2]	(39 to 70) in	(390 + 2.6*L*) µin	CMM Oshkosh, WI Stacy, MN
Cylindrical Rings [2]	(0.025 to 18) in	(8 + 1.8*D*) µin	Mahr 828 Measuring Machine, ASME B89.1.6 Oshkosh, WI
Cylindrical Rings [1,2]	(0.25 to 8) in	(12 + 3*D*) µin	Fowler Lab Concept Measuring Machine, ASME B89.1.6 Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Cylindrical Plugs [2]	(0.010 to 30) in	(2.7 + 6*D*) µin	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]	(0.010 to 4) in	(53 + 0.4*D*) µin	Plug Gage Comparator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Thread Rings [2] Pitch Diameter Pitch Diameter Minor Diameter	Up to Setting plug size Up to 16 in Up to 14 in Up to 9 in	(240 + 0.3*D*) µin 38 µin 120 µin	Setting Plug Gages, ULM 600 Measuring Machine, ID Bore Gages, ASME B1.2 Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
NPT Rings (Standoff and Basic Length)	(0.0625 to 8) in	250 µin	NPT Plugs, P&W LabMaster, ASME B1.20.5 Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
NPT Plugs (Standoff and Basic Length)	(0.0625 to 6) in	490 µin	NPT Rings, P&W LabMaster, ASME B1.20.5 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
Thread Plugs [2] Pitch Diameter Major Diameter	 Up to 24 in Up to 24 in	 (73 + 0.9*D*) µin (40 + 1.2*D*) µin	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 + 3.2*D*) µin (53 + 4.1*D*) µin	Plug Gage Comparator Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Thread Wires [2]	Up to 0.5 in	(11 + 1.5*D*) µin	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 + 15*L*) µin	Gage Blocks Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Indicators [1,2]	Up to 4 in	(36 + 10*L*) µin	Indicator Checker 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
Test Indicators [1]	Up to 0.06 in	39 µin	Indicator Checker Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
OD Micrometers [1,2]	Up to 60 in	(72 + 12*L*) µin	Gage Blocks Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
ID Micrometer [1,2]	(1.5 to 40) in	(370 + 7*L*) µin	Gage Blocks Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Height Gages [1,2]	Up to 40 in	(96 + 14*L*) µin	Gage Blocks Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Bore Gages [1]	(0.25 to 12) in	45 µin	Cylindrical Rings 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
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
Profilometers [1]	(2 to 300) µin Ra	2.2 µin	Roughness Specimen Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Profilometer Reference Specimens	(0.01 to 300) µin Ra	2.1 µin	Profilometer Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Surface Plates [1,2] Repeat Reading Overall Flatness	 (4 to 34) in*DL* (34 to 175) in*DL*	 35 µin (92 + 0.14*DL*) µin	In accordance to with ASME B89.3.7 using Repeat-O-Meter Electronic Levels 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
CMM Calibration [1,2] Volumetric Linearity	(5 to 40) in (1 to 60) in > 60 in	(12 + 14*L*) µin (7 + 14*L*) µin (20 + 0.4*L*) µin	Ball Bars, Step Gage, Renishaw Laser System, B89.4.1 Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Linear Measurements	Up to 1 560 in	(38 + 0.5*L*) µin	Renishaw Laser System Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Optical Comparators [1,2] Linearity Magnification	Up to 12 in 10x, 20x, 31.25x, 50x, 62.5x, 100x, 200x	(97 + 12*L*) µin 460 µin	Glass Scale, Precision Balls, Calibration Sphere Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
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
ULMs [1] (Length)	(1 to 100) mm	0.19 µm	Gage Blocks 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
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
Brinell Scopes [1]	(1 to 6) mm	11 µm	Stage Micrometer 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
Bench and Floor Scales [1,5]	Up to 5 000 lb	0.000 7 lb/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

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Analytical Balances [1,5]	Up to 6 kg	0.19 µg/g	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
Mass – Avoirdupois	100 lb 50 lb 25 lb 20 lb 10 lb 5 lb 2 lb 1 lb 0.5 lb 8 oz 4 oz 2 oz 1 oz 0.5 oz 0.25 oz 0.125 oz 0.062 5 oz 0.031 25 oz	0.77 g 0.65 g 0.46 g 0.37 g 0.12 g 0.11 g 84 mg 73 mg 24 mg 23 mg 22 mg 21 mg 21 mg 0.44 mg 0.26 mg 0.19 mg 0.17 mg 0.13 mg	Class 1 Weights and Analytical Balance, Modified Substitution Oshkosh, WI Fenton, MO (Class F Only) Stacy, MN (Class F Only)

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Mass – Metric	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	46 mg 30 mg 23 mg 18 mg 16 mg 16 mg 1.8 mg 0.9 mg 0.47 mg 0.32 mg 0.19 mg 0.11 mg 61 µg 45 µg 36 µg 26 µg	Class 1 Weights and Analytical Balance, Modified Substitution Oshkosh, WI Fenton, MO (Class F Only) Stacy, MN (Class F Only)
Mass – Metric	500 mg 300 mg 200 mg 100 mg 50 mg 30 mg 20 mg 10 mg 5 mg 3 mg 2 mg 1 mg	20 µg 18 µg 15 µg 13 µg 11 µg 9.5 µg 9.1 µg 8.0 µg 7.5 µg 7.1 µg 6.8 µg 6.7 µg	Class 1 Weights and Analytical Balance, Modified Substitution Oshkosh, WI Fenton, MO (Class F Only) Stacy, MN (Class F Only)
Pressure [1]	(-1 to 1) inWc (-5 to 5) inWc	0.1 % of reading + 0.000 2 inWc 0.12 % of reading + 0.001 4 inWc	Setra MicroCal Pressure Calibrator 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
Absolute Pressure	(0.2 to 500) psia	0.013 % of reading	Ruska 2465 Deadweight Tester Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Gauge Pressure	(3 000 to 40 000) psig	0.2 % of reading	Budenberg BGH2600 Deadweight Tester Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Durometers [1] Spring Force	Up to 100 duro Up to 45 N	0.35 duro 0.05 N	Direct Verification per ASTM D2240 Durometer Calibrator, Triple Beam Balance
Indenter Angle	(20 to 40) °	0.07 °	Video Measuring Machine
Indenter Radius	Up to 0.1 in	340 µin	Video Measuring Machine
Indenter Length	Up to 0.198 in	330 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 Verification of Indenter Mean Diameter	 (500, 750, 1 500, 2 000, 3 000) kgf 10 mm 5 mm	 7.2 kgf 0.002 mm 0.002 mm	Direct Verification per ASTM E10 using Morehouse Proving Ring Video Measuring Machine Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Brinell Hardness Testers [1]	(1 to 7) mm	0.03 mm	Indirect Verification per ASTM E10 using Brinell Test Blocks and Brinell Scope Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Knoop and Vickers Hardness Testers [1]	(1 to 200) µm (1 to 200) µm	0.25 µm 0.17 µm	Indirect Verification per ASTM E384 using Knoop and Vickers Test Blocks Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Leeb Hardness Tester [1]	(300 to 900) LD	20 LD	Indirect Verification per ASTM A596 using Leeb Test 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
Rockwell Hardness Testers [1]	HRBW Low HRBW Med HRBW High HRA Low HRA Med HRA High HRC Low HRC Med HRC High HRE Low HRE Med HRE High HRF Low HRF Med HRF High HRH Low HRH Med HRH High HRKW Low HRKW Med HRKW High HRMW Low HRMW Med HRMW High HR15N Low HR15N Med HR15N High HR30N Low HR30N Med HR30N High	1.4 HRBW 1.4 HRBW 1.3 HRBW 1.2 HRA 1.2 HRA 0.75 HRA 1.2 HRC 1.2 HRC 0.7 HRC 1.3 HRE 1.4 HRE 1.4 HRE 1.4 HRF 1.4 HRF 1.4 HRF 1.4 HRH 1.4 HRH 1.4 HRH 1.4 HRKW 1.3 HRKW 1.3 HRKW 1.4 HRMW 1. 4 HRMW 1.3 HRMW 1.5 HR15N 1.3 HR15N 0.9 HR15N 1.3 HR30N 1.3 HR30N 0.9 HR30N	Indirect Verification per ASTM E18 using Rockwell Test 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
Rockwell Hardness Testers [1]	HR45N Low HR45N Med HR45N High HR15TW Low HR15TW Med HR15TW High HR30TW Low HR30TW Med HR30T High HR45TW Low HR45TW Med HR45TW High	1.4 HR45N 1.3 HR45N 0.95 HR45N 2 HR15TW 1.4 HR15TW 1.5 HR15TW 2 HR30TW 1.5 HR30TW 1.3 HR30TW 2 HR45TW 1.3 HR45TW 1.4 HR45TW	Indirect Verification per ASTM E18 using Rockwell Test Blocks Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Force [1]	Up to 100 lb 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 0.05 % of reading 0.07 % of reading 0.1 % of reading 0.1 % of reading 0.1 % of reading	Dead Weight Load Cells Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Force	Up to 200 lb Up to 1 000 lb (1 000 to 10 000) lb (10 000 to 100 000) lb	0.05 % reading 0.03 % reading 0.03 % reading 0.04 % reading	Dead Weight Load Cells Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
Wedge Tester [1]	Up to 40 000 N	32 N	Load Cell 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
Torque Transducers [1]	(Up 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
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
Pipettes	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

Mass and Mass Related

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
Foundry Sand Test Equipment / Measurement [1]			
Ultrasonic Cleaner/Scrubber	18 ºF 30 m	1.7 ºF 1.2 s	Temperature Calibrator Stopwatch
Wet Tensile Tester	0.449 N/cm² (300 to 320) ºF	0.003 1 N/cm² 2 ºF	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
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 ºF)	1.9 ºF	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

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	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	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

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
Infrared Thermometers [1]	(122 to 932) °F	2.2 °F	Hart Scientific 9132 Blackbody λ = (8 to 14) µm, ε = 0.95 Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC
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
Temperature – Measure [1]	(-30 to 600) °C (600 to 1200) °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

Thermodynamic

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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 Rockford, IL 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
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

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

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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
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

Time and Frequency

Parameter/Equipment	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method, and/or Equipment
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

DIMENSIONAL MEASUREMENT

2 Dimensional

Specific Tests and / or Properties Measured	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
Surface Finish (Ra)	(0.01 to 300) µin	2.1 µin	Profilometer Oshkosh, WI Fenton, MO Stacy, MN Rockford, IL Monroe, NC

3 Dimensional

Specific Tests and / or Properties Measured	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Dimensional Inspection Volumetric Linear	Up to (28 x 40 x 24) in Up to (28 x 40 x 24) in	320 µin (38 + 5.2*L*) µin	Coordinate Measuring Machine Oshkosh, WI Stacy, MN

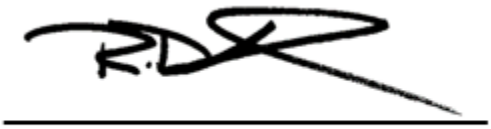
3 Dimensional

Specific Tests and / or Properties Measured	Range	Expanded Uncertainty of Measurement (+/-)	Reference Standard, Method and/or Equipment
Angular	Up to 180 °	0.002 5 °	Starrett AVR300 Oshkosh, WI Fenton, MO 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. This scope is formatted as part of a single document including Certificate of Accreditation No. ACT-1272.



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